



The Effect of Maternal Trace Element Status (Copper, Zinc, Selenium, and Chromium) on Neonatal Wellbeing

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Abstract. Trace elements such as copper, zinc, selenium, and chromium play essential roles in various enzymatic reactions, antioxidant defense mechanisms, and overall metabolic regulation, making them crucial for maternal and fetal health. During pregnancy, the demand for these micronutrients increases significantly due to physiological changes and the needs of the developing fetus. Inadequate or excessive levels of these trace elements can lead to altered fetal development and may impact neonatal outcomes immediately after birth. Given the sensitive developmental window of gestation, the intrauterine environment—including micronutrient status—has been hypothesized to influence neonatal physiological parameters such as heart rate, respiratory rate, and Apgar scores, which are commonly used to assess neonatal wellbeing in the early minutes of life. This study attempts to explore the impact of maternal trace element status—specifically copper, zinc, selenium, and chromium—along with selected maternal parameters (BMI, parity, gravida) on indicators of neonatal wellbeing, including heart rate, respiratory rate, and 5-minute Apgar score. A cross-sectional study was conducted in the Delivery Room of the Obstetric Hospital in Al-Diwaniya City, Iraq, involving 50 mother-infant pairs. Data collection occurred from December 1, 2024, to February 10, 2025. Maternal blood samples were analyzed using atomic absorption spectrophotometry to determine serum concentrations of copper, zinc, selenium, and chromium. Neonatal outcomes were assessed via standard clinical evaluations: heart rate and respiratory rate were measured immediately postpartum, and Apgar scores were recorded at five minutes. Statistical analyses included Pearson correlation and multiple linear regression to assess associations between maternal factors and neonatal outcomes. Bivariate and multivariate analyses indicated limited but noteworthy associations. Maternal serum chromium levels were significantly associated with increased neonatal respiratory rate ($p = 0.026$), suggesting a possible stimulatory or stress-related effect.

Keywords: APGAR score, Chromium, Copper, Selenium, Zinc.

1. INTRODUCTION

Pregnant women often have specific nutritional requirements due to the changes in their bodies and the needs of their growing fetus (Krebs et al., 2023). Pregnancy necessitates a nutritious diet that provides sufficient calories, vitamins, proteins, and minerals to satisfy the requirements of both the mother and the fetus (Thompson, 2018). Copper is an essential trace element that readily accepts and donates electrons, explaining its central role in reduction-oxidation reactions (Hellman and Gitlin, 2002). Studies indicate that maternal copper deficiency can result in anemia, impaired brain development, and increased oxidative stress in neonates (Köhrle and Gärtner, 2009). Excess copper, on the other hand, may lead to toxicity, increasing the risk of neurological disorders and hepatic dysfunction in neonates (Arthur, McKenzie and Beckett, 2003). Zinc serves a crucial structural and functional role in various enzyme systems vital for gene expression, cellular development and division, neurotransmission, as well as reproductive

and immunological processes (Lukaski, 1999). Maternal zinc insufficiency is linked to low birth weight (LBW), preterm birth, and congenital anomalies, such as neural tube problems (Mertz, 1969). Zinc supplementation throughout pregnancy has demonstrated a reduction in infection risk and enhancement of newborn immune function (Prasad, 2009). Selenium is an essential trace element necessary for antioxidant defence and thyroid hormone metabolism throughout gestation. It is a critical cofactor in selenoproteins, including glutathione peroxidases (GPxs) and thioredoxin reductases, which defend cells against oxidative stress, significant during placental development and fetal growth (Rayman, 2012). Adequate maternal selenium supports neonatal antioxidant capacity and immune system development. Deficiency may impair neonatal defense mechanisms, increasing susceptibility to oxidative damage and infections post-birth. Maternal selenium levels influence neonatal immune responses, as selenium-containing enzymes modulate inflammation and lymphocyte function. Deficiency may lead to weakened immune defense, making neonates more susceptible to infections (Avery and Hoffmann, 2018). Numerous neonatal illnesses have been demonstrated to be partially attributable to oxygen-free radicals, including brain destruction associated with hypoxic-ischemic encephalopathy, retinopathy of prematurity, bronchopulmonary dysplasia, patent ductus arteriosus, and necrotizing enterocolitis. An optimal selenium diet is crucial for antioxidant protection in newborns (Gathwala and Yadav, 2002). Mothers with elevated dietary selenium consumption throughout pregnancy experienced prolonged gestation and a reduced risk of premature delivery (Barman et al., 2020). In the same research population, increased dietary selenium consumption was associated with higher birth weight and a reduced likelihood of being categorized as small for gestational age (Solé-Navais et al., 2020). Chromium is a vital trace element necessary for proper glucose metabolism. The biological role of chromium is intricately linked to insulin, with the majority of chromium-induced responses being insulin-dependent (Anderson, 1981). Chromium exposure may occur through the consumption of food, ingestion of water, and inhalation of air containing the metal (Kotaś and Stasicka, 2000). Chromium can traverse the placenta to developing babies (Ziaee et al., 2007). Maternal exposure to high amounts of chromium while pregnant may enhance the risk of delivering low-birth-weight neonates, especially female newborns (Xia et al., 2016). This study aimed to investigate the effects of maternal trace elements. Status (Copper, Zinc, Selenium, and Chromium) and other maternal parameters on neonatal wellbeing (heart rate, respiratory rate, and 5-minute Apgar score).

2. METHODS

The Obstetric Hospital's Delivery Room in Al-Diwaniya City was the site of a cross-sectional study with 50 pairs of pregnant women and their newborns. Data were collected from December 1, 2024, to February 10, 2025. The mother's history was recorded, including her age, how far along she was in her pregnancy, how many times she had been pregnant before, her body mass index (BMI) before she got pregnant, and any medical issues she had, such as diabetes, high blood pressure, or thyroid problems. Women between the ages of 18 and 35 with singleton term pregnancies (37 to 41 weeks plus 6 days) that were delivered vaginally were included. Pregnancies with congenital abnormalities or chronic diseases in the mother were not included. We took 2 cc of blood from women when they were admitted, using low-adsorption tubes to keep the samples clean. The samples were spun in a centrifuge and kept at -20°C until they were analysed. We used an atomic absorption spectrophotometry (Model AA-7000, Shimadzu, Japan) to quantify serum heavy metal concentrations. For copper, we used Flame Atomic Absorption Spectroscopy (FAAS), and for selenium, we used Hydride Generation AAS (HG-AAS). Nitric acid and hydrogen peroxide were used in the digesting process to convert proteins and unbound metals into solutions that could be measured (Lukaski, 1999). To make sure the calibration was accurate, standard solutions were made, and the Flame types and gas discharge rates were modified. The limits established by the World Health Organisation (WHO) and the European Food Safety Authority (EFSA) were considered when comparing heavy metal. The levels of copper ranged from 700 to 1,500 $\mu\text{g/l}$ (0.7 to 1.5 ppm), zinc from 700 to 1,200 $\mu\text{g/l}$ (0.7 to 1.2 ppm), selenium from 46 to 143 $\mu\text{g/l}$ (46 to 143 ppb), and chromium was less than 1.4 $\mu\text{g/l}$ (1.4 ppb). Quality control samples made sure that the results were accurate, and matrix interference was fixed where it was needed (Goldhaber, 2003). The Statistical analysis is conducted using Microsoft Excel 2019 and the Statistical Package for the Social Sciences (SPSS) version 26. The mean, median, standard deviation, and range were displayed. Bivariate correlations looked at the connections between maternal outcomes and trace elements, while multivariate assessment found the trace elements that had the biggest effect. A P-value below 0.05 was accepted (Daniel and Cross, 2013).

3. RESULTS

The sample group is mostly young adult women, with (17–39 years) as a median age of 26 years and a mean age of 26.38 ± 5.42 years. The median gravida present 2 (1 to 7), and the median parity was 1 (0–5). The abortion rate was minimal for the majority, with a median of nil (0–3). All participants were at term about gestational age, with a median of 39 weeks (range 37–40).

Table 1 shows that the average BMI of moms before they were pregnant was 23.44, with a range of 16.44 to 36.72.

Table 1. Maternal Demographic Characteristics.

Parameter	Mean±SD	Median (Range)
Abortion	0.22±0.55	0 (0-3)
Age (year)	26.38±5.42	26 (17-39)
BMI (kg/m ²) *	24.53±4.26	23.44 (16.44-36.72)
Gestational age (week)	38.68±1.08	39 (37-40)
Gravida	2.74±1.68	2 (1-7)
Parity	1.52±1.54	1 (0-5)

BMI: Maternal body mass index before pregnancy

The average concentrations of copper in maternal serum during labour were 1.68 ± 0.69 (µg/L), the mean zinc concentration was 2.53 ± 2.62 , the mean selenium concentration was 75.92 ± 24.64 (µg/L), and the mean chromium value was 1.86 ± 1.01 , as shown in Table 2.

Table 2. Levels of maternal serum trace elements at the time of labour.

Parameter	Median (Range)	Mean±SD
S. Chromium (µg/L)	1.63 (0.69-5.77)	1.86±1.01
S. Copper (µg/L)	1.76 (0.2-4.17)	1.68±0.69
S. Selenium (µg/L)	74.46 (37.2-135.91)	75.92±24.64
S. Zinc (µg/L)	1.4 (0.02-11.46)	2.53±2.62

Table 3 shows median and range of heart rate of the neonate 125 beat/min (103-145), average 124.36 ± 8.06 , the median and range of respiratory rate 55 cycle/min (40-70), average 54.9 ± 7.68 in addition to the median and range of Apgar score (5 min) 8 (3-10), average 8.48 ± 1.31 .

Table 3. Neonatal characteristics after labor.

Parameter	Median (Range)	Mean±SD
Apgar score (5 min)	8 (3-10)	8.48±1.31
Heart rate (beat/min)	125 (103-145)	124.36±8.06
Respiratory rate (cycle/min)	55 (40-70)	54.9±7.68

Bivariate Pearson correlation of neonatal respiratory rate with maternal trace elements levels and other parameters shown in table 4 revealed no significant correlations between them (all of them, $r < 0.3$, $p > 0.05$). Only maternal serum chromium showed a statistically significant positive correlation with neonatal respiratory rate ($r = 0.369$, $p = 0.008$) (Figure 1).

Table 4. Bivariate Pearson correlation of neonatal respiratory rate with maternal trace elements levels and other parameters.

Parameter		Neonatalrespiratoryrate (cycle/min)
Age(year)	r	0.161
	p	0.263
Gravida	r	0.172
	p	0.231
Parity	r	0.180
	p	0.210
Abortion	r	0.020
	p	0.890
Gestationalage(week)	r	-0.006
	p	0.965
BMI (kg/m ²)*	r	0.105
	p	0.469
Systolicbloodpressure(mmHg)	r	-0.034
	p	0.816
Diastolicbloodpressure(mmHg)	r	-0.060
	p	0.680
S. Copper (µg/L)	r	-0.162
	p	0.260
S.Zinc (µg/L)	r	-0.095
	p	0.511
S.Selenium(µg/L)	r	0.154
	p	0.285
S.Chromium(µg/L)	r	0.369
	p	0.008

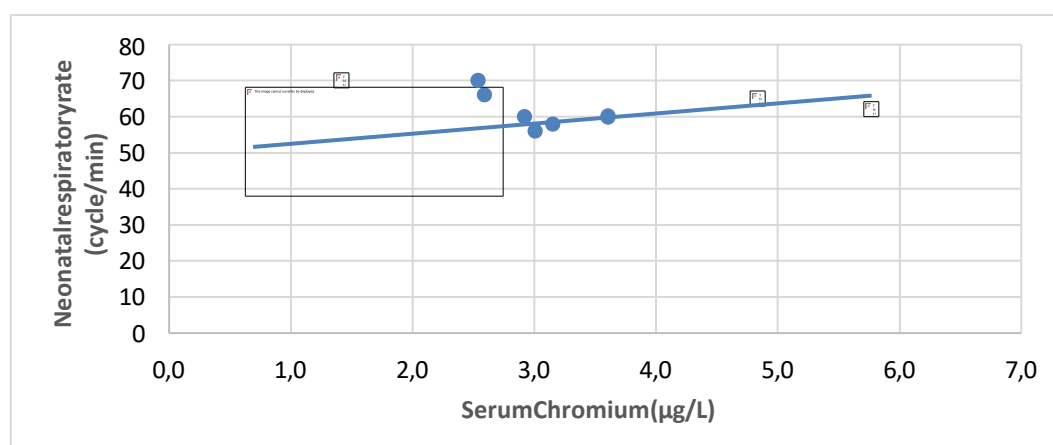


Figure 1. Correlation of maternal serum chromium with neonatal respiratory rate.

Mutiple lineaar regression were used to fing the best predictor of the studied parameters affecting neonate respiratory rate, found that only 25% of the variance ($R^2 = 0.250$) related to neonate respiratory rate. Among predictors, only maternal serum chromium was significantly associated with neonatal respiratory rate ($B = 2.697$, $p = 0.026$), suggesting a 2.7 breaths/min increase per 1 µg/L rise in chromium. Other maternal factors and trace elements showed no significant effects as shown in Table 5.

Table 5. Multiple linear regression analysis of maternal trace element levels and additional characteristics as predictors of neonatal respiratory rate.

Predictor	B	SE	β	P value	95% CI Lower	95% CI Upper
Abortion	-4.935	6.710	-0.351	0.467	-18.531	8.660
Age (year)	0.166	0.304	0.117	0.589	-0.450	0.782
BMI (kg/m ²)	0.311	0.288	0.172	0.288	-0.273	0.894
Diastolic blood pressure (mm Hg)	-0.274	0.259	-0.252	0.297	-0.799	0.251
Gestational age (week)	-0.362	1.144	-0.051	0.753	-2.680	1.956
Gravida	3.325	6.125	0.726	0.591	-9.086	15.735
Parity	-2.791	6.180	-0.561	0.654	-15.313	9.731
S. Chromium (μ g/L)	2.697	1.166	0.355	0.026	0.334	5.060
S. Copper (μ g/L)	-0.743	1.914	-0.067	0.700	-4.620	3.135
S. Selenium (μ g/L)	0.062	0.051	0.198	0.230	-0.041	0.164
S. Zinc (μ g/L)	-0.304	0.474	-0.104	0.525	-1.265	0.657
Systolic blood pressure (mm Hg)	0.049	0.192	0.050	0.802	-0.341	0.439

Table 6 shows bivariate correlation analysis showed no significant associations between neonatal heart rate and maternal factors ($p > 0.05$ all for all parameters), however, maternal selenium exhibited a nearly strong positive relationship ($r = 0.266$, $p = 0.062$).

Table 6. Bivariate Pearson correlation of neonatal heart rate with maternal trace elements levels and other parameters.

Parameter		Neonatal heart rate (beat/min)
Age (year)	r	-0.069
	p	0.634
Gravida	r	-0.032
	p	0.824

Parity	r	-0.007
	p	0.961
Abortion	r	-0.079
	p	0.587
Gestational age (week)	r	-0.008
	p	0.958
BMI (kg/m ²)	r	0.177

	p	0.218
Systolic blood pressure (mm Hg)	r	-0.130
	p	0.369
Diastolic blood pressure (mm Hg)	r	-0.097
	p	0.503
S. Copper ($\mu\text{g/L}$)	r	-0.149
	p	0.300
S. Zinc ($\mu\text{g/L}$)	r	0.105
	p	0.470
S. Selenium ($\mu\text{g/L}$)	r	0.266
	p	0.062
S. Chromium ($\mu\text{g/L}$)	r	-0.017
	p	0.905

Table 7 Multiple linear regression was used to identify the best predictors of neonatal heart rate, and the model explained only a small proportion of the variance ($R^2 = 0.170$), suggesting that just 17% of the variability in neonatal heart rate could be attributed to the included maternal factors and trace elements. Among the studied predictors, only maternal BMI was significantly associated with neonatal heart rate ($B = 0.626$, $p = 0.046$), indicating a 0.6 beats/min increase per 1 kg/m^2 rise in BMI. Other maternal characteristics, and serum levels of trace elements, showed no significant associations with neonatal heart rate.

Table 7. Multiple linear regression analysis maternal trace elements levels and other parameters as predictors for neonate heart rate

Predictor	B	SE	β	p-value	95% CI Lower	95% CI Upper
Age (year)	-0.395	0.320	-0.266	0.224	-1.043	0.253
Gravida	-1.199	6.439	-0.249	0.853	-14.246	11.848
Parity	1.895	6.497	0.363	0.772	-11.269	15.058
Abortion	0.962	7.054	0.065	0.892	-13.331	15.254
Gestational age (week)	-0.059	1.203	-0.008	0.961	-2.495	2.378
BMI (kg/m^2)	0.626	0.303	0.331	0.046	0.012	1.240
Systolic blood pressure (mm Hg)	-0.099	0.202	-0.097	0.627	-0.509	0.311
Diastolic blood pressure (mm Hg)	-0.097	0.273	-0.085	0.724	-0.649	0.455
S. Copper ($\mu\text{g/L}$)	-1.985	2.012	-0.170	0.330	-6.061	2.092
S. Zinc ($\mu\text{g/L}$)	0.230	0.499	0.075	0.648	-0.781	1.240
S. Selenium ($\mu\text{g/L}$)	0.143	0.053	0.436	0.011	0.035	0.250
S. Chromium ($\mu\text{g/L}$)	-0.363	1.226	-0.046	0.769	-2.847	2.121

Bivariate correlation analysis showed no statistically significant associations between maternal factors and 5-minute Apgar scores. The strongest, yet non-significant, positive correlations was observed with a p-value of 0.149 and an r-value of 0.207, as indicated in Table 8.

Table 8. Bivariate Pearson correlation of neonatal Apgar score at 5 minutes with maternal trace elements levels and other parameters.

Parameter		Apgar score (5 min)
Age (year)	r	0.083
	p	0.568
Gravida	r	0.123
	p	0.396
Parity	r	0.207
	p	0.149
Abortion	r	-0.150
	p	0.297
Gestational age (week)	r	0.154
	p	0.285
BMI (kg/m ²)	r	-0.031
	p	0.832
Systolic blood pressure (mm Hg)	r	-0.083
	p	0.568
Diastolic blood pressure (mm Hg)	r	0.002
	p	0.990
S. Copper (µg/L)	r	-0.051
	p	0.725
S. Zinc (µg/L)	r	0.098
	p	0.499
S. Selenium (µg/L)	r	-0.031
	p	0.833
S. Chromium (µg/L)	r	0.149
	p	0.302

In table 9, Multiple linear regression was used to identify the best predictors of neonatal Apgar score at 5 minutes, and the model explained a modest proportion of the variance ($R^2 = 0.220$), indicating that 22% of the variability in Apgar scores could be attributed to the included maternal factors and trace element levels. However, none of the predictors reached statistical significance ($p > 0.05$). Parity showed a borderline association ($B = 1.956$, $p = 0.080$), suggesting a potential positive effect, while gravida approached significance with a negative trend ($B = -1.795$, $p = 0.104$). Maternal serum levels of copper, zinc, selenium, and chromium, as well as other maternal characteristics showed no significant associations with Apgar score at 5 minutes.

Table 9. Multiple linear regression analysis maternal trace elements levels and other parameters as predictors for neonate Apgar score at 5 minute

Predictor	B	SE	β	p-value	95% CI Lower	95% CI Upper
Age (year)	-0.003	0.053	-0.011	0.960	-0.111	0.106
Gravida	-1.795	1.077	-2.291	0.104	-3.977	0.387
Parity	1.956	1.087	2.297	0.080	-0.246	4.158
Abortion	1.295	1.180	0.538	0.279	-1.095	3.686
Gestational age (week)	0.157	0.201	0.129	0.439	-0.250	0.565
BMI (kg/m ²)	-0.043	0.051	-0.138	0.406	-0.145	0.060
Systolic blood pressure (mm Hg)	-0.044	0.034	-0.265	0.200	-0.113	0.024
Diastolic blood pressure (mm Hg)	0.032	0.046	0.172	0.485	-0.060	0.124
S. Copper ($\mu\text{g/L}$)	-0.141	0.336	-0.074	0.677	-0.823	0.541
S. Zinc ($\mu\text{g/L}$)	0.082	0.083	0.163	0.335	-0.087	0.251
S. Selenium ($\mu\text{g/L}$)	-0.006	0.009	-0.106	0.531	-0.024	0.012
S. Chromium ($\mu\text{g/L}$)	0.233	0.205	0.179	0.263	-0.182	0.649

4. DISCUSSION

Neonatal wellbeing reflects the overall health status of the newborn and is influenced by multiple maternal factors, including nutritional and trace element status. Key indicators such as Apgar score and vital signs provide early insights into neonatal adaptation and survival. Understanding how maternal micronutrients impact these Outcomes are important for making prenatal care and the health of newborns better. The study revealed no significant association

between infant respiration rate and maternal serum concentrations of copper, zinc, or selenium. However, animal studies have demonstrated that deficiencies in these elements during pregnancy impair fetal lung development and function, potentially predisposing neonates to respiratory complications (Abdel-Mageed et al., 1994)(Sarricolea, Villa-Elizaga and Lopez, 1993)(Johnson et al., 2019)(Sherlock et al., 2022).

In contrast, maternal serum chromium levels showed a significant positive correlation with neonatal respiratory rate, suggesting possible physiological or toxicological effects that warrant further investigation. Regarding heart rate, No substantial connection was found between maternal copper levels and heart rate, and this remains a subject of current research. A Chinese case-control study indicated that Women who have elevated copper levels are at a significantly increased risk of having progeny with congenital heart defects (CHD). (Hu et al., 2014). Zinc supplementation during pregnancy has been linked to improved fetal heart rate variability (Merialdi et al., 1999). This study found that selenium showed a borderline positive correlation, indicating a potential relationship in larger cohorts. A comprehensive research and meta-analysis investigated the correlation between prenatal selenium exposure and congenital heart abnormalities (CHDs) in children. The research did not directly evaluate newborn heart rate but indicated that low maternal selenium levels may correlate with a heightened incidence of congenital heart abnormalities (CHDs), suggesting a possible influence on cardiac development (Pan, Zhu, Zhu and Zhang, 2022). Chromium do not significantly predict neonate heart rate in this model. Other study shows Chromium may indirectly affect fetal cardiovascular regulation through placental oxidative stress and altered blood flow (Banu et al., 2018).

This research demonstrated no significant link between maternal serum copper levels and infant Apgar scores. This discovery is consistent with prior research, such as that conducted by Yazar and colleagues (Yazar, Yuvacı and Elmas, 2023).

No statistically significant correlation was found between maternal copper levels and Apgar scores in a cohort of 59 pregnant women in their third trimester, although higher copper levels were observed in mothers carrying female fetuses. Previous investigations by Sann et al. (Sann et al., 1980) and Wang et al. (Wang et al., 2023) similarly identified an absence of direct association between maternal copper concentrations and neonatal Apgar scores. Regarding zinc, A cohort study that included 117 mother-infant pairs supports the current findings. Which showed that neonates born to mothers with lower serum zinc concentrations had significantly lower 1- and 5-minute Apgar scores. However, the connection diminished in significance after controlling for maternal age, BMI, and birth weight (Khadem et al., 2012). Further research, such as that conducted by Yazar et al. (Yazar, Yuvacı and Elmas, 2023), showed that there was no significant link between the amount of zinc in a mother's body and the Apgar scores of full-

term pregnancies. Research in a secondary care hospital indicated that maternal serum zinc levels below 56 µg/dL correlated with increased odds of preterm birth and diminished Apgar scores, suggesting a potential association between zinc of shortage and adverse newborn outcomes (Değer, Turan and Peker, 2022). Findings related to selenium were inconsistent with the present study findings. Recent research by Pieczyńska et al. (Pieczyńska et al., 2024) showed that maternal selenium status, encompassing dietary intake, blood levels, and glutathione peroxidase activity, was associated with newborn anthropometric measures and Apgar scores, particularly in physiologically sound pregnancies. A linear link was established by Makhoul and associates (Makhoul et al., 2004) between umbilical cord selenium levels and the 5-minute Apgar score. Maternal serum chromium levels in the current study exhibited a positive trend with Apgar scores, although the association was not statistically significant. This may suggest subtle effects that could be more apparent in larger or stratified cohorts. Supporting this, a Chinese study indicated that heightened maternal chromium levels correlated with a greater chance of preterm birth, which is a recognized factor in diminished apgar scores (Pan et al., 2017).

5. CONCLUSIONS

Maternal serum selenium levels emerged as a statistically significant positive predictor of neonatal heart rate, in addition to maternal BMI. Additionally, maternal serum chromium levels showed a significant positive correlation with neonatal respiratory rate, indicating potential physiological or toxicological influences. However, no maternal trace elements or clinical parameters were significantly associated with the 5-minute Apgar score. Further investigation in larger cohorts is recommended to reveal more impact of trace elements on neonatal well-being.

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