

A randomized, placebo-controlled trial of the effect of zinc supplementation during pregnancy on pregnancy outcome in Bangladeshi urban poor¹⁻³

Saskia JM Osendarp, Joop MA van Raaij, Shams E Arifeen, MA Wahed, Abdullah H Baqui, and George J Fuchs

ABSTRACT

Background: Maternal zinc supplementation has been suggested as a potential intervention to reduce the incidence of low birth weight in developing countries. To date, placebo-controlled trials have all been performed in industrialized countries and the results are inconsistent.

Objective: The objective of this study was to evaluate whether zinc supplementation in Bangladeshi urban poor during the last 2 trimesters of pregnancy was associated with pregnancy outcome.

Design: We conducted a double-blind, placebo-controlled trial in which 559 women from Dhaka slums, stratified by parity between 12 and 16 wk of gestation, were randomly assigned to receive 30 mg elemental Zn/d ($n = 269$) or placebo ($n = 290$). Supplementation continued until delivery. Serum zinc was estimated at baseline and at 7 mo of gestation. Dietary intake was assessed at baseline and anthropometric measurements were made monthly. Weight, length, and gestational ages of 410 singleton newborns were measured within 72 h of birth.

Results: At 7 mo of gestation, serum zinc concentrations tended to be higher in the zinc-supplemented group than in the placebo group (15.9 ± 4.4 compared with $15.2 \pm 4.3 \mu\text{mol/L}$). No significant effect of treatment was observed on infant birth weight (2513 ± 390 compared with 2554 ± 393 g; NS) or on gestational age, infant length, or head, chest, or midupper arm circumference. The incidence and distribution of low birth weight, prematurity, and smallness for gestational age also did not differ significantly after zinc supplementation.

Conclusions: Supplementation with 30 mg elemental Zn during the last 2 trimesters of pregnancy did not improve birth outcome in Bangladeshi urban poor. These results indicate that interventions with zinc supplementation alone are unlikely to reduce the incidence of low birth weight in Bangladesh. *Am J Clin Nutr* 2000;71:114-9.

KEY WORDS Zinc supplementation, pregnancy, pregnancy outcome, low birth weight, developing countries, Bangladesh, urban poor, small-for-gestational-age infants, prematurity

INTRODUCTION

South Asia, and Bangladesh in particular, has among the highest incidences of low birth weight (LBW; <2500 g) in the world. An estimated 40-50% of all live births in Bangladesh are classi-

fied as LBW, 70-80% of which are the result of intrauterine growth retardation (IUGR) (1-3). Infants born with IUGR have higher mortality rates and are at higher risk of growth retardation, poor cognitive development, increased morbidity, and impaired immunity later in life than are their normal-birth-weight counterparts (4, 5). Effective interventions aimed at preventing LBW are therefore particularly important potential strategies for reducing childhood malnutrition and improving infant health. Recently, maternal zinc supplementation was suggested as one possible nutritional intervention during pregnancy to improve pregnancy outcome in developing countries (6).

The results of cross-sectional studies suggest that low dietary zinc intake or low maternal plasma zinc are associated with an increased risk of LBW and preterm delivery (7-9). Low plasma zinc has also been reported to correlate with pregnancy complications such as prolonged labor, hypertension, postpartum hemorrhage, spontaneous abortion, and congenital malformation (10). However, the results of zinc-supplementation trials in pregnant women to improve pregnancy outcome are not consistent (11-18), possibly reflecting the use of insufficient sample sizes (11, 13, 16) or the fact that populations have varying risks of LBW and zinc deficiency (19). A clinically and statistically significant effect on birth weight and head circumference was observed in one controlled intervention trial in which only women with low plasma zinc concentrations at enrollment were selected (17). These results strengthened the hypothesis that zinc supplementation during pregnancy might be beneficial only in populations that are zinc deficient and at high risk of poor fetal growth (19, 20). Although

¹From the Centre for Health and Population Research, the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), Dhaka; the Division of Human Nutrition and Epidemiology, Wageningen University, Netherlands; the Department of Pediatrics, School of Medicine, Louisiana State University, New Orleans; and the Department of International Health, Johns Hopkins University, Baltimore.

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³Address reprint requests to GJ Fuchs, ICDDR,B, GPO Box 128, Dhaka 1000, Bangladesh. E-mail: gfuchs@icddr.org.

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women from developing countries are more likely to be zinc deficient and to have a greater risk of producing LBW infants, we are aware of only 2 published supplementation trials from developing countries (21, 22). One trial in India showed a significant increase in birth weight after zinc supplementation (21), whereas the other study, which was carried out in South Africa, showed no effect (22). However, neither of these studies used a double-blind design and both were lacking a true placebo group.

It is in this context that we performed a double-blind, placebo-controlled zinc-intervention trial among pregnant women from the urban slums of Dhaka, Bangladesh. These women belonged to a very poor and deprived part of the population in which LBW is highly prevalent and the poor quality of diets is likely to result in zinc deficiency.

SUBJECTS AND METHODS

Study population

Between March and June 1996, a total of 559 pregnant women from selected areas of Dhaka city slums were identified between 12 and 16 wk of gestation through an established pregnancy-identification system. Gestational age on enrollment was determined by the women's recalled date of their last menstrual period (LMP). Women were included in the study if they planned to remain at or near their residences in Dhaka for the delivery, did not have an established medical risk for reduced or excessive birth weight (eg, hypertension, renal disease, or diabetes), and provided informed consent. The study was approved by the Ethical Review Committee of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). The final sample size required to enable detection of a difference of 250 g in birth weight with 80% power and a type I error of 5%, assuming an SD of 500 g, was estimated to be 300 (150 per treatment group).

Study design

The study was double blind and women were stratified by parity and randomly assigned to receive either 30 mg elemental Zn/d as zinc acetate ($n = 269$) or a cellulose placebo ($n = 290$). Before randomization, information was collected on the socioeconomic status of the women's households and the reproductive history of the women. Categories for socioeconomic status were defined according to an index for urban populations that was developed on the basis of ownership of household durable goods (23). The amount of zinc given was based on twice the recommended daily intake for zinc during the last 2 trimesters of pregnancy, assuming low or moderate bioavailability (24, 25), and was used previously in pregnant women without reports of adverse effects (26). The zinc content of the zinc tablets (\bar{x} : 31.0 mg Zn/tablet; range: 28.6–32.6; $n = 20$) and placebo tablets (\bar{x} : 0.0 mg Zn/tablet; range: 0.0–0.1; $n = 20$) was verified in our laboratory and confirmed in a second independent laboratory. The placebo was a cellulose tablet indistinguishable from the zinc supplement in both appearance and taste. Health workers provided a 1-wk supply of zinc or placebo tablets (ACME Ltd, Dhaka) to the houses of the women weekly and instructed the women to consume one tablet daily between meals and not together with other vitamin or mineral supplements. Compliance with this regimen was assessed by counting the remaining tablets in each strip at the next visit. Unannounced compliance checks between regular visits were performed monthly in subsamples of 10% of the study partici-

pants. The women were prospectively followed up and supplementation continued until delivery. Randomization was achieved by computer-generated random-letter assignment, and the codes remained unknown to both investigators and participants until the study was completed. Serum zinc concentrations, hemoglobin concentrations, and blood pressure were assessed at baseline and again at 7 mo of gestation during visits to the ICDDR,B Clinical Research and Service Centre. Information on dietary intake was collected at baseline and anthropometric measurements were made monthly from baseline until 8 mo of gestation during home visits. Gestational age assessment, birth-weight measurements, and infant anthropometric measurements were performed by trained physicians within 72 h of birth.

Blood analyses and blood pressure

Nonfasting venous blood was obtained during morning hours for serum zinc determination by using trace-mineral-free plastic syringes, stainless steel needles, and trace-mineral-free plastic tubes. Serum was separated at a maximum of 6 h after collection and stored at -20°C until analyzed. Before analysis, the serum samples were diluted (1:12) with 0.03% polyoxyethylene 23 lauryl ether and 10 mmol HNO_3/L . Zinc concentration was measured by using flame atomic absorption spectrophotometry (27). For quality control, a commercial zinc reference (Utak Laboratories, Inc, Los Angeles) was used in concentrations of 0.1, 0.25, 0.5, and 1.0 mg/L. The CV of the analyses was always $<5\%$. Hemoglobin was measured by using a commercial kit (Sigma Diagnostics, St Louis). According to general practice in Bangladesh, iron supplements (200 mg ferrous sulfate plus 200 μg folate/d) were provided by the study team to women with a hemoglobin concentration <90 g/L at 4 mo ($n = 14$; 2.5%) and 7 mo ($n = 40$; 8.5%) of gestation. The women were specifically instructed not to consume iron tablets together with the zinc supplements to avoid potential competition for intestinal absorption (28). The blood pressure of the women was measured at 4 and 7 mo of gestation by registered nurses following standard procedures.

Anthropometry and dietary intake during pregnancy

The weights of the women were measured to the nearest 0.1 kg on an electronic bathroom weighing scale (model 770; Seca, Hamburg, Germany), and height was measured to the nearest 0.1 cm with a height stick. Midupper arm circumference (MUAC) was measured to the nearest millimeter with numeral-insertion tapes. Intra- and interobserver variation were regularly assessed and found to be acceptable, with CVs $<1\%$ for all anthropometric measures.

Dietary intake was assessed by a 24-h dietary recall and separate questions on the use of vitamin or mineral supplements. Portion sizes were estimated by using standard household measures quantified in grams by repeated measurements of 10 independent samples representative of the food concerned. A computerized food-composition table was developed especially for this study on the basis of nutrient values taken primarily from the Hyderabad table for Indian foods (29) and completed with values from other sources (30–33). All anthropometric measurements and assessments of dietary intake were performed by trained fieldworkers who were closely supervised.

Pregnancy outcome

Newborns were weighed by physicians on a portable beam-balance scale (model 725; Seca) to the nearest 10 g during a home

visit within 72 h of birth. The scales were regularly calibrated against standard weights. The period of 72 h was considered feasible and valid as a measure of birth weight in a field setting and was used in previous studies conducted at the ICDDR,B (2). In our study, the average time between measurement and birth was found to be similar in both groups. Infants' length and head, arm, and chest circumferences were measured to the nearest millimeter. Gestational age was calculated by using the LMP as recalled on enrollment. The Capurro method (34) was used for 72 infants (18%) for whom LMPs were considered invalid (ie, <26 or >46 completed weeks or a difference between the LMP and the results of the Capurro method of >4 wk). Infants were classified as small for gestational age or appropriate for gestational age by using the 10th percentile of a US fetal growth curve (35) as a cutoff.

Statistical methods

Differences between the zinc-supplemented and placebo groups for the main outcome variables were tested by using Student's *t* test, a chi-square test, or the Wilcoxon signed-rank test (SPSS 7.5 FOR WINDOWS; SPSS Inc, Chicago). Multiple stepwise regression was performed to identify variables that contributed significantly to the variation in outcome variables and that required adjustment as covariates during multivariate analyses on the effect of supplementation.

Analysis of covariance (ANCOVA) was used to test for differences after adjustment for the effect of the covariates with the different outcome measures as dependent variables and treatment as the independent variable. For maternal weight and maternal MUAC during gestation, ANCOVA for repeated measurements was used. Some of the confounding variables had to be transformed into dummy variables (36) to enable the mathematical model for ANCOVA to be expressed as a model for multiple regression. For serum zinc, log-transformed values were used because the distribution approached normality only after log transformation. The distribution of other variables did not violate the assumption of normality. *P* values <0.05 were considered significant.

RESULTS

Of the 559 women enrolled, 113 (20.2%) were lost to follow-up before delivery [55 (20.4%) in the zinc-supplemented group and 58 (20.0%) in the placebo group; NS]. As anticipated for this highly mobile population and despite the restrictions at enrollment, most losses to follow-up (*n* = 60) were due to out-migration during the course of the study or to women leaving the area to deliver in their home villages. No differences in reasons for women being lost to follow-up were observed between the 2 groups.

A higher percentage of nulliparity was observed among the women who were lost to follow-up because nulliparous women were more likely to go back to their home villages for delivery. No differences in other relevant baseline characteristics were observed (Table 1).

Of the 446 women who completed the follow-up until delivery, 19 (12 in the zinc-supplemented and 7 in the placebo group; NS) delivered a stillborn infant or an infant that died shortly after birth. Four deliveries (2 in the zinc-supplemented and 2 in the placebo group; NS) took place outside Dhaka and 6 birth weights (3 in the zinc-supplemented and 3 in the placebo group; NS) were obtained >72 h after delivery and were excluded from further analyses. Another 7 women (3 in the zinc-supplemented and 4 in the placebo group; NS) delivered twins and were excluded

TABLE 1
Maternal baseline characteristics¹

	Women lost to follow-up (<i>n</i> = 113)	Women who completed follow-up (<i>n</i> = 446)
Age at enrollment (y)	23.6 ± 5.8 ²	23.1 ± 5.5
Nulliparous (%)	32.7	22.0 ³
Multiparous only (%)		
Previous SGA infant	9.1	13.2
Previous preterm infant	13.0	9.5
Previous miscarriage	30.9	26.5
Socioeconomic status (%) ⁴		
Poor	41.6	38.3
Very poor	41.6	39.5
Weight (kg)	41.6 ± 6.3	41.8 ± 6.3
Height (cm)	148.9 ± 5.9	148.6 ± 5.1
BMI (kg/m ²)	18.7 ± 2.3	18.9 ± 2.5
MUAC (mm)	224 ± 24	226 ± 24
Hemoglobin (g/L)	117 ± 13	114 ± 13
Serum zinc (μmol/L)	15.8 ± 4.6	15.3 ± 4.3

¹SGA, small for gestational age; MUAC, midupper arm circumference.

² $\bar{x} \pm SD$.

³Significantly different from women lost to follow-up, *P* < 0.05 (chi-square test).

⁴Based on an index of household assets (26).

from the birth-weight analyses. The final sample size for the analyses of birth weight and gestational age therefore consisted of 410 singleton infants.

Overall, 79% of the women came from households classified as "poor" or "very poor" on the basis of an index of the household assets (23). Median dietary intakes of energy (6073 kJ/d) and zinc (6.5 mg/d) at baseline were not significantly different between the zinc-supplemented and placebo groups (Table 2). Carbohydrates supplied 67.8% of the daily energy intake, whereas fat and protein contributed 19.8% and 12.4%, respectively. Most (74%) of the daily zinc intake came from cereals (rice) and pulses. Consumption of iron and vitamin or mineral supplements was not common in this population, with only 11 women (2%) reporting intake of iron supplements and 45 (8%) reporting intake of other vitamin or mineral supplements during the previous 14 d at 4 mo of gestation.

The mean compliance with supplementation as calculated by the percentage of days during follow-up that a woman reported having consumed a supplement was 86%, and the mean (±SD) duration of supplementation of the 446 women who completed

TABLE 2
Maternal daily intake of energy and selected nutrients at baseline¹

	Zinc-supplemented group (<i>n</i> = 214)	Placebo group (<i>n</i> = 232)
Energy (kJ)	5881 (4386–7726)	6252 (4357–8488)
Protein (g)	40 (24–58)	39 (26–69)
Fat (g)	31 (21–43)	32 (21–45)
Carbohydrate (g)	240 (179–349)	263 (168–379)
Iron (mg)	11.3 (6.0–19.5)	11.7 (6.0–23.4)
Zinc (mg)	6.3 (4.2–8.8)	6.4 (4.3–10.2)

¹All values are expressed as medians (first quartile to third quartile). There were no significant differences between groups.

the follow-up until delivery was 24.6 ± 3.5 wk. No differences in compliance with and duration of supplementation were observed between the 2 groups.

Pregnancy and maternal characteristics

At 7 mo of gestation, serum zinc concentrations tended to be higher in the zinc-supplemented group (15.9 ± 4.4 $\mu\text{mol/L}$) than in the placebo group (15.2 ± 4.3 $\mu\text{mol/L}$; $P = 0.065$; Student's t test) (Table 3). The zinc-supplemented women tended to have higher mean serum zinc concentrations at 7 mo of gestation than at 4 mo of gestation, whereas zinc concentrations in the placebo group tended to be lower at 7 mo of gestation than at 4 mo of gestation. The difference in response (1.08 $\mu\text{mol/L}$) was not significant. After 4 mo of supplementation (at 8 mo of gestation) there were no significant differences in mean maternal weight and MUAC between women in the zinc-supplemented and placebo groups who completed the follow-up (ANCOVA for repeated measurements). Mean weight gain between 4 and 8 mo of gestation was 4.9 ± 2.2 kg (4.7 ± 2.3 kg in the zinc-supplemented group compared with 5.1 ± 2.1 kg in the placebo group; NS, ANCOVA). The mean change in MUAC was 3 ± 11 mm (3 ± 12 mm in the zinc-supplemented group compared with 4 ± 11 mm in the placebo group; NS, ANCOVA). Mean blood pressure and hemoglobin concentrations at 7 mo of gestation were also not significantly different between groups.

Infant characteristics

No significant effect of treatment was observed for weight, gestational age, length, head or chest circumference, or MUAC at birth in the 410 singleton infants with valid anthropometric measures. The incidence and distribution of LBW (<2500 , <2000 , and <1500 g), prematurity (<37 and <32 wk), and smallness for gestational age also did not differ significantly between infants of the zinc-supplemented and placebo groups (Table 4).

Infant birth weight was significantly correlated with maternal body mass index (BMI; in kg/m^2) at baseline, socioeconomic status of the mother's household, and parity of the mother. We therefore examined the effect of zinc supplementation on women from different subgroups. Overall, nulliparous women ($n = 92$) delivered infants with a significantly lower birth weight than did multiparous women ($n = 318$) (2446 ± 325 and 2560 ± 405 g, respectively; $P = 0.01$). Likewise, women with a baseline BMI <18.5 ($n = 194$) had significantly smaller infants than did women with a higher initial BMI ($n = 211$) (2461 ± 400 and 2598 ± 375 g, respectively; $P = 0.00$), whereas infants from very poor households ($n = 160$) had significantly lower birth weights than did

infants from middle-income households ($n = 93$) (2466 ± 392 and 2605 ± 419 g, respectively; $P = 0.001$). No treatment effects of zinc or placebo were observed for any of the outcome variables in women from the different subgroups. A total of 45 pregnancies (20 in the zinc-supplemented group and 25 in the placebo group; NS) resulted in miscarriage, stillbirth, or early neonatal death.

DISCUSSION

In a recent systematic review of 5 published randomized, controlled maternal-zinc-supplementation trials (20), it was concluded that, although current available data did not provide enough evidence for routine zinc supplementation during pregnancy, supplementation may be beneficial in zinc-deficient populations in which LBW is highly prevalent. We therefore performed a randomized, double-blind, placebo-controlled trial in a poor urban population of Dhaka. The prevalences of LBW (42.9%) and smallness for gestational age (74.6%) in our study population were very high, similar to data from other studies in rural (1, 3) and urban (2) Bangladesh and higher than observed in other developing countries (3). The median dietary intake of zinc was 6.5 mg/d, although an intake of 15 mg is recommended during the last 2 trimesters of pregnancy (24, 25). Moreover, we assumed that only 20% of the dietary zinc was potentially available for absorption (24) because it came mainly from cereals that are high in phytate and pulses, and because the intake of zinc and protein from animal products was low.

After 3 mo of supplementation, serum zinc concentrations tended to be higher in the zinc-supplemented group than in the placebo group, but the difference was small. Increased blood zinc concentrations or a reduced number of low zinc values were reported after zinc supplementation in some (13, 17) but not all (11, 15) of the previous trials. It is recognized that the specificity of serum zinc as an indicator of body zinc status has limitations (24, 37), and we believe that supplementation in our study was successful in improving maternal zinc status. Compliance with taking the supplements was good; the supplements were consumed between meals to avoid potential competition for absorption and the zinc tablets substantially increased the daily dietary zinc intake.

Supplementation with 30 mg elemental Zn/d during the last 2 trimesters of pregnancy did not result in improved pregnancy outcomes. These findings were unexpected because our study was performed in a very malnourished population in which the dietary zinc intake was low and poorly bioavailable. Our supplementation provided twice the recommended dietary zinc intake for pregnant women, which is similar to or even higher

TABLE 3
Maternal characteristics at baseline and at 7 or 8 mo of gestation¹

	Zinc-supplemented group ($n = 214$)		Placebo group ($n = 232$)	
	4 mo of gestation	7 or 8 mo of gestation	4 mo of gestation	7 or 8 mo of gestation
Weight (kg)	41.7 ± 6.2	46.4 ± 6.0	42.0 ± 6.5	47.1 ± 6.6
MUAC (mm)	226 ± 24	229 ± 23	226 ± 24	231 ± 22
Blood pressure (mm Hg)				
Diastolic	54.0 ± 7.8	53.8 ± 6.6	53.7 ± 7.1	54.6 ± 6.7
Systolic	86.6 ± 11.1	84.4 ± 8.7	85.1 ± 10.1	84.7 ± 8.7
Hemoglobin (g/L)	114 ± 14	108 ± 13	115 ± 11	108 ± 11
Serum zinc ($\mu\text{mol/L}$)	15.3 ± 4.1	15.9 ± 4.4	15.5 ± 4.4	15.2 ± 4.3

¹ $\bar{x} \pm \text{SD}$. Values were controlled for maternal height, age, and parity. There were no significant differences between the zinc-supplemented and placebo groups. MUAC, midupper arm circumference.

TABLE 4
Birth characteristics of singleton infants of the zinc-supplemented and placebo groups¹

	Zinc-supplemented group (n = 194)	Placebo group (n = 216)
Weight (g)	2513 ± 390 ²	2554 ± 393
Low birth weight (%)		
<2500 g	45.9	40.3
<2000 g	8.9	8.8
<1500 g	1.0	0.5
Gestational age (wk)	38.8 ± 2.4	38.9 ± 2.1
Prematurity (%)		
<37 wk	17.5	15.7
<32 wk	1.0	0.9
Small for gestational age (%)	74.7	74.5
Length (cm)	46.8 ± 2.3	47.0 ± 2.2
Head circumference (cm)	32.6 ± 1.4	32.7 ± 1.5
Chest circumference (cm)	30.2 ± 1.8	30.4 ± 1.9
MUAC (mm)	92 ± 8	91 ± 8

¹ Values were controlled for baseline maternal weight, parity, and socioeconomic status. There were no significant differences between groups. MUAC, midupper arm circumference.

² $\bar{x} \pm SD$.


than the dosages used in most of the other zinc-supplementation trials. Effects on birth weight and IUGR were observed in trials with use of dosages of 22.5 (16) and 25 mg elemental Zn/d (17).

As expected in this highly mobile urban population, the dropout rate was substantial. More nulliparous women were lost to follow-up than were women who had previously given birth, which may have resulted in a lower number of LBW infants. However, because the percentages and reasons for women being lost to follow-up were not different between the zinc-supplemented and placebo groups, it is unlikely that the high dropout rate affected the outcome of our study. In addition, the final sample size of 410 infants was still sufficient to enable a difference in birth weight as small as 110 g to be detected.

Surprisingly, in our population only 4 women had serum zinc concentrations <9.18 $\mu\text{mol/L}$, which was used as the reference point for zinc deficiency in other studies (13, 38). Food intake may have contributed to the relatively high serum zinc concentrations observed in our study population because blood samples were taken during morning hours under nonfasting conditions. Serum zinc is known to vary by 15–20% within individuals throughout the day, primarily as a result of food intake (37). The amount of time between collection and separation is also known to influence final serum zinc concentrations of samples because zinc leaks from cells into serum (39). In our study, this delay of a maximum of 6 h may have caused an increase in serum zinc in some cases. Whether or not the relatively high serum zinc concentrations may reflect an adaptation to habitually low dietary zinc intakes in our study population is unknown. Inverse relations between dietary zinc supply and zinc status were observed in several studies (25), probably because of lower intestinal excretion of endogenous zinc (40). Serum zinc is known to be susceptible to contamination during sample collection, storage, and analysis. However, we believe that contamination is not a likely cause of the high serum zinc values observed in our study because special care was given to avoid contamination and because random contamination would not explain the systematically high values we observed.

Even though the poor dietary intake and nutritional status of our study population indicated otherwise, the possibility that this population was not zinc deficient on enrollment and hence did not benefit from additional zinc supplementation must be considered. We therefore also analyzed only women with low serum zinc concentrations to assess whether the zinc status of our population affected the outcome of the study. In a trial among African American women who were already receiving a non-zinc-containing prenatal multivitamin or mineral tablet, Goldenberg et al (17) observed an increase in birth weight after zinc supplementation in women with low plasma zinc concentrations on enrollment. In our population, only 21 women had serum zinc concentrations comparable with the cutoffs used in Goldenberg's trial (<10.6 $\mu\text{mol/L}$ at 13 wk of gestation), and restricting analysis to those women resulted in no significant differences in mean infant birth weight [2360 ± 195 compared with 2375 ± 602 g in the zinc-supplemented (n = 10) and placebo (n = 11) group, respectively], but the sample was small.

We believe that the absence of any effect of zinc supplementation in our study population was most likely due to the concurrent existence of other nutrient deficiencies that reduced the bioavailability of zinc or limited fetal growth. The median intake of energy was 6.2 MJ/d, which is lower than the recommended maintenance requirements of 7.5 MJ/d for pregnant women with similar body weights (41). Maternal nutritional status was extremely poor at 4 mo of gestation, and most of the women undoubtedly had entered pregnancy in an already disadvantaged nutritional state. The average weight gain between 4 and 8 mo of gestation was 4.9 kg, whereas in developing countries, weight gains of 1.5 kg/mo during the last 2 trimesters of pregnancy are recommended (42, 43). A total of 132 women (32.5%) had a decrease in MUAC during gestation, indicating that, instead of laying down fat stores for fetal growth later in pregnancy and for lactation and maternal recuperation, these women were actually depleting already-poor fat and lean tissue stores during gestation. Our data clearly show a population at high risk of having infants with LBW that is apparently not reversible with a single micronutrient supplement.

In summary, zinc supplementation alone during the last 2 trimesters of pregnancy in very poor urban Bangladeshi women did not improve infant birth weight or gestational age despite the fact that supplementation resulted in a marginal improvement in maternal zinc status. It is possible that zinc supplementation earlier in gestation or before conception would have a positive effect. However, in most developing countries it is not feasible to identify pregnant women before 12 wk of gestation. The results of our study therefore indicate that public health interventions with zinc supplementation alone are unlikely to reduce the incidence of LBW in a developing country such as Bangladesh. 

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