ORIGINAL ARTICLE

Maternal Zinc Status and Birth Outcomes among Yemeni Women: A Cross-Sectional Study

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Abstract

Aim: This study aims to evaluate Yemeni pregnant women's socioeconomic status, lifestyle, food habits, and reproductive health traits. In addition, it was intended to evaluate the mothers' and their babies' zinc levels and investigate the association between these factors. **Materials and Methods:** Al-Sabeen Maternal Referral Hospital in Sana'a was the site of this descriptive cross-sectional study. Ninety-two Yemeni pregnant women presenting for delivery and their infants made up the total of 184 participants. Data on personal and dietary history were collected using a structured questionnaire. Serum zinc concentrations were measured in venous blood samples taken from mothers and the umbilical cord. **Results and Discussion:** The majority of participating mothers (91.3%) were housewives, and 34.78% were illiterate. Carbohydrates constituted the primary component of daily dietary intake, while protein intake was comparatively low. The mean maternal serum zinc concentration was 68.57 ± 21.81 μg/dL, whereas the mean neonatal serum zinc level was 65.05 ± 20.04 μg/dL. Maternal serum zinc levels and neonatal birth weight were found to be statistically significantly correlated, with an average birth weight of 2.8 ± 0.47 kg. **Conclusion:** Neonatal zinc status was found to be significantly associated with maternal serum zinc levels. Approximately 44% of newborns exhibited low serum zinc concentrations, suggesting inadequate transplacental zinc transfer during pregnancy. These findings underscore the importance of targeted interventions, such as micronutrient supplementation, nutritional education, and dietary counseling, to enhance maternal nutritional status, which is essential for promoting optimal outcomes for both mothers and their newborns.

Key words: Micronutrients, newborns, pregnant women, zinc status

INTRODUCTION

Nutrients are broadly categorized into macronutrients and micronutrients. Micronutrients, which include vitamins and some minerals, are needed in trace amounts to sustain health. (typically <1 g/day). They are usually absorbed in their original form and often serve catalytic functions in the body.[1] Trace elements, a subset of micronutrients, are required in very small amounts and are present in body tissues in minute concentrations.[2]

Despite their limited quantities, micronutrient deficiencies are linked to a number of adverse health effects and are a significant cause of malnutrition, especially in developing nations.[3] These shortages usually result from high losses, poor absorption or utilization, insufficient intake, or a combination of these. During times of increased physiological demand, such as infancy, puberty, and pregnancy, these problems are frequently made worse.[4] Iron, zinc, copper, Vitamin B_{12}, folic acid, and Vitamin C are among the critical micronutrients that the body needs more during pregnancy. Deficiencies in any of these micronutrients can negatively impact maternal health, pregnancy outcomes, and fetal development.[4]

The 1940s saw the first reports of zinc deficiency in undernourished adults in China, followed by teenage farmers

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in Iran and Egypt. Zinc insufficiency has been identified over time as a major public health issue that affects people of all ages in numerous nations.[5]

Several studies have reported that chronic zinc deficiency is linked to compromised immunity, more proneness to infections, slow recovery of wounds, persistent dermatological issues, stunting of growth, and male infertility.[6,7]

During pregnancy, zinc requirements increase substantially. These needs can be met either by enhancing dietary intake or through physiological adaptations in zinc metabolism, including improved absorption, reduced excretion, and redistribution of zinc within the body. However, during pregnancy and lactation, the vast majority of women do not considerably increase their dietary zinc intake, making these physiological compensations crucial to maintaining adequate zinc levels.[8]

The most widely used indicator for determining zinc status in humans is serum zinc concentration. While methods such as flame atomic absorption spectrometry offer accurate measurements, they are costly, require sophisticated equipment, and are sensitive to sample matrix effects. In contrast, spectrophotometric methods are more accessible, cost-effective, and suitable for routine clinical and laboratory use, even in resource-limited settings.[9,10]

This study aimed to evaluate the socioeconomic status, lifestyle, Yemeni pregnant women's eating patterns, and reproductive health characteristics. In addition, it was planned to assess zinc status in both the mothers and their newborns and to investigate how these variables relate to one another.

MATERIALS AND METHODS

Al-Sabeen Maternal Referral Hospital in Sana'a, Yemen, was the site of this descriptive cross-sectional study. This hospital is the principal governmental center for maternal and child healthcare in the region. Data collection was carried out from November 2008 to February 2009. The study included 184 participants, comprising 92 pregnant Yemeni women admitted for delivery and their corresponding newborns. Participants were selected based on their admission to the hospital during the study period. Women with chronic infectious or non-infectious diseases (including malaria), obstetric complications, or any pregnancy-related disorders were excluded. Women who declined to participate were also not included.

Before enrollment, the study was explained to each participant, and informed consent was obtained. Ethical protocols were strictly followed throughout the research process.

Data collection procedures

Questionnaire

A predesigned structured questionnaire was administered to collect comprehensive data on identification, socioeconomic status, dietary habits, and medical history (both present and past).

Clinical assessment

All participating mothers underwent a complete physical examination. At the time of delivery, the following data were recorded:

- Gestational age, type and course of labor, as well as the incidence of bleeding before or after delivery
- Neonatal parameters, including birth weight, Apgar score, and presence of congenital anomalies.

Investigations in the lab

Non-heparinized tube-syringes were used to draw 7.5 mL of venous blood from the mother's antecubital vein. The mother's end of the umbilical cord was used to draw blood.[11] A Vacutainer free of trace elements and devoid of anticoagulant was filled with 5 mL of the sample. Trace element-free methods were used to separate the serum.

Samples of serum were labeled, sealed with foil, and stored in ice-packed containers. They were subsequently frozen at –20°C until analysis.[12]

The samples were subsequently transferred under cold-chain conditions to the laboratory at the National Centre for Research in Cairo, Egypt, for zinc analysis. The FAR kit for colorimetrically determining zinc in serum was utilized without deproteinization in accordance with the protocols outlined by.[13,14]

Reference values: 68.0–107.0 μg/dL (10.4–16.4 μmol/L)

All historical data, clinical assessments, and laboratory investigations were encoded, input into the computer, and analyzed using the Statistical Package for the Social Sciences version 16. Univariate and multivariate analysis. Pearson's correlation coefficient was employed to evaluate linear relationships across variables, whereas Chi-square tests were utilized to study the link between maternal and newborn parameters for categorical variables. Independent samples *t*-tests were employed for comparing paired data. Statistical significance was established at $P < 0.05$, with all findings presented at a confidence interval of 95%.

RESULTS

A total of ninety-two Yemeni pregnant women presenting for delivery at Al-Sabeen Referral Hospital during the study, and their infants, were included in the study. The participants' ages ranged from 18 to 40 years, with a mean age of 26 years. The majority of the women (n = 77; 83.7%) were between 20 and 34 years of age. Early marriage was reported in 22 participants (23.9%), who had married before the age of 18 years. Regarding occupational status, most of the participants (n = 84; 91.3%) were housewives, while a small proportion (n = 3; 3.3%) were employed.

Participants' total monthly household income ranged from 30,000 to 100,000 Yemeni Rials (YR), with a mean of 47,766.67 ± 19,512.05 YR. Moreover, 61 (66.3%) of them had low income. Income data were obtained either through direct reporting of monthly earnings or estimated based on daily income.

Regarding maternal education, 32 mothers (34.8%) were illiterate, while 26 (28.3%) had attained only primary-level education. A statistically significant correlation was identified between the mother's educational level and the serum zinc concentration in their newborns (P = 0.029) [Table 1].

Furthermore, 62 (67.39%) of the mothers did not practice the qat-chewing habit (takhzeen), and 22 (23.91%) chewed qat once per week. Maternal qat-chewing was significantly related to their serum zinc levels (P = 0.015), but not to those of their newborns [Table 2].

Regarding dietetic style characteristics, high-energy, protein-poor foods like bread and rice were taken more frequently by mothers; 79 (85.87%) of them took bread-containing meals. Beans were taken 2–3 times daily by 49 (53.26%) mothers, while 59 (64.13%) mothers got dairy products once daily. Animal protein-rich foods such as meat, chicken, and eggs were used weekly by most mothers. Thirty-two mothers (34.78%) didn't take fish at all, while 59 (64.13%) of them took fish once weekly. Servings of vegetables were taken once daily by 89 (96.74%) mothers, while fruits were taken once weekly by 50 (54.35%) mothers. Vitamins and mineral supplements were used during pregnancy by 36.96% (n = 34) of the mothers.

The number of pregnancies among mothers ranged between 1 and 10. Moreover, 59 (64.13%) of the mothers were either primigravida or para two; while 19 (20.65%) had pregnancies 3–5 times; and 14 mothers (15.22%) were multigravida of more than 5 times. Nineteen (20.65%) of mothers had a history of abortions once. Spacing between births ranged between a minimal period of 10 months to maximal period of 7 years; 40.58% of mothers had spaced by 2–3 years; while birth spacing time of <2 years was encountered among 26.1% of them.

The mean birth weight of the newborns was 2.8 ± 0.47 kg. Of the total, 75 newborns (81.5%) had a birth weight of 2.5 kg or more, while 17 (18.5%) were classified as low birth weight (LBW) (<2.5 kg). Maternal serum zinc levels and baby birth weight were found to be statistically significantly correlated (P = 0.033) [Table 3].

Table 1: Relationship of maternal educational state and their zinc levels and their newborns' birth weight and zinc levels

Parameters	Educational state												*P*-value
	Illiterate		Read and write		1 ry Sch		2 ry Sch		Higher		Total		
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Serum zinc mother													
Low	9	29.0	6	42.9	9	37.5	4	30.8	2	28.6	30	33.7	0.930
Normal	20	64.5	7	50.0	13	54.2	9	69.2	5	71.4	54	60.7	
High	2	6.5	1	7.1	2	8.3	0	0.0	0	0.0	5	5.6	
Total	31	100.0	14	100.0	24	100.0	13	100.0	7	100.0	89	100.0	
Newborn weight													
Low	5	15.6	3	21.4	5	19.2	1	7.7	3	42.9	17	18.5	0.402
Normal	27	84.4	11	78.6	21	80.8	12	92.3	4	57.1	75	81.5	
Total	32	100.0	14	100.0	26	100.0	13	100.0	7	100.0	92	100.0	
Serum zinc newborn													
Low	15	48.4	3	27.3	15	62.5	2	16.7	2	33.3	37	44.0	0.029*
Normal	16	51.6	7	63.6	9	37.5	10	83.3	3	50.0	45	53.6	
High	0	0.0	1	9.1	0	0.0	0	0.0	1	16.7	2	2.4	
Total	31	100.0	11	100.0	24	100.0	12	100.0	6	100.0	84	100.0	

(*) A statistically significant correlation at a level of 0.05 or lower

Table 2: Relationship of maternal qat chewing habit and their serum zinc and their newborns' birth weight and zinc levels

Parameters	Qat chewing								*P*-value
	Daily		Weekly		None		Total		
	n	%	*n*	%	*n*	%	*n*	%	
Serum zinc mother									
Low	2	25.0	7	33.3	21	35.0	30	33.7	0.015*
Normal	4	50.0	11	52.4	39	65.0	54	60.7	
High	2	25.0	3	14.3	0	0.0	5	5.6	
Total	8	100.0	21	100.0	60	100.0	89	100.0	
Newborn weight									
Low	3	37.5	2	9.1	12	19.4	17	18.5	0.198
Normal	5	62.5	20	90.9	50	80.6	75	81.5	
Total	8	100.0	22	100.0	62	100.0	92	100.0	
Serum zinc newborn									
Low	2	40.0	13	59.1	22	38.6	37	44.0	0.430
Normal	3	60.0	8	36.4	34	59.6	45	53.6	
High	0	0.0	1	4.5	1	1.8	2	2.4	
Total	5	100.0	22	100.0	57	100.0	84	100.0	

(*) A statistically significant correlation at a level of 0.05 or lower

Table 3: Relationship of newborns' birth weight and maternal and newborn's serum zinc levels

Parameters	Newborn weight (kg)						*P*-value
	<2.50		2.50+		Total		
	n	%	*n*	%	*n*	%	
Serum zinc mother							
Low	2	6.67	28	93.33	30	100	0.033*
Normal	15	27.78	39	72.22	54	100	
High	0	0.00	5	100.00	5	100	
Total	17	19.10	72	80.90	89	100	
Serum zinc newborn							
Low	6	16.2	31	83.8	37	100	0.29
Normal	10	22.2	35	77.8	45	100	
High	1	50.0	1	50.0	2	100	
Total	17	20.2	67	79.8	84	100	

(*) A statistically significant correlation at a level of 0.05 or lower

Serum zinc levels were analyzed for 89 mothers and 84 newborns; some samples were excluded due to loss or insufficient volume. The mean maternal serum zinc concentration was 68.57 ± 21.81 µg/dL, while the mean for newborns was 65.05 ± 20.04 µg/dL. According to the reference range established by Makino *et al*. (1982), normal serum zinc levels for both mothers and newborns are defined as 68.0–107.0 µg/dL (10.4–16.4 µmol/L). Among the mothers, 54 (60.7%) had serum zinc levels within the normal range, whereas 30 (33.7%) had levels below the reference range. Similarly, 45 newborns (53.6%) had normal serum zinc levels, while 37 (44.1%) presented with subnormal levels. A statistically significant correlation was observed between maternal and neonatal serum zinc levels ($P < 0.001$) [Table 4].

DISCUSSION

Micronutrient status plays a vital role in determining both maternal health and pregnancy outcomes. Pregnancy is characterized by increased physiological demands, leading to heightened requirements for numerous micronutrients to support fetal development and maternal well-being.[15] Micronutrient deficiencies during this period may result from a variety of factors, including increased nutritional losses, malabsorption related to underlying medical conditions, and insufficient dietary intake. Furthermore, deficiencies may be exacerbated by limited nutritional knowledge, ingrained dietary practices, or cultural and traditional dietary restrictions often observed during pregnancy. Such deficiencies are of particular concern due to their potential to adversely affect both maternal and neonatal health. Inadequate micronutrient levels have been associated with an elevated likelihood of adverse outcomes, including preterm birth, LBW, impaired fetal development, and maternal morbidity.[16,17] Therefore, ensuring optimal micronutrient intake through dietary counseling, supplementation, and public health interventions is critical for improving pregnancy outcomes and promoting long-term health for both mother and child.

This study is part of our larger research program designed to determine the micronutrient status of Yemeni pregnant women and its effects on pregnancy outcomes.[18]

Table 4: Correlation between serum zinc mother and serum zinc newborn

Parameters	Serum zinc newborn			Total	*P*-value
	Low	Normal	High		
Serum zinc mother					
Low					
Count	20	6	1	27	
% within Serum Zinc Mother	74.1	22.2	3.7	100.0	<0.001*
Normal					
Count	15	37	0	52	
% within Serum Zinc Mother	28.8	71.2	0.0	100.0	
High					
Count	0	2	1	3	
% within Serum Zinc Mother	0.0	66.7	33.3	100.0	
Total					
Count	35	45	2	82	
% within Serum Zinc Mother	42.7	54.9	2.4	100.0	

(*) A statistically significant correlation at a level of 0.05 or lower

Our findings revealed that the majority of mothers (91.3%) were housewives. A small proportion were employed: 3.26% worked in non-specific employment, 2.17% were teachers, a similar number were self-employed, and one mother was a student. These results are consistent with earlier research conducted in similar socio-cultural settings. For example, a study by Al-Kaaky[19] reported that 86.5% of mothers in Aden City were housewives. More recent data from developing nations also show high rates of maternal unemployment, particularly among females of reproductive age.[20]

An expanding corpus of evidence links physically demanding activities during pregnancy, such as prolonged standing, heavy lifting, fatigue, and high levels of household labor, with adverse outcomes such as preterm birth and LBW. For instance, a systematic review by Van Beukering *et al*.[21] found that physically strenuous work was associated with a modestly increased risk of preterm delivery. Similarly, a meta-analysis had confirmed that maternal occupational physical activity, especially involving heavy lifting or long periods of standing, increases the possibility of prenatal growth inhibition as well as preterm birth.[22] Although housework is often overlooked as a source of physical stress, it can involve significant exertion, particularly in rural and suburban settings where women may lack access to labor-saving technologies. This potential risk factor merits further investigation through large-scale, well-controlled studies to better understand its impact on maternal and neonatal health.

Monthly household income was categorized into three levels: low (>50,000 YR), moderate (50,000–100,000 YR), and high (<100,000 YR). The majority of families (66.3%) were classified as having low income, consistent with findings reported by the.[23,24] No statistically significant association was observed between total family income and maternal or neonatal health parameters. This may be attributed to the fact that employment status alone does not accurately reflect household income, due to multiple confounding factors. These include informal financial support from relatives, economic instability, and variable market prices, particularly for essential goods such as food. However, other studies have demonstrated a strong association between socioeconomic disadvantage and adverse birth outcomes, including LBW. For instance, Taylor and Sarathchandra[25] found that low socioeconomic status negatively affects fetal development through increased physical and psychological stress, lower educational attainment, inadequate housing conditions, and limited access to healthcare services and nutritious food.

Our study showed that 34.78% of mothers were illiterate or informally educated. This was less than that reported by Boucek[26] who reported that the national literacy rate in Yemen was about 50%; with female illiteracy near 70%[19] also found that 69.6% of mothers were illiterate in a study conducted in Aden city. There was a statistically significant relation between maternal educational status and their newborns' serum zinc level ($P = 0.029$) [Table 1]. This may be attributed to the higher bioavailability of dietary zinc of the educated mothers; educational level usually determines the economic condition of the family and hence more chance for access to supply of foods rich in different micronutrients.[27] Therefore, programs aimed at improving pregnancy outcomes should prioritize promoting maternal education and ensuring early and consistent antenatal care.

Chewing qat (locally known as takhzeen al-qat), a psychoactive plant, represents a deeply entrenched addictive habit within Yemeni culture. Historically, qat has been cultivated and consumed for its stimulant properties for centuries, not only in Yemen but also across the Arabian

Peninsula and the Horn of Africa.[28,29] In the current study, the majority of mothers (67.39%) reported not engaging in qat chewing. This observation aligns with the findings of previous studies.[19,30] However, other research has indicated a much higher prevalence, estimating that approximately 80% of Yemeni men and 60% of Yemeni women chew qat.[29] The consumption of qat is associated with various psychological, medical, social, and economic consequences.[28] Notably, maternal qat use was found to be significantly associated with lower maternal serum zinc levels ($P = 0.015$), although no significant relationship was observed with the zinc levels of their newborns.

Maternal nutrition is strongly influenced by a variety of factors, including economic status, social and cultural context, and individual behavioral habits.[31] Several studies have reported a significant association between qat (khat) chewing during pregnancy and reduced birth weight in newborns.[32,33] This adverse outcome is likely linked to cathinone, an active alkaloid in qat, along with other compounds that may suppress maternal appetite and impair placental blood flow.

High-energy, protein-poor foods like bread and rice were taken more frequently by mothers; 85.87% of them had bread-containing meals 2–3 times daily. Yemeni meals in this pattern revealed that carbohydrates were the predominant nutrients in the habitually consumed daily meals, and they were the main source of energy requirements. Vegetables and fruits (which are rich in vitamins and minerals) were consumed less frequently, especially fruits, which were taken once weekly by most of the mothers. Proteins of high biological value were the least abundant. The current results confirm that the price of fruits and other healthy foods is a barrier for low-income consumers. This highlights the need to encourage public policies that make these nutritious options more affordable for families with limited incomes.[34,35]

Spacing between births ranged from a minimal period of 10 months to a maximal period of 7 years. Most of the mothers (40.58%) were separated between births by a period of 2–3 years. Our findings showed that spacing between births was not significantly related to the newborns' birth weights. Several authors, however, reported a significant relationship between short interpregnancy interval and LBW, either preterm delivery or intrauterine growth retardation, and perinatal and infant mortality.[36,37]

The mean of the newborns' weight was 2.8 kg ±0.47. Most of the newborns (81.52%) had a birth weight of 2.5 kg or more, while only 18.45% weighed <2.5 kg, LBW. Newborns' birth weight was significantly related to their mothers' serum zinc level ($P = 0.033$) [Table 4]. Our finding of mean birth weight was less than that reported by Al-Asbahi[36] in Aden city, which was 3.1 kg. The overall percentage of LBW in our study (18.45%) was more than that reported in that study (9.3%), which may be attributable to the effect of altitude differences between the two regions. Higher altitudes are characterized by less oxygen partial pressure and hence lower metabolic performance. Birth weight is a key and reliable indicator of an infant's overall health. LBW babies are generally more inclined to physical and mental developmental issues, increased susceptibility to illnesses, and a greater likelihood of early mortality.[38]

The average serum zinc level among the mothers was 68.57 ± 21.81 μg/dL, which falls within the normal range, though it is close to the lower limit. In contrast, their newborns had a mean serum zinc level of 65.05 ± 20.04 μg/dL, which is below the normal range. These values are higher than those reported by Shommo.[39] Consistent with our findings,[39,40] also observed that maternal zinc levels were higher than those of their newborns. However, other studies, including those by Suman *et al*.,[41,42] reported the opposite trend—lower maternal zinc levels compared to their newborns.

Moreover, 33.71% of the mothers had serum zinc levels less than normal, whereas serum zinc levels of the newborns were less than normal in 44.05% of them. There was a significant relation ($P < 0.001$) between mothers' and their newborns' serum zinc levels [Table 4]. In agreement with our study, other studies found lower maternal plasma zinc level to be a risk factor for preterm delivery and LBW.[41,42] Others could not find any correlation.[43] The reduced zinc levels in newborns indicate insufficient zinc transfer to the rapidly developing fetus during the final stages of pregnancy.

CONCLUSION

This study's results showed that 34.78% of the mothers were illiterate, while 15.22% had only informal education. The neonates' serum zinc levels and the mothers' educational attainment were shown to be significantly correlated. The average birth weight of the newborns was 2.8 ± 0.47 kg, with 18.45% classified as having LBW. Birth weight showed a significant association with maternal serum zinc levels. In addition, there was a strong relationship between maternal and neonatal serum zinc concentrations. Approximately 44% of the newborns had low serum zinc levels, suggesting inadequate zinc transfer during pregnancy to support fetal growth.

We recommend enhancing maternal knowledge on antenatal care and the importance of nutritional supplementation during pregnancy. Efforts should focus on promoting balanced diets and healthy lifestyles through structured nutrition education programs and targeted interventions. Further studies are strongly advised to assess the dietary patterns and micronutrient status of pregnant women in Yemen, utilizing larger and more diverse samples across various regions of the country.

AUTHORS' CONTRIBUTIONS

Nasraddin Othman Bahakim conceived the study, developed the research proposal, collected and analysed the data, and drafted the manuscript. Amal Mahmoud Saeed provided support from the initial concept through to the review of the final manuscript. Towfik Albusaili supported the process from concept note to manuscript review. All the authors have read and approved the final version of this manuscript.

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