

Research Article

Frequency of Preterm Delivery with and Without Zinc Supplementation in Pregnant Women Presenting In the Third Trimester: A Prospective Comparative Study

Sana Ayesha^{1*}, Sumera Kanwal², Fatmeh Waqar³, Sameea Akram⁴, Alia Rehman⁵, Kiran Nasir⁶

^{1*}Consultant Obstetrician & Gynaecologist, Department of Obstetrics & Gynaecology, Maryam Nawaz Hospital Chak 173P, Sadiqabad, Pakistan.

²Associate Professor, Department of Obstetrics and Gynecology, Lady Willingdon Hospital, King Edward Medical University, Lahore, Pakistan.

³Former Demonstrator, Department of Community Medicine, King Edward Medical University, Lahore, Pakistan.

⁴Assistant Professor, Department of Pediatrics, Nawaz Sharif Medical College / Aziz Bhatti Shaheed Teaching Hospital, Gujrat, Pakistan.

⁵Assistant Professor, Department of Pharmacology, Mohtarma Benazir Bhutto Shaheed Medical College, Mirpur, Azad Kashmir, Pakistan.

⁶Consultant Gynecologist, Department of OBS and Gynae, DHQ teaching hospital Mianwali, Pakistan.

Corresponding Author: Dr. Sana Ayesha

Consultant Obstetrician & Gynaecologist, Maryam Nawaz Hospital Chak 173P, Sadiqabad, Pakistan.

Email: frndsprovidant05@gmail.com

Received: 19.08.2026 Revised: 21.09.2026 Accepted: 23.10.2026

ABSTRACT

Objective: To compare the frequency of preterm delivery among pregnant women receiving zinc supplementation and those without supplementation.

Study Design: Prospective comparative cohort study.

Place and Duration of Study: Tertiary care hospital, Pakistan, from 1 January 2026 to 30 June 2026.

Methodology: A total of 618 pregnant women with singleton pregnancies at 28-34 weeks of gestation were enrolled through consecutive sampling. Participants were categorized into zinc supplementation (20 mg/day) and non-supplementation groups. Following losses to follow-up, 557 women (282 receiving zinc and 275 without zinc) were analyzed. Preterm delivery was defined as childbirth before 37 completed weeks. Associations were assessed using comparative statistical tests and multivariable logistic regression adjusting for maternal and obstetric factors.

Results: The mean maternal age was 28.0 ± 4.8 years in the zinc group and 27.8 ± 4.4 years in the non-zinc group. Preterm delivery occurred in 25 (8.9%) women receiving zinc compared with 39 (14.2%) without supplementation, representing an absolute difference of 5.3 percentage points (RR 0.63, 95% CI 0.39-1.00). The unadjusted association was borderline and sensitive to statistical testing (Pearson $p = 0.049$; Fisher $p = 0.062$). After adjustment for maternal and obstetric factors, zinc supplementation was associated with lower odds of preterm delivery (adjusted OR 0.51, 95% CI 0.30-0.89; $p = 0.018$). Previous preterm birth was independently associated with increased risk (adjusted OR 3.13, 95% CI 1.50-6.51; $p = 0.002$).

Conclusion: Antenatal zinc supplementation was associated with a lower frequency of preterm delivery after adjustment for maternal and obstetric factors. Larger randomized studies are needed to establish its preventive effectiveness.

Keywords: Zinc Supplementation, Preterm Birth, Pregnancy, Prenatal Care, Maternal Nutrition.

INTRODUCTION

Preterm birth, defined as delivery before 37 completed weeks of gestation, remains a major contributor to neonatal mortality, childhood morbidity, and long-term developmental impairment worldwide. Despite improvements in antenatal surveillance, obstetric management, and neonatal intensive care, the global burden of prematurity remains substantial, particularly in low- and middle-

income countries. Ohuma et al. estimated that approximately 13.4 million infants were born preterm worldwide in 2020, representing 9.9% of all live births. Southern Asia accounted for a disproportionately high burden, with an estimated preterm birth rate of 13.2%. Pakistan had an estimated rate of 14.4%, placing it among the countries with the greatest burden of prematurity [1]. Lawn et al. further emphasized that infants born prematurely

experience increased risks of neonatal death and adverse developmental outcomes, particularly when prematurity is accompanied by fetal growth restriction [2].

The etiology of preterm delivery is multifactorial, involving maternal nutritional deficiencies, intrauterine inflammation, infection, placental dysfunction, obstetric complications, and previous adverse pregnancy outcomes. Mitrogiannis et al. identified several maternal and obstetric factors associated with preterm birth, highlighting the complex interactions between clinical, environmental, and biological determinants [3]. Because many established risk factors are difficult to modify during pregnancy, maternal nutritional interventions have attracted considerable attention as potentially accessible approaches to improving birth outcomes.

Zinc is an essential trace element involved in cellular differentiation, DNA synthesis, protein metabolism, immune regulation, and antioxidant defense. During pregnancy, adequate zinc availability supports maternal physiological adaptation, placental development, and fetal growth. Zinc deficiency may compromise maternal immune responses and contribute to inflammatory processes implicated in the initiation of preterm labor. Nevertheless, the relationship between maternal zinc status and gestational duration remains incompletely established. Carducci et al., in a Cochrane review involving 25 randomized controlled trials and more than 18,000 mothers and infants, reported that zinc supplementation produced little or no clear reduction in preterm birth, with a pooled relative risk of 0.87 (95% CI 0.74–1.03) across 21 trials [4].

The potential benefits of zinc supplementation may depend on baseline nutritional status, supplementation timing, maternal dietary intake, and coexisting micronutrient deficiencies. Evidence regarding combined micronutrient supplementation also suggests that improvements in maternal nutritional intake do not necessarily translate into substantial reductions in premature delivery. Therefore, determining the independent relationship between zinc supplementation and preterm birth remains clinically relevant, particularly in populations with a high prevalence of nutritional deficiencies.

The Pakistani context provides a strong rationale for evaluating this association. A multicountry investigation by researchers involved in the Women First Preconception

Maternal Nutrition Trial reported hypozincemia among 65% of Pakistani participants at 12 weeks of gestation and 74% at 34 weeks, suggesting a considerable burden of inadequate maternal zinc status [5]. Combined with Pakistan's high frequency of preterm delivery and disparities in access to maternal healthcare, these findings indicate the need for locally generated evidence. The present study was therefore conducted to compare the frequency of preterm delivery among pregnant women receiving zinc supplementation and those not receiving zinc, and to examine whether the observed association persisted after adjustment for relevant maternal and obstetric characteristics.

METHODOLOGY

This prospective comparative cohort study was conducted at a tertiary care hospital in Pakistan over six months, from 1 January 2026 to 30 June 2026. The study aimed to compare the frequency of preterm delivery among pregnant women receiving zinc supplementation during the third trimester with those who did not receive zinc supplementation. The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Ethical approval was obtained from the Institutional Review Board/Ethical Review Committee, and written informed consent was obtained from all participants before enrollment.

Pregnant women attending the antenatal outpatient department were recruited using a non-probability consecutive sampling technique. The required sample size was calculated using a two-sided significance level of 5%, 80% statistical power, an anticipated preterm delivery frequency of 15% in the non-supplemented group, and an expected relative reduction of 50% with zinc supplementation. The minimum calculated sample size was 278 women per group, which was increased to 309 per group to accommodate an anticipated 10% loss to follow-up. Accordingly, 618 pregnant women were initially enrolled, with 309 allocated to each comparison group. Following losses to follow-up, 557 women (282 in the zinc group and 275 in the non-zinc group) were included in the final analysis.

Women aged 18–40 years with singleton pregnancies between 28 weeks and 34 weeks plus 6 days of gestation were eligible for inclusion. Gestational age was determined using the last menstrual period and confirmed

by first- or early-second-trimester ultrasonography. Women with multiple pregnancies, polyhydramnios, placenta previa, cervical insufficiency or cervical cerclage, preeclampsia, diabetes mellitus, and known genitourinary or intra-amniotic infections were excluded to minimize the influence of established risk factors for preterm delivery.

Participants were categorized into two groups according to zinc supplementation status at enrollment. Group A (zinc supplementation) comprised women receiving 20 mg of elemental zinc orally once daily from enrollment until delivery, whereas Group B (no zinc supplementation) included women who did not receive additional zinc supplementation. Both groups continued routine antenatal care, including standard iron and calcium supplementation. Group allocation was non-randomized, and participants were analyzed according to their supplementation status at enrollment. Adherence to zinc supplementation was assessed through tablet counts, with consumption of at least 80% of prescribed tablets considered satisfactory adherence. Participants were followed through subsequent antenatal visits until delivery, and pregnancy outcomes were recorded from clinical and hospital records.

Data were collected using a structured proforma incorporating maternal age, body mass index (BMI), parity, gestational age at enrollment, hemoglobin concentration, previous history of preterm delivery, supplementation status, and pregnancy outcomes. The primary outcome was preterm delivery, defined as childbirth before 37 completed weeks of gestation. Secondary outcomes included gestational age at delivery and mode of delivery. Gestational age at delivery was determined using the gestational dating established at enrollment. Data were obtained through participant interviews, antenatal records, and delivery documentation. Maternal age, BMI, parity, gestational age at enrollment, hemoglobin concentration, and previous preterm birth were identified as potential confounding variables before statistical analysis.

Data were analyzed using R statistical software (version to be confirmed). Continuous variables were assessed for normality using the Shapiro–Wilk test and summarized as mean $\pm$ standard deviation or median with interquartile range, as appropriate. Normally distributed continuous variables were compared using Welch's independent-samples t-test, whereas non-

normally distributed variables were analyzed using the Wilcoxon rank-sum test. Categorical variables were expressed as frequencies and percentages and compared using Pearson's chi-square test or Fisher's exact test, where appropriate. The frequency of preterm delivery was compared between the supplementation groups, and unadjusted relative risks (RRs), risk differences, and odds ratios (ORs) were calculated with corresponding 95% confidence intervals.

Multivariable binary logistic regression was performed to determine the association between zinc supplementation and preterm delivery after adjustment for maternal age, BMI, parity, gestational age at enrollment, hemoglobin concentration, and previous preterm birth. Adjusted odds ratios (aORs) with 95% confidence intervals were reported. Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test, while correlations among explanatory variables were examined to identify potential multicollinearity. Exploratory subgroup analyses were conducted according to maternal age, parity, BMI, and gestational age at enrollment. Interaction terms were evaluated to assess potential effect modification by maternal age and parity. Sensitivity analyses using Fisher's exact test and continuity-corrected chi-square testing were also performed. Participants lost to follow-up were excluded from the final complete-case analysis, and attrition was reported separately for both groups. All statistical tests were two-sided, with a p-value of less than 0.05 considered statistically significant. Subgroup analyses were interpreted as exploratory without adjustment for multiple comparisons.

RESULTS

A total of 618 pregnant women were enrolled, including 309 in the zinc-supplementation group and 309 in the comparison group. Follow-up data were unavailable for 27 women receiving zinc (8.7%) and 34 women not receiving zinc (11.0%), predominantly because they delivered outside the study hospital. The final complete-case analysis included 557 women: 282 in the zinc group and 275 in the no-zinc group (Figure 1).

The mean maternal age was 28.0 ± 4.8 years in the zinc group and 27.8 ± 4.4 years in the no-zinc group ($p = 0.702$). Body mass index, gestational age at enrollment, hemoglobin concentration, and parity were broadly comparable between groups. A history of previous preterm birth was more frequent

Sana Ayesha et al / Frequency of Preterm Delivery with and Without Zinc Supplementation in Pregnant Women Presenting In the Third Trimester: A Prospective Comparative Study

among women receiving zinc (12.1% versus 5.8%; $p = 0.010$). The proportion undergoing

cesarean delivery was 39.4% versus 33.5%, respectively ($p = 0.148$) (Table 1).

Table 1. Baseline Characteristics of Participants Included In the Analysis (N = 557)

Characteristic	Zinc (n = 282)	No zinc (n = 275)	p-value
Maternal age (years)	28.0 $\pm$ 4.8	27.8 $\pm$ 4.4	0.702
BMI (kg/m ²)	25.8 $\pm$ 3.7	25.9 $\pm$ 3.5	0.664
Gestational age at enrollment (weeks)	31.0 $\pm$ 2.0	31.1 $\pm$ 2.0	0.543
Hemoglobin (g/dL)	10.5 $\pm$ 1.1	10.6 $\pm$ 1.1	0.134
Multiparous	143 (50.7%)	161 (58.5%)	0.063
Previous preterm birth	34 (12.1%)	16 (5.8%)	0.010
Cesarean delivery	111 (39.4%)	92 (33.5%)	0.148

Values are mean $\pm$ standard deviation or n (%). Reported p-values are retained from the source manuscript.

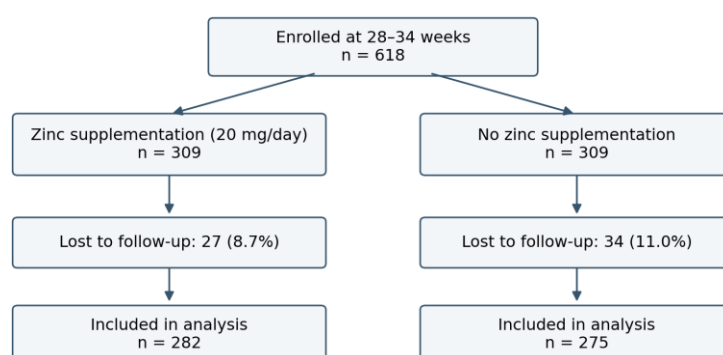


Figure 1. Participant Recruitment, Follow-Up and Analysis in the Prospective Comparative Cohort.

Preterm delivery before 37 completed weeks occurred in 25 of 282 women receiving zinc (8.9%) and 39 of 275 women not receiving zinc (14.2%). The absolute risk difference was -5.3 percentage points (95% CI -10.6 to approximately 0.0), and the unadjusted relative risk was 0.63 (95% CI 0.39-1.00; upper unrounded limit approximately 1.004). Although the originally reported Pearson chi-square test yielded $p = 0.049$, the association was not statistically significant using Fisher's

exact test ($p = 0.062$) or a continuity-corrected chi-square test ($p = 0.067$). Accordingly, the unadjusted evidence was sensitive to the statistical method (Table 2; Figure 2).

Median gestational age at delivery was similar between groups (38.4 weeks [IQR 37.7-39.2] versus 38.5 weeks [IQR 37.6-39.3]; $p = 0.763$). Delivery before 34 weeks was reported in 3 women in the zinc group and 9 in the no-zinc group (Table 2).

Table 2. Primary and Selected Secondary Birth Outcomes

Outcome	Zinc (n = 282)	No zinc (n = 275)	Estimate / p-value
Preterm delivery (<37 weeks)	25 (8.9%)	39 (14.2%)	RR 0.63 (95% CI 0.39-1.00); $p = 0.049$
Unadjusted risk difference (percentage points)	—	—	-5.3 (95% CI -10.6 to ~0.0)
Sensitivity tests	—	—	Fisher $p = 0.062$; corrected χ^2 $p = 0.067$
Gestational age at delivery, weeks	38.4 (37.7-39.2)	38.5 (37.6-39.3)	$p = 0.763$
Delivery before 34 weeks	3 (1.1%)	9 (3.3%)	Not reported

RR, relative risk; CI, confidence interval; IQR, interquartile range. Outcome values and statistical results are from the source

manuscript. No new significance test was inferred for delivery before 34 weeks.

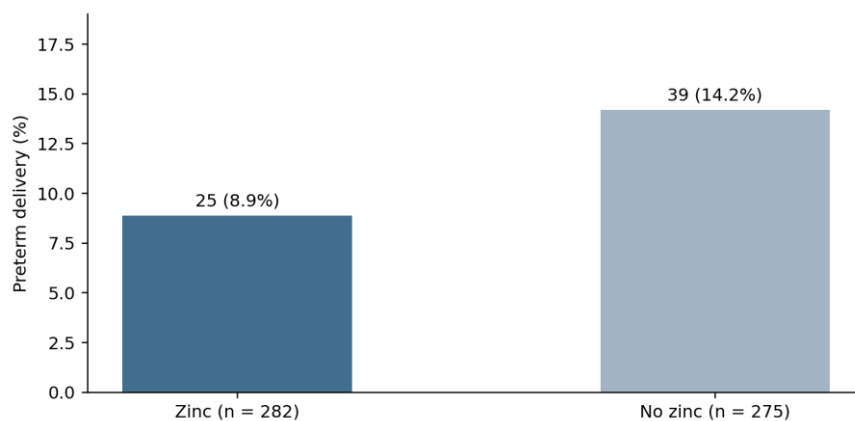


Figure 2. Observed Frequency Of Preterm Delivery In the Zinc and No-Zinc Groups.

Across the prespecified strata defined by maternal age, parity, BMI, and gestational age at enrollment, the point estimates for preterm delivery consistently favored zinc supplementation, although the subgroup estimates were imprecise. Nominal subgroup differences were reported for multiparous women (7.7% versus 14.9%; RR 0.52; p =

0.049) and women enrolled at 32–34 weeks (7.8% versus 15.7%; RR 0.50; p = 0.049). Interaction testing provided no evidence that the association differed by parity (p for interaction = 0.422) or maternal age (p for interaction = 0.696). These subgroup findings were exploratory and were not adjusted for multiple testing (Table 3; Figure 3).

Table 3. Exploratory Stratified Analysis of Preterm Delivery

Stratum	Zinc, n/N (%)	No zinc, n/N (%)	RR	p-value
Age ≤25 years	7/91 (7.7%)	12/82 (14.6%)	0.53	0.145
Age >25 years	18/191 (9.4%)	27/193 (14.0%)	0.67	0.164
Primiparous	14/139 (10.1%)	15/114 (13.2%)	0.77	0.443
Multiparous	11/143 (7.7%)	24/161 (14.9%)	0.52	0.049
BMI <25 kg/m ²	8/113 (7.1%)	16/107 (15.0%)	0.47	0.061
BMI ≥25 kg/m ²	17/169 (10.1%)	23/168 (13.7%)	0.73	0.303
Enrollment at 28–31 weeks	15/154 (9.7%)	18/141 (12.8%)	0.76	0.410
Enrollment at 32–34 weeks	10/128 (7.8%)	21/134 (15.7%)	0.50	0.049

RR, relative risk. P-values reproduced from the source manuscript; comparisons are exploratory.

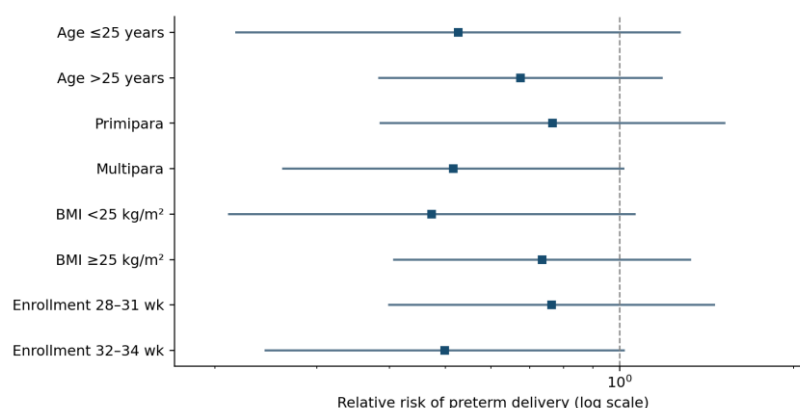


Figure 3. Subgroup Relative Risks With Approximate 95% Confidence Intervals Calculated From The Reported Group Counts. The Vertical Reference Line Indicates RR = 1. These Confidence Intervals Are Descriptive And Were Not Supplied In The Original Manuscript.

In multivariable logistic regression adjusting for maternal age, BMI, parity, gestational age at enrollment, hemoglobin concentration, and previous preterm birth, zinc supplementation was associated with lower odds of preterm delivery (adjusted OR 0.51, 95% CI 0.30–0.89; $p = 0.018$). A previous preterm birth was independently associated with higher odds of

the outcome (adjusted OR 3.13, 95% CI 1.50–6.51; $p = 0.002$), whereas the other modeled covariates were not statistically significant (Table 4). The source analysis reported a Hosmer–Lemeshow goodness-of-fit p -value of 0.513 and a maximum pairwise predictor correlation of 0.07.

Table 4. Multivariable Logistic Regression for Preterm Delivery (N = 557; 64 Events)

Predictor	Adjusted OR	95% CI	p-value
Zinc supplementation (yes vs no)	0.51	0.30–0.89	0.018
Maternal age (per year)	0.99	0.94–1.05	0.813
BMI (per kg/m ²)	1.00	0.93–1.08	0.899
Multiparity (vs primiparity)	0.98	0.57–1.66	0.930
Gestational age at enrollment (per week)	1.00	0.88–1.14	0.989
Hemoglobin (per g/dL)	0.87	0.68–1.11	0.256
Previous preterm birth (yes vs no)	3.13	1.50–6.51	0.002

OR, odds ratio; CI, confidence interval. All values are reproduced from the submitted manuscript.

DISCUSSION

The present prospective comparative cohort study evaluated the association between antenatal zinc supplementation and preterm delivery among 557 pregnant women. Preterm delivery occurred in 8.9% of women receiving zinc supplementation compared with 14.2% of those without supplementation, corresponding to an absolute risk reduction of 5.3 percentage points and an unadjusted relative risk of 0.63 (95% CI 0.39–1.00). Although the Pearson chi-square test indicated borderline significance ($p = 0.049$), Fisher's exact test ($p = 0.062$) and the continuity-corrected analysis ($p = 0.067$) did not. After adjustment for maternal and obstetric characteristics, zinc supplementation remained associated with lower odds of preterm delivery (adjusted OR 0.51, 95% CI 0.30–0.89; $p = 0.018$).

These findings are supported by Iqbal et al., whose umbrella review of 15 meta-analyses suggested a reduction in preterm birth following maternal zinc supplementation, although the evidence was heterogeneous [6]. Huang et al., in a Chinese cohort of 10,179 pregnant women, reported that lower zinc intake during the third trimester was associated with increased odds of very preterm birth (OR 2.04, 95% CI 1.07–3.90) and spontaneous

preterm birth (OR 1.38, 95% CI 1.01–1.88) [7]. Kumari et al. described the involvement of zinc in immune regulation and inflammatory signaling, providing biological plausibility for its potential relationship with premature labor [8]. Nevertheless, the findings should be interpreted alongside evidence from larger supplementation studies. Gomes et al., analyzing 16 trials of antenatal multiple micronutrient supplementation, found that among seven trials using ultrasound-based gestational dating, supplementation was associated with a preterm birth RR of 0.90 (95% CI 0.79–1.03), indicating no statistically conclusive reduction [9]. This is consistent with the uncertainty observed in the unadjusted analysis of the present study. Similarly, Garlapati et al. reported significantly lower maternal zinc concentrations among mothers of preterm than term infants ($p = 0.03$), although their observational findings could not establish a causal effect [10].

Previous preterm delivery emerged as the strongest independent obstetric predictor in the present study (adjusted OR 3.13, 95% CI 1.50–6.51). Aktar et al. also identified substantial recurrence risks across pregnancy cohorts in Bangladesh [11]. Van Gils et al. reported recurrent preterm birth rates ranging from

19.0% to 29.5% among women with previous spontaneous pregnancy loss or preterm birth between 16 and 28 weeks [12]. Zhang et al. likewise emphasized the contribution of maternal and obstetric characteristics to preterm delivery risk in a multicenter Chinese investigation [13]. These findings support adjustment for previous preterm birth, particularly because its prevalence differed significantly between our groups (12.1% versus 5.8%; $p = 0.010$).

Maternal nutritional status may also influence the observed association. Ambreen et al. demonstrated the relevance of maternal nutritional characteristics to adverse fetal growth outcomes in peri-urban Karachi [14]. Schuster et al. examined vaginal microbiota among pregnant women at increased risk of recurrent preterm birth, illustrating the contribution of biological pathways beyond nutritional deficiency [15]. Sámano et al. further reported associations between maternal micronutrient status, gestational weight gain, and infant birthweight [16]. These findings suggest that zinc supplementation should be considered within the broader context of maternal health.

The exploratory subgroup analyses indicated lower preterm delivery frequencies among multiparous women (7.7% versus 14.9%) and women enrolled at 32–34 weeks (7.8% versus 15.7%). However, the absence of significant interaction effects and the lack of multiplicity adjustment prevent firm conclusions about differential supplementation benefits.

An important limitation was the loss of 61 participants during follow-up, representing 9.9% of the enrolled population. Furthermore, the observational design, absence of documented baseline serum zinc concentrations, and potential residual confounding limit causal interpretation. The relatively small number of preterm events also warrants caution regarding multivariable estimates.

Overall, the findings suggest that antenatal zinc supplementation was associated with a lower frequency of preterm delivery in this cohort. However, the sensitivity of the unadjusted findings to statistical methods and the mixed international evidence indicate that larger randomized studies incorporating maternal zinc measurements, supplementation adherence, and earlier gestational enrollment are required before a causal preventive benefit can be established.

Earlier intervention studies provide additional context. Nossier et al. reported fewer preterm deliveries following zinc supplementation among 675 zinc-deficient Egyptian women [17]. In contrast, Osendarp et al. found no significant improvement in prematurity among 559 Bangladeshi women randomized to zinc or placebo [18]. Caulfield et al. similarly observed no improvement in gestational duration in a Peruvian trial involving 1,295 women [19]. Danesh et al. reported no significant gestational-age benefit among women with previous preterm birth [20]. Conversely, Wang et al. found a higher adjusted risk of preterm birth among women with low serum zinc concentrations (adjusted OR 2.41), reinforcing the distinction between zinc deficiency as a risk marker and supplementation as an effective intervention [21].

CONCLUSION

Pregnant women receiving zinc supplementation had a lower observed frequency of preterm delivery than those without supplementation (8.9% versus 14.2%). This association remained statistically significant after adjustment for maternal and obstetric factors, while previous preterm birth emerged as an important predictor. These findings suggest a potential benefit of antenatal zinc supplementation, although larger randomized controlled trials are required to confirm its effectiveness in preventing preterm delivery.

REFERENCES

1. Ohuma EO, Moller AB, Bradley E, Chakwera S, Hussain-Alkhateeb L, Lewin A, et al. National, regional, and global estimates of preterm birth in 2020, with trends from 2010: a systematic analysis. *Lancet*. 2023;402(10409):1261-1271. doi:10.1016/S0140-6736(23)00878-4.
2. Lawn JE, Ohuma EO, Bradley E, Suárez-Idueta L, Hazel E, Okwaraji YB, et al. Small babies, big risks: global estimates of prevalence and mortality for vulnerable newborns to accelerate change and improve counting. *Lancet*. 2023;401(10389):1707-1719. doi:10.1016/S0140-6736(23)00522-6.
3. Mitrogiannis I, Evangelou E, Efthymiou A, Kanavos T, Birbas E, Makrydimas G, et al. Risk factors for preterm birth: an umbrella review of meta-analyses of observational studies. *BMC Med*. 2023;21(1):494. doi:10.1186/s12916-023-03171-4.

4. Carducci B, Keats EC, Bhutta ZA. Zinc supplementation for improving pregnancy and infant outcome. *Cochrane Database Syst Rev*. 2021;3(3):CD000230. doi:10.1002/14651858.CD000230.pub6.
5. Kemp JF, Hambidge KM, Westcott JL, Ali SA, Saleem S, Garcés A, et al. Zinc supplementation initiated prior to or during pregnancy modestly impacted maternal status and high prevalence of hypozincemia in pregnancy and lactation: the Women First Preconception Maternal Nutrition Trial. *J Nutr*. 2024;154(6):1917-1926. doi:10.1016/j.tjnut.2024.04.018.
6. Iqbal S, Ali I. Effect of maternal zinc supplementation or zinc status on pregnancy complications and perinatal outcomes: an umbrella review of meta-analyses. *Heliyon*. 2021;7(7):e07540. doi:10.1016/j.heliyon.2021.e07540.
7. Huang L, Yue L, Nan N, Guo J, He L, Mao B, et al. Association between maternal zinc intake and preterm birth in Gansu Province in 2010-2012. *Wei Sheng Yan Jiu*. 2023;52(6):936-949. doi:10.19813/j.cnki.weishengyanjiu.2023.06.013.
8. Kumari D, Garg S, Bhawrani P. Zinc homeostasis in immunity and its association with preterm births. *Scand J Immunol*. 2022;95(4):e13142. doi:10.1111/sji.13142.
9. Gomes F, Askari S, Black RE, Christian P, Dewey KG, Mwangi MN, et al. Antenatal multiple micronutrient supplements versus iron-folic acid supplements and birth outcomes: analysis by gestational age assessment method. *Matern Child Nutr*. 2023;19(3):e13509. doi:10.1111/mcn.13509.
10. Garlapati S, Venigalla N, Mane S, Dharmagadda A, Sravanthi K, Gupta A. Correlation of zinc and copper levels in mothers and cord blood of neonates with prematurity and intrauterine growth pattern. *Cureus*. 2024;16(7):e63674. doi:10.7759/cureus.63674.
11. Aktar S, Nu UT, Rahman M, Pervin J, Rahman SM, Arifeen SE, et al. Trends and risk of recurrent preterm birth in pregnancy cohorts in rural Bangladesh, 1990-2019. *BMJ Glob Health*. 2023;8(11):e012521. doi:10.1136/bmjgh-2023-012521.
12. Van Gils AL, Ravelli AC, Kamphuis EI, Kazemier BM, Pajkrt E, Oudijk MA, et al. Preterm birth recurrence after spontaneous preterm birth between 16-28 weeks: a national cohort study. *Eur J Obstet Gynecol Reprod Biol X*. 2024;24:100356. doi:10.1016/j.eurox.2024.100356.
13. Zhang YJ, Shen J, Lin SB, Lu C, Jiang H, Sun Y, et al. The risk factors of preterm birth: a multicentre case-control survey in China in 2018. *J Paediatr Child Health*. 2022;58(8):1396-1406. doi:10.1111/jpc.16002.
14. Ambreen S, Yazdani N, Alvi AS, Qazi MF, Hoodbhoy Z. Association of maternal nutritional status and small for gestational age neonates in peri-urban communities of Karachi, Pakistan: findings from the PRISMA study. *BMC Pregnancy Childbirth*. 2024;24(1):214. doi:10.1186/s12884-024-06420-3.
15. Schuster HJ, Bos AM, Himschoot L, van Eekelen R, Matamoros SPF, de Boer MA, et al. Vaginal microbiota and spontaneous preterm birth in pregnant women at high risk of recurrence. *Heliyon*. 2024;10(10):e30685. doi:10.1016/j.heliyon.2024.e30685.
16. Sámano R, Martínez-Rojano H, Chico-Barba G, Gamboa R, Tolentino M, Toledo-Barrera AX, et al. Serum folate, red blood cell folate, and zinc serum levels are related with gestational weight gain and offspring's birth-weight of adolescent mothers. *Nutrients*. 2024;16(11):1632. doi:10.3390/nu16111632.
17. Nossier SA, Naeim NE, El-Sayed NA, Abu Zeid AA. The effect of zinc supplementation on pregnancy outcomes: a double-blind, randomised controlled trial, Egypt. *Br J Nutr*. 2015;114(2):274-285. doi:10.1017/S000711451500166X.
18. Osendarp SJ, van Raaij JM, Arifeen SE, Wahed MA, Baqui AH, Fuchs GJ. A randomized, placebo-controlled trial of the effect of zinc supplementation during pregnancy on pregnancy outcome in Bangladeshi urban poor. *Am J Clin Nutr*. 2000;71(1):114-119. doi:10.1093/ajcn/71.1.114.
19. Caulfield LE, Zavaleta N, Figueroa A, Leon Z. Maternal zinc supplementation does not affect size at birth or pregnancy duration in Peru. *J Nutr*. 1999;129(8):1563-1568. doi:10.1093/jn/129.8.1563.

20. Danesh A, Janghorbani M, Mohammadi B. Effects of zinc supplementation during pregnancy on pregnancy outcome in women with history of preterm delivery: a double-blind randomized, placebo-controlled trial. *J Matern Fetal Neonatal Med.* 2010;23(5):403-408. doi:10.1080/14767050903165214.
21. Wang H, Hu YF, Hao JH, Chen YH, Wang Y, Zhu P, et al. Maternal serum zinc concentration during pregnancy is inversely associated with risk of preterm birth in a Chinese population. *J Nutr.* 2016;146(3):509-515. doi:10.3945/jn.115.220632.