Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
Vol. 10, Issue 3, pp: (346-351), Month: September - December 2023, Available at: www.noveltyjournals.com

Toxic Trace Elements Exposure During Pregnancy and Its Associated Health Risks

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DOI: https://doi.org/10.5281/zenodo.10207484

Published Date: 26-November-2023

Abstract: **Based on former research, this review highlights the most common complications and health risks associated with the accumulation of toxic trace elements in maternal and fetal bodies during the course of pregnancy. While non-essential trace metals, including Al (aluminium), cadmium (Cd), mercury (Hg), arsenic (As), and lead (Pb) trigger both pregnancy and non-pregnancy situations, pregnant cases and their fetuses are obviously more susceptible to metal toxicity due to changing chemistry and metabolic activities of the body. Given the high sensitivity of pregnancy to trace-element contaminations, the pregnant women must be avoided of exposure to toxic metals at all times even at their very low concentrations.**

Keywords: **Trace elements, pregnancy, health risks, fetus, contamination, toxicity.**

1. INTRODUCTION

Trace elements are commonly present in living tissues in small quantities primarily as catalyst minerals in enzyme systems. In addition, human body can be exposed to different elements via soil, sediment, water, aquatic biota, air, and food chain.[1,2] Other studies particularly highlight anthropogenic activities, including mining practices, construction, manufacturing, waste waters, and effluents as sources for significant accumulation of trace metals in the environment.[3,4] The sources that distribute individual trace elements can differ by geographical settings and lifestyle features. For instance, trace metals in non-aquatic environments are commonly exposed through wind-driven processes.[5] Direct or indirect exposures to toxic trace elements occur also via run off.[6–8] Regardless of their essential (e.g., iron (Fe), zinc (Zn), calcium (Ca), fluorine (F), selenium (Se), copper (Cu), chromium (Cr), iodine (I), manganese (Mn), and molybdenum (Mo)) or non-essential (e.g., Al (aluminium), arsenic (As), cadmium (Cd), mercury (Hg), and lead (Pb)) function for the human body, trace elements can however be toxic if consumed or if one is exposed to them at adequately high concentrations for long periods of time.[9] Exposure that do not exceed recommended threshold concentrations of essential micronutrient elements are however important during pregnancy. Nevertheless, because of changes associated with the chemistry of body during pregnancy, pregnant women are especially vulnerable to accumulations of trace elements, especially non-essential ones, e.g., significant reduction in Fe levels of blood cells, which can lead to increased blood Cd concentrations.[10] In these situations, the placenta plays a vital role for circulation of trace elements between the body of mother and the fetus (Fig. 1). While functioning as a barrier that reduces the passage of toxic materials and protecting the embryo and the fetus from exposure to toxicants, the placenta is however not perfectly impervious so that trace metals can be traced both in placental tissues and in amniotic fluid.[11]

Given the particular significance of non-essential trace elements in pregnant cases, this work is dedicated to a concise but comprehensive review and discussion of the sources of Al, As, Cd, Hg, and Pb release into soil and urban/rural ecosystems, their level of impacts on a pregnant body, and their adverse effects on pregnancy when exceeding the recommended levels.

2. NON-ESSENTIAL METALS IN A PREGNANT BODY

Previous works demonstrate that Fe, Zn and Ca status affect gastrointestinal absorption of Cd, in particular during pregnancy, a contaminant that is toxic to kidneys, bone and endocrine systems. It is documented that the levels of Cd and Mn in blood are markedly associated with and similarly affected by low blood Fe concentrations.[12] While Cd is commonly released into soils and water through anthropogenic sites, especially mining activities, it is usually added to the human body via the food chain.[1] A review by Osman et al. (2000) found that Cd concentrations in the cord blood are commonly far lower than those in maternal blood, implying that the placenta acts as a partial barrier for this trace element.[13] Nevertheless, its accumulation in the placenta and later consequences on placental function make Cd always a threat to fetuses.[14] Accordingly, in terms of birth outcomes, Cd levels above 0.0002 part per million (ppm) per day can increase the risk of low birth weight and spontaneous abortion.[15] These adverse effects Cd has on the placenta and embryo have been also attributed to its impact on gene methylation.[16]

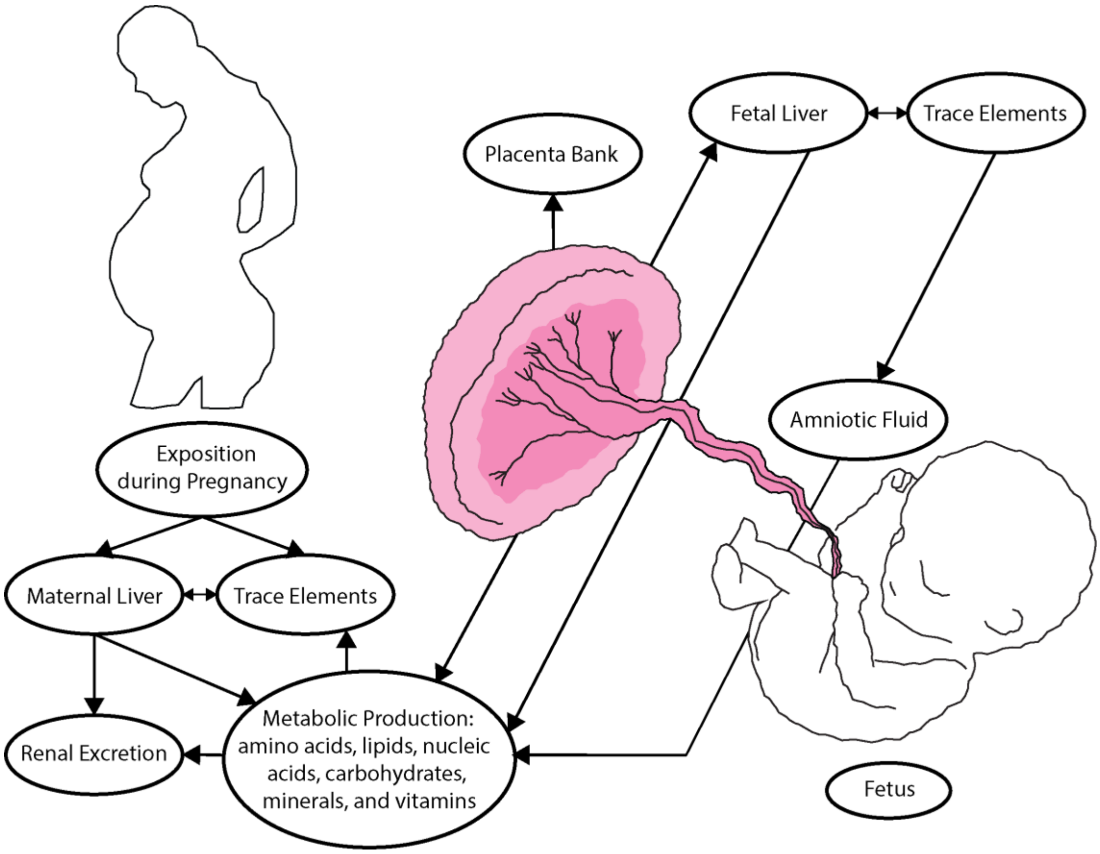

Figure 1. Diffusion of trace metals from maternal circulation to the fetus via the placenta.

The usual source of Hg to human body is via the seafood. Women consuming excessive amounts of seafood in pregnancy (more than 2 weekly average size servings) can absorb high levels of Hg. Hair Hg concentrations above 0.3 ppm strongly suggest a potentially excessive body burden, and the increasing risk of methylmercury toxicity.[17] Although the threshold limit value–time-weighted average (TLV–TWA) concentrations of Hg vapour below 0.05 mg/m^3 are recommended as safe levels, these values might not sufficiently protect fetuses.[18] Enzymatic imbalances and nerve excitability have been reported in adults exposed to 0.01 to 0.05 mg/m^3 of Hg, and thus pregnant women should avoid exposure to Hg levels higher than 0.01 mg/m^3.[19] A pregnant woman exposed to high levels of Hg can suffer real problems for her and her baby. Mercury can damage many parts of their organs, including lungs, kidneys, and nervous system, and may even cause hearing and vision problems.[20]

As a potent toxic element, As is usually traced in drinking water, but its impacts on maternal and fetal health are not well known. The presence of As in the human body can also be partly a consequence of consumed aquatic biota of surface water bodies, in particular fish tissue, exposed to entering agricultural poisons and drainage waters of the agricultural

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lands alongside river margins.[6] The modes of function for As during pregnancy if its concentration is above the safe level (> 0.13 ppm) can include enzyme inhibition and oxidative stress, in addition to immune, endocrine, and epigenetic impacts as well as increased blood pressure and anaemia.[21] Vulnerability to As anyway depends on the biomethylation metabolism, during which the elevated levels of methylarsonic acid, as a metabolite in urine, can be a general risk factor. Enhanced arsenic methylation and renal excretion may partially protect the pregnancy against arsenic-induced toxicity.[21] As can also simply passes the placenta, which may include a high risk of impaired fetal growth and the possibility of increased fetal mortality.[22]

The presence of Pb in the blood of pregnant and non-pregnant women is commonly the consequence of consumed Pb-contaminated drinking water. The water can be easily contaminated with Pb in residential areas, where the drinking water is supplied to the homes through leaded pipes and/or source lines with lead. The drinking water can also be Pb-contaminated if the drinking water is affected by municipal or industrial waste effluents and sewages, and fossil-fuel combustion.[3] Prenatal Pb exposure adversely affects maternal health and fetal outcomes across a broad range of maternal blood Pb concentration.[23] No safe levels of Pb exposure are currently identified in pregnant cases and there is no threshold to address the adverse Pb effects.[24] However, for pregnancies with blood Pb values above 0.05 ppm the source of exposure should be detected and the pregnant patient should avoid further exposure.[25] As Pb passes the placental protective membrane without concentrating in the placenta, interventions in pregnancies with blood Pb levels of 0.05 ppm and higher are thus strongly recommended.[26] Long exposure to Pb levels above this level increases the risk for miscarriage. Furthermore, such an unsafe blood Pb concentrations cause the early baby birth or the birth of a very small baby as well as hurting the baby's brain, kidneys, and nerves, and causing the child to develop learning or behavioural deficiencies.[27–29]

Al is commonly released into the natural waters through weathering of detrital aluminosilicates[30–33], and is adsorbed by soils, and can thus be transferred into the human bodies via the food chain and drinking waters. The levels of Al in natural waters is commonly less than 0.1 ppm, and in drinking waters is usually not exceeding this safe level. However, Al is considered as a toxicant in all developmental stages of pregnancy even at low levels.[34] Al is documented as a toxic metal with effects on the development and growth of fetuses and offspring in humans if traced in the blood above the safe concentration. The exact impacts of the toxic levels of Al on pregnancy are not currently known. Nevertheless, exposure to Al during pregnancy has resulted in growth retardation, resorptions, abnormality of tissues, and toxicity in soft tissues of rats.[35] It is also noted that excessive levels of Al and Pb in the blood circulation of pregnant patients can also develop rare uterine anomalies, such as rudimentary uterine horns, which commonly terminate in life-threatening rupture of the horn, because of prolonged intraperitoneal bleeding, if it is not diagnosed before rupture (Fig. 2).[36]

Figure 2. Rudimentary uterine horn with a gestational sac in a pregnant woman (with permission from Elsevier).[36]

3. DISCUSSION AND CONCLUDING REMARKS

Based on existing literature, this study reviewed the effects of non-essential trace elements on maternal and fetal health during pregnancy. Although non-essential trace elements are harmful to both pregnant and non-pregnant women at levels exceeding their safe threshold, various toxic metals markedly affect maternal body and the fetus even under very low intensity and toxicity levels. Such a differences between the response of a pregnant body to trace-metal contamination as compared with non-pregnant cases can be attributed to alterations in the metabolism and chemistry of the body as well as the changing health behaviours due to pregnancy. Therefore, in consultation with medical specialists, the avoidance of exposure to toxicant metals even in occasions where the toxicity falls below the unsafe levels is strongly recommended in the context of pregnancy. While the present work has attempted interrogating the recent state of the art on trace-metals-contaminated pregnancies, further research based on widespread data collection from various age groups is required for undertaking inclusive analyses (also enclosing pairwise comparison for multiple samples), which lead to more realistic conclusions on the outcome of metal-polluted pregnant cases.

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