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Research Article

# Toxic Metallic Trace Elements in Post-Delivery Mothers and their Newborns Residing near and far from Mining Operating Plants in Lubumbashi

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## Abstract

**Background:** Many cases of environmental pollution by metallic trace elements (TE) have been documented in Lubumbashi for years. The purpose of this study was to determine blood concentrations of toxic TE and correlation coefficients in post-delivery mothers and their newborns living < of 3km and >3km from the mining processing plants in the city.

**Method:** Two prospective cohorts were formed based on distance between the home of the pregnant women and mineral processing plants (< of 3km and >3km). Three TE (Al, Cd and Pb) were tested at the laboratory of the Congolese Control Office of Lubumbashi by ICP-OES in total blood samples of 378 post-delivery mothers and 378 newborns, voluntarily and consecutively recruited.

**Results:** The difference in TE geometric means concentrations between the two cohorts (study population living < of 3km and >3km from the mining processing plants)was not significant ($p>0.05$).Our study showed excessive geometric means of toxic TE estimated at 28.0 µg/L in the post-delivery mothers and 27.8 µg/L in the newborns for Al (RV: < 9.4 µg/L) ,2.59 µg/L in the post-delivery mothers and 2.83 µg/L in the newborns for Cd (RV: < 1 µg/L) , 17.86 µg/L in the post-delivery mothers and 15.58 µg/L in the newborns for Pb (RV: < 4.13 µg/L).This was confirmed by bioaccumulation factors > 1. The correlation coefficient between TE concentration of the post-delivery mothers and newborns was positive ($p<0.05$).

**Conclusion:** Excessive concentration of Al, Cd et Pb and bioaccumulation factor >1 were observed in post-delivery mothers and their newborns residing in the city of Lubumbashi but no difference in geometric means of total blood toxic TE has been observed between the post-delivery mothers and newborns living < of 3km and those residing >3km from the mining processing plants. Analysis of determinants of the toxic TE bioaccumulation and their impact on maternal and neonatal morbidity should be purpose of future studies.

**Keywords:** Toxic metal trace elements; Post-delivery mothers; Newborns; Lubumbashi

## Abbreviations and Acronyms

Al= Aluminum

Cd= Cadmium

Pb= Lead

TE= Metallic Traces Elements

RV= Reference value

BF= Bioaccumulation factor

Ppm= particle per million

UNILU= University of Lubumbashi

## 1. Introduction

Metallic trace elements (TE) are chemicals found naturally in the environment in negligible concentrations (<100 ppm or 100 µg/g). Some TE are involved in essential biological processes such as gene expression, protein synthesis thus essential for growth, development, and physiology of the organism. TE can be toxic to living organisms if bioavailability thresholds are crossed, therefore initiating alternative biochemical reactions that may contribute to the development of diseases or nutritional disorders [1-5]. Depending on their health impact, the World Health Organization (WHO) groups TE into three categories: potentially toxics (F, Pb, Cd, Hg, Al, As, Sn, Li,) ;probably essentials (Mg, Mn, Si, Ni, B, V, Co) and essentials (Cr, Cu, Zn, Se, Mo, I) [6].

Soil is the major source of TE in the environment (Cu, Ni, Pb, Zn, and Se), they are non-biodegradable and have half-life of several centuries. TE can be partially purified from the soil by the roots of certain plants and through foliate penetration [7-10]. An insufficient state in TE is mainly related to inadequate nutritional intake or increased needs, while excessive intake of toxic TE is often linked to environmental pollution [11]. In the Democratic Republic of Congo, specifically in the city of Lubumbashi, artisanal and industrial mining has a negative impact on the environment (soil, air, streams) and riparian populations [12-15]. Exposure of pregnant women to toxic agents and nutritional imbalance can result in adverse effects on gene expression and potentially affect embryonic and fetal developments, therefore causing miscarriage, intrauterine growth retardation, fetal death, cognitive and/or motor deficit in childhood, impaired health conditions later in life and other morbid conditions for the pregnant women such as preeclampsia, anemia, gestational diabetes, etc., [16].

To our knowledge the concentrations of potentially toxic TE in post-delivery mothers and newborns, as well as their health impact, have not yet been studied in Lubumbashi. The objective of this study is to determine the total blood concentrations and correlation coefficient of TE in post-delivery mothers and their newborns living < of 3km and >3km from the mining processing plants in the city of Lubumbashi.

## 2. Methodology

### 2.1 Study design

A prospective cohort study of mothers and newborns exposed to TE was conducted from November 30, 2018 to May 30, 2019.

### 2.2 Study area

The study was done in Lubumbashi, a city born from the exploitation by the Union Minière du Haut Katanga (Gécamines) of copper deposits (1906-1910). Since the 2000s, minerals are also exploited by private mining companies including: STL, Ruashi mining, Chemaf, Somika, CDM, Anvil Mining, etc.

### 2.3 Study population

It was composed by post-delivery mothers and their newborns consecutively enlisted in ten medical institutions in Lubumbashi (Lubumbashi University Clinics, Jason Sendwe Provincial General Hospital, CMDC, Imani Polyclinic, Tshamilemba Learning and Researcher Health Center, la garde Medical Center, Ruashi Military Hospital, Eben Ezer Health Center, Crisem Medical Center, and Luna Medical Center). The monofetally pregnant women included in the study should have clearly consented to participate in the study; have their antenatal consultations in the host institution and give birth there. These pregnant women should have lived in the city for at least 2 years and spent the entire gestation period in the study district. They should not be smokers or have a smoking spouse/partner. According to the distance between the residential area and a mineral processing plant (<3 km and >3 km) the study population has been divided in two cohorts.

This distribution is supported by the previously documented finding that in neighbourhoods less than 3 km from metallurgical industries or mining activities the geometric means of urinary concentrations of TE (As, Cd, Co, Cu, Pb and U.) were significantly higher than those found in people living between 3 and 10 km [13]. We have used google map to locate the various ore processing plants of the city of Lubumbashi and established a perimeter of 3km around the factory to categorize the residential districts according to whether or not they end up within the 3km perimeter.

### 2.4 Data collection

Data collection sheets with a semi-closed questionnaire were used to collect the data. Trained investigators collected history, physical and morbid information during gestation and at delivery, then in immediate postpartum blood samples. Each data collection sheet had a code matching with the one found on the Eppendorf tubes used to collect blood samples. The data collection sheets, and the Eppendorf tubes were transmitted daily to the principal investigator. Blood collected by puncture of the post-delivery mother's cubital vein and umbilical vein of the newborn was stored at 10 $^0$ C in Eppendorf tubes without EDTA, before processing by the laboratory of the Congolese Control Office (OCC/Lubumbashi). After TE dosage, results were transmitted to the principal investigator.

### 2.5 Metal trace elements analysis

The dosage of TE in total blood was done using Perkin Elmer brand ICP- OES Optima 8300 (Optical Emission inductively coupled plasma spectrometry system) at the laboratory of the Congolese Control Office (ISO 9150 quality certification since 2010). The following potentially toxic TE (Al, Cd and Pb) were measured.

### 2.6 Bioaccumulation factor (BAF)

TE have the ability to accumulate in living organisms. The living organism is able to metabolize and eliminate TE and the concentration observed is the result of absorption and elimination phenomena. The Bioaccumulation factor (BAF) of a substance therefore represents the total intake coming from the environment (environment) and food. There is a health risk for humans in terms of intoxication when the value of BAF> 1 for both potentially toxic and essential TE, and deficiency if the value is <1 for essential TE. The BF reflects normal state (no health risk) for potentially toxic TE if <1 [17].

### 2.7 Statistical analysis

Our data was encoded using the EPI info 7 software. The Kolmorogov-Smirnov test (K-S test) allowed us to test the normality and log-normality of the data distribution. We used the XLSTAT 2019.2.2 software. 59614, to calculate arithmetic and geometric means of blood TE levels. SPSS 23 allowed us to compare the geometric means of TE concentrations in the two cohorts by one way ANOVA and to analyze the nominal variables presented in percentages, the calculation of the correlation coefficient of concentrations in the maternal compartments and the newborn performed for each TE.

### 2.8 Ethical considerations

This study was approved by the Medical Ethics Committee of the School of Public Health of the University of Lubumbashi (UNILU/CEM/117/2018 delivered the 10/10/2018).All study participants gave their informed consent prior to answer to the questionnaire and collection of blood samples.

## 3. Results

### 3.1 Participation in the study and socio-demographic profile of the post-delivery mothers included in the study

A total of 378 post-delivery mothers and 378 newborns were included in the study. Table 1 presents the socio-demographic characteristics of the post-delivery mothers.

| Sociodemographic characteristics | number (n=378) | Pourcentage (%) |
|---|---|---|
| **Age (years)** | | |
| **<18** | 2 | 0,50 |
| **18-35** | 321 | 84,90 |
| **>35** | 55 | 14,6 |
| **Residential district** | | |
| **< 3km from mining plants** | 152 | 40.2 |
| **> 3km from mining plants** | 226 | 59.8 |
| **Level of education** | | |
| **Analphabete** | 19 | 5,0 |
| **Primary school** | 30 | 7,9 |
| **Secondary school** | 184 | 48,7 |
| **University** | 138 | 36,5 |
| **Post-graduate** | 7 | 1,9 |
| **Occupation of the pregnant woman** | | |
| **Unemployed** | 243 | 64,3 |
| **State official** | 68 | 18,0 |
| **Informal** | 65 | 17,2 |
| **Artisanal miner** | 2 | 0,5 |
| **Profession of the partner/spouse** | | |
| **State official** | 216 | 57,1 |
| **Informal** | 143 | 37,8 |
| **Artisanal miner** | 14 | 3,7 |
| **Unemployed** | 5 | 1,3 |
| **Parity** | | |
| **Nulliparous(0)** | 4 | 1,1 |
| **Primiparous (1)** | 86 | 22,8 |
| **Pauciparous (2-3)** | 140 | 37,0 |
| **Multiparous (4-5)** | 91 | 24,1 |
| **Large multiparous (≥6)** | 57 | 15,1 |

The mean age of the post-delivery mothers was 29 ± 6 years; the majority (59.8%, n=226) resided in neighbourhoods located >3 km from the mines; 48.70% (n= 226) had a secondary education level and 36.5% (n=138) university level;64.30% (n=243) were unemployed;57.10% (n=216) had a spouse state official;37% (n=140) were pauciparous, 22.8% (n=86) of primiparous and 15.1% (n=57) of large multiparous.

**Table 1:** Sociodemographic characteristics of the post-delivery mothers.

### 3.2 Geometric means of toxic TE in cohorts residing near and far from mining operating plants (<3Km;>3Km)

Table 2 summarizes the comparison of the geometric means of the concentrations of TE in post-delivery mothers and their newborns residing < 3km and >3 km from mineral processing plants.

| Maternal TE | Number of samples | Geometric mean <3km | Geometric mean >3km | p value (CI 95%) | Newborns TE | Number of samples | Geometric mean <3km | Geometric mean >3km | p value (CI 95%) |
|---|---|---|---|---|---|---|---|---|---|
| Al | 323 | 29.2 | 26.7 | 0.071 | Al | 318 | 28 | 27.6 | 0.472 |
| Cd | 187 | 2.9 | 2.3 | 0.234 | Cd | 220 | 2.8 | 2.46 | 0.053 |
| Pb | 215 | 19.1 | 16.6 | 0.269 | Pb | 209 | 16.2 | 14.8 | 0.253 |

**Table 2:** ANOVA of geometric means of toxic TE concentration in post-delivery mothers and their newborns in the cohorts (<3Km;>3Km).

This table shows that the difference between geometric means of toxic TE concentrations based on the distance from the residential districts of the study population and the mineral processing plants is not statistically significant (p>0.05).

Although post-delivery mothers and their newborns within 3 km of the plants had relatively high geometric mean of the concentration of TE compared to those residing more than 3 km away.

### 3.3 Geometric means of toxic TE and bioaccumulation factors in the total blood of post-delivery mothers and newborns

Table 3 shows geometric means of toxic TE concentration in total blood of post-delivery mothers and their bioaccumulation factors.

| Metallic trace elements | Number of samples | Geometric mean (µg/L) | Reference value (µg/L) (source) | Bioaccumulation factor (µg/L) | Observation |
|---|---|---|---|---|---|
| Al | 323 | 28.0 | < 9.4 [18] | 2.97 (>1) | High |
| Cd | 187 | 2.59 | < 1 [18] | 2.59 (>1) | High |
| Pb | 215 | 17.86 | < 4.13 [19] | 4.32 (>1) | High |

Compared to reference values, we found that the geometric means of TE concentrations in the total blood of the post-delivery mothers were high for Al, Cd, and Pb with bioaccumulation factors > 1.

**Table 3:** Concentrations of TE in total blood of post-delivery mothers and their bioaccumulation factors.

Table 4 shows geometric mean of toxic TE in newborns and their bioaccumulation factors.

| Metallic trace elements | Number of samples | Geometric mean (µg/L) | Reference value (µg/L) (source) | Bioaccumulation factor (µg/L) | Observation |
|---|---|---|---|---|---|
| Al | 318 | 27.8 | < 9.4 [18] | 2.96 (>1) | High |
| Cd | 220 | 2.83 | < 1 [18] | 2.83 (>1) | High |
| Pb | 209 | 15.58 | < 4.13 [19] | 3.77 (>1) | High |

For newborns, the geometric mean of toxic TE concentrations in total blood were also high for Al, Cd and Pb with bioaccumulation factors > 1, compared to reference values.

**Table 4:** Concentrations of toxic TE in total blood of newborns and their bioaccumulation factors.

### 3.4 Correlation between toxic TE in total blood of the post-delivery mothers and newborns

Table 5 shows correlation coefficients and p values that exist between the concentrations of toxic TE in the total blood of the post-delivery mothers and the concentrations of toxic TE in the total blood of the newborns.

| TE | Maternal mean (µg/L) | Newborns mean (µg/L) | Correlation coefficient | P value |
|---|---|---|---|---|
| **Al** | 28.0 | 27.8 | 0.59 | 0.000 |
| **Cd** | 2.83 | 2.83 | 0.46 | 0.000 |
| **Pb** | 17.86 | 15.58 | 0.87 | 0.000 |

This table shows that mean concentrations of toxic TE in post-delivery mothers and their newborns are positively correlated. The correlation coefficient is statistically significant for Al, Cd and Pb ($p < 0.05$).

**Table 5:** Correlation coefficient of the concentration of toxic TE in total blood of post-delivery mothers and newborns.

## 4. Discussion

The purpose of this study was to determine the total blood concentration of toxic TE and their correlation coefficient in post-delivery mothers and their newborns in the city of Lubumbashi. The main results presented in Tables 2, 3 and 4 show the geometric means of toxic TE expressed in µg/L and their bioaccumulation factor. While Table 5 reflects TE correlation coefficient in maternal and neonatal compartments. Table 6 compares our results to other studies worldwide.

### 4.1 Comparison of geometric means of toxic TE in cohorts residing near and far from mining operating plants

It appears from our results that the difference in geometric means of toxic TE concentrations in the two cohorts is not statistically significant. ($p>0.05$) However, post-delivery mothers living within 3 km of the plants had relatively high geometric means concentrations compared to those located more than 3 km away (Table 2). A study conducted in the same city in 2012 showed the opposite [13]. The difference between the two studies may be due to the multiple pathways of toxic TE contamination (respiratory, skin, digestive) [4]; therefore it can be said that a person does not expose himself to toxic TE only by the proximity of his home to the mines. It has also been shown that depending on the type of mining operation (underground or surface) ,the closer people are to the mining operations the more they are exposed to its various releases into the environment of toxic polluting substances. The immediate environment is polluted by the contamination of runoff, waterways, soils and groundwater by discharges from mining operating plants (mine water and acid mine drainage).Pollution can also be the consequence of discharges in the form of smokes in the atmosphere which will form a pollution cone around the mining operating plants and thus pollute far from [20]. In addition, the means of transporting raw materials and refined products are routes for the dissemination of dust loaded with toxic substances far from the mining operating plants.

Fishing products from polluted streams in which the residues from mining processing plants are dumped, and market gardening products grown on polluted soils are consumed by the population of Lubumbashi [13, 18, 21, 22, 23] . The consumption of these foods heavily loaded with toxic TE is not the preserve of a particular neighbourhood. The diet as well as certain eating habits are mostly the same for inhabitants of Lubumbashi. Therefore, pregnant women may well have blood concentration of toxic TE as high as those of local residents. The possibility that, prior to the current pregnancy, pregnant women have migrated from one neighborhood to another should also be considered because the absorption of toxic TE by an organism is usually a result of long-term exposure [24]. The findings made in our study are all the more worrying since they show that no neighbourhood is spared and the city of Lubumbashi as a whole is concerned by exposure to toxic TE. The findings also hence the need to identify the main sources of exposure to toxic TE in pregnant women.

### 4.2 Blood concentrations of toxic TE in post-delivery mothers and their newborns

We found that the geometric means of TE concentrations in the total blood of post-delivery mothers and their newborns were high for Al, Cd and Pb compared to reference values. (Table 3 and 4). Compared to other studies (Table 6), our results show high concentrations of toxic TE (Al, Cd and Pb). A study in China found blood concentration of Al higher than ours [25] and in Bolivia Pb concentration were significantly higher [24]. In settings where the management of mining tailings is suboptimal, environmental contamination leads to exposure of populations to toxic TE. Industrial or artisanal mining activities have a significant environmental impact from the initiation of the mining project and throughout its various phases of exploration, development, and active mining processing. The extraction of ore, its enrichment, its transport, and the disposal of treatment residues are sources of air, soil, and water pollution of riparian communities.

| Country | Number of samples | Geometric means of toxic TE concentrations in the post-delivery mothers(µg/L) | Geometric means of toxic TE concentrations in the newborns (µg/L) | References |
|---|---|---|---|---|
| **Aluminum (Al)** | | | | |
| DRC (Lubumbashi) | 378/378 | 28.0 | 27.8 | [26] |
| Canada (Québec) | 100 | 3.1 (1.2–17.3) | | [25] |
| China (Ma'anshan) | 2382/2382 | 57.50 (32.62-132.65) | 46.14 (13.34-123.49) | [19] |
| France (Nord) | 1016 | 2.18 (2.00 - 2.37) | | [27] |
| Italy | | 2-8 | | [28] |
| Italy (Rome) | 143 | | 3.14 | [26] |
| Cadmium (Cd) | | | | |
| DRC(Lubumbashi) | 378/378 | 2.59 | 2.83 | Our study |
| Belgium (Flanders) | 235/241 | 0.312 (0.291–0.334) | 0.073 (0.066–0.081) | [29] |
| Brazil (Parana) | 512 | 0.09 (0.08, 0.11)<br>RV :1.33 | | [30] |
| Canada (Québec) | 100 | 0.03 (0.01–0.05) | | [26] |
| Canada (Québec) | 317 | 0.688(0.622- 0.761) | | [27] |
| China (Beijing) | 156/156 | 0.72 ± 0.51 (<0.03–2.68) | 0.22 ± 0.2 (<0.03–0.46) | [25] |
| China (Shenjing) | 180/180 | 1.155(0.338-3.119) | 0.142(0.000-16.780) | [31] |
| China (Ma'anshan) | 2382/2382 | 0.06629 (0.02673-0.15869) | 0.03914 (0.0563-0.19801) | [18] |
| France (Nord) | 1016 | 0.39 [0.37 - 0.41] | | [32] |
| France (Le Havre) | 106 | 6.0 (0.13–1.82) | | [33] |
| Italy | | 0.1 - 2 | | [28] |
| Italy (Rome) | 143 | | 0.11 | [34] |
| Nepal (Terai) | 94 | 0.29 | | [27] |
| RDC(Lubumbashi) | 40 | 0.7 (0.5–1.0) | | [5] |
| South Afri | 96/96 | 0.15 (0.06–0.48) | 0.04 (0.01–0.1) | [35] |
| South Saudia | 1565/1566 | 0.983(0.233–3.157) | 0.704(0.245–15.325) | [18] |
| Spain (canary Island) | 471 | | 0.01 ± 0.02 | [36] |
| Spain (Tarragona) | 40/31 | 0.4 (0.3–2.5) | 0.5 (0.2–0.9) | [31] |
| Lead (Pb) | | | | |
| DRC(Lubumbashi) | 378/378 | 17.86 | 15.58 | Our study |
| Belgium (Flanders) | 235/241 | 11.1 (10.6–11.7) | 8.6 (8.1–9.2) | [37] |
| Bolivia | 419/240 | 26.53 (4.38–801.60) | 22.57 (3.26–707.15) | [24] |
| Brazil (Parana) | 512 | 15.8 (15.0, 16.5)<br>RV : 45.1 | | [36] |
| Canada (Québec) | 100 | 0.062(0.014–0.25) | | [29] |
| Canada (Québec) | 311 | 1.886(1.786- 2.007) | | [38] |
| China (Beijing) | 156/156 | 23.1 ± 21.2 (3.22–151) | 14.2 ± 7.6 (3.51–44.0) | [34] |
| China (Shenjing) | 180/180 | 21.105(0.000-121.70) | 21.625(0.000-436.300) | [39] |
| China (Ma'anshan) | 2382/2382 | 0.86 (0.18-9.25) | 0.72 (0.12-16.42) | [34] |
| France (Nord) | 1016 | 15.6 [15.0 - 16.1] | | [17] |
| France (Le Havre) | 106 | 240(5.4–39.3) | | [30] |
| Italy | | 40 - 290 | | [26] |
| Nepal (Terai) | 79 | 23.1 | | [27] |
| RDC(Lubumbashi) | 40 | 66.6 (51.6–79.4) | | [13] |
| Saudi Arabia | 1577/1572 | 25.4 (0.73–59.55) | 20.57 (1.54–56.511) | [25] |
| South Africa | 96/96 | 32.9 (16.3–81.5) | 24(15–87) | [35] |
| Spain (canary Island) | 471 | | 1.62 ± 2.26 | [18] |
| Spain (Tarragona) | 40/31 | 12(5.2–41) | 7.9 (2.8–32) | [31] |

**Table 6:** Comparison of toxic TE geometric means concentrations in post-delivery mothers and their newborns in Lubumbashi to the results published by other authors.

These abnormally high concentrations of toxic TE in the blood of post-delivery mothers and newborns of Lubumbashi are a public health problem given the health effects on pregnancy. This is particularly the case with long-term exposure to Pb can be responsible for anemia, high blood pressure and has reprotoxicity effects..., Al is neurotoxic, and long-term exposure to Cd is responsible for itai-itai disease and others [40].

### 4.3 Bioaccumulation factors of toxic TE in post-delivery mothers and their newborns

Bioaccumulation factors in post-delivery mothers and their newborns for Aluminum, Arsenic, Cadmium and Lead were greater than 1. Bioaccumulation of a substance is its ability to accumulate in living organisms. The living organism is able to metabolize and eliminate the substance and the concentration observed is the result of absorption and elimination phenomena. The BF of a substance therefore represents the total intake coming from the environment and food [40]. A BF > 1 is abnormal and reflects abnormal and long-term exposure to toxic TE through different sources: contamination of drinking water, groundwater, streams, and fishing products (crustaceans, shellfish, and fish) and vegetables growing on polluted soils [13, 18, 20].

Long term exposure to toxic TE can interfere on gene expression and potentially affect embryonic and fetal developments, therefore causing miscarriage, intrauterine growth retardation, fetal death, cognitive and/or motor deficit in childhood, impaired health conditions later in life and other morbid conditions for the pregnant women such as preeclampsia, anemia, gestational diabetes, etc., [16].

### 4.4 Correlation coefficients between toxic TE concentrations in total blood of post-delivery mothers and newborns

The concentration of toxic TE in post-delivery mothers and newborns were positively correlated (Table 5). The correlation coefficient is statistically significant for Al, Cd and Pb ($p < 0.05$). These correlation coefficients reveal that the unique source of fetal contamination by toxic TE is its mother. It is a reproductive hazard given mutagenic and carcinogenic effects of some toxic TE and their roles in the occurrence of many morbid conditions. Periods of embryonic, fetal and child development are sensitive to nutritional imbalance, stress, and environmental influences. Long exposure of pregnant women to toxic agents before conception and during gestation can have adverse effects on gene expression, especially of those involved in fetal development [16]. Our results demonstrate the need to protect next generations. Due to the physiological immaturity of its main systems, the fetus is vulnerable to toxic TE exposure. The protection of the latter therefore requires preventive measures allowing the pregnant woman to not to exposed to toxic TE.

## 5. Conclusion

Our study has noticed no difference in the geometric means of the concentrations of toxic TE in total blood of post-delivery mothers and their newborns living < 3km and >3 km from the mining operating plants. Although excessive concentration of toxic TE in the study population was observed along with bioaccumulation factor >1. These findings hence the need to identify the main sources of exposure and analyze impact of these excessive concentration of toxic TE on maternal and neonatal morbidity by futures investigations.

## Conflicts of Interest

None.

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