Mercury And Lead Levels in Pregnant Women And Their Newborns After Delivery in Cairo, Egypt

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Abstract

Background: Exposure to heavy metals has risen recently as a consequence of increasing pollution from industry and the environment. The foetus is especially sensitive to the impacts of heavy metals owing to the quickness with which cells proliferate and differentiate. Despite the fact that birth weight and length are crucial markers of a child's survival and future development, morbidity, and cognitive aptitude in terms of growth, lead (Pb) exposure demands additional research. In Egypt, Pb and Hg exposures have received little attention. To see whether there was a relationship between prenatal exposures and anomalies in the infant's anthropometry, researchers evaluated perinatal Pb and Hg concentrations as well as neonatal anthropometry.
Methods: We recruited 70 pregnant women for this longitudinal research at the Al-Hussein and Bab-El-Sharia university Hospitals between January and November 2021. The bulk of the women were recruited in their second trimester of pregnancy. Although no specific exclusion criteria were used. Women with significant pregnancy problems were not included. Women were told about the study's objectives, duration, and stipend. The subjects provided written informed consent. Metal analysis was done for all participants.
Results: Pregnant mothers BMI mean was 25.3 Kg/m2, while mean gestational length was 40 weeks with SD of 3.6. Most new-borns were males (64.3%). Average weight was 3345 g at birth, The average new-borns height was 52 cm. Average HC was 36 centimetres. High amounts of mercury (Hg) were commonly discovered in both the mother and the foetus, with the exception of breast milk and meconium. Maternal Blood Pb and Meconium Pb had inverse relationships with BW and BL. Placental Pb, on the other hand, was shown to be positively associated to new-born anthropometry.
Conclusion: Pb exposure levels had a substantial affect on infant anthropometry. Even modest levels of Pb exposure may have an impact on intrauterine development.

Key Words: Lead, Mercury, Pregnancy, Neonate
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Introduction

Recently, heavy metal exposure has increased as a result of both industrial pollution and natural sources. Heavy metals' influence on growth and development is an increasing topic of worry [1]. Heavy metals may cause negative pregnancy outcomes such as pre-eclampsia, early delivery, and neonates who are too small for their gestational age. Pb and Hg are commonly transferred via the placenta [2].

Heavy metals such as lead (Pb) and mercury (Hg) may have serious influences on a child's brain development, particularly if they are eaten during pregnancy [3].

Because of the rapid rate of cell proliferation and differentiation, the foetus is particularly vulnerable to the effects of heavy metals.

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Even at modest levels of exposure, which are not dangerous to the mother, this shows that the development of the foetus and the growth and development of the child during infancy may be seriously damaged [4].

Since a child's health and development depend so much on newborn anthropometry (among other things), further research on the relationship between Pb exposure and newborn anthropometry is required. The placenta and the blood-brain barrier are obviously incapable of preventing Pb and Hg access to the foetus, but the underlying transfer processes remain unclear [6].

There are no defined safe quantities of heavy metals in the mother that transfer via the placenta to the infant. Reduced maternal exposure is the sole strategy to limit foetal exposure [7]. For this reason, it's vital to acquire trustworthy data on heavy metal blood levels in pregnancy from a broad variety of nations and individuals with varying degrees of environmental exposure [8].

There are only three criteria for Pb and Hg levels of concern, and only three of them are definitely relevant to pregnancy. Pregnancy-related levels of Pb and Hg are not comparable to contemporary levels of concern, thus comparing them is challenging [9].

Pb and Hg exposures have received little attention in Egypt [10]. Species of mercury have not been investigated. We were especially interested in placental concentrations [11] since the placenta is in charge of transport and storage of potentially hazardous substances. [12].

The levels of lead and cadmium throughout pregnancy and the first few years of a child's life were studied to learn more about the variables that determine these levels and to see whether they may impact the development of a kid. Maternal blood, hair, prenatal placenta blood, cord blood, meconium, and breast milk were some of the tissues we employed to tackle these challenges. Bivariate analysis and regression models used to predict birth weight, length at birth, and circumference of the head indicated significant modulators of prenatal and early childhood Pb and Hg exposures (HC).

Material and methods

Between January and November 2021, we involved 70 pregnant women for this longitudinal study at Al-Hussein and Bab El-Sharia University Hospitals. Most of them were at the 2nd trimester. Women experiencing major pregnancy complications were not included, despite the fact that no particular exclusion criteria were employed. The aims, length, and stipend of the study were explained to the pregnant mothers . Informed consent was taken and Al-Azhar University's, Faculty of Medicine ethical committees approved the study.

Blood sample from the mothers (7 millilitres of venous blood) and an occipital hair strand that had been clipped as close to the scalp as feasible between weeks 34 and 38 of pregnancy. Researchers obtained intact placentas and a modest amount of cord blood immediately after birth (7 microliters). Meconium samples were gathered during the course of the first 5 days after delivery. 5–10 mL of breast milk was gathered between weeks 2 and 8. All samples were stored at (-20) degrees Celsius until further processing. Having access to a full set of samples from 19 mother-child pairs may be responsible for the lower sample counts (Nb53) per tissue. In a prenatal hospital, pregnant women were questioned by prenatal physicians. Questionnaire 1 (trimesters 1 and 2) contained information on the mother's age, anthropometry, medical history, pregnancy, lifestyle, dental amalgam fillings, hair-colorant use, and smoking habits. When asked how often they ate (fish) , respondents had the alternative of saying "never," "sometimes," or "often" (N once a week) (N once a week). The weekly intake of fish (grams), as well as the daily intake of fish (grams), has also been lowered (g per week). As previously noted, advancements since the last visit were recorded by third and fourth trimester questionnaires as well as by surveys three and four (postpartum weeks 2 to 8), Weeks two through nine after delivery Birth weight, birth circumference, and height and weight at birth (BW, BL, and HC) were all reported in the patient's medical records (BW, BL, and HC). The study participants' eating, smoking, and amalgam filling behaviours did not alter significantly during the course of the investigation (PN0.05) respectively.

Sample preparation for metal analysis

Approximately comparable to trimesters 1, 2, and 3, three-cm-long hair strands were employed to imitate exposure to Hg throughout the preceding nine months. We took at least one 3-cm-long strand of hair from each participant based on their hair length. After washing with deionized water, each hair segment was lyophilized (-48 °C). Blood-flushed tissue was done after thawing and removal of the placenta, cord, and amniotic fluid. A 6 X 6 cm chunk of placenta was removed from the core and homogenised using a ceramic knife. 2 mL of whole blood, 20–100 mg of hair (one 3-cm hair segment), 10–100 mg meconium, 50–100 mg placenta homogenate, and reference materials were all microwaved (2 mL Seronorm) we depended on BCR-397, IRMM (Seronorm). Samples of placenta and breast milk weighing 0.1 mg each were deposited in 15 mL HDPE containers for I-Hg and Me-Hg tests. After adding 2.5 mL of mobile phase to the samples, they were extracted in an ultrasonic bath for 15 minutes. The suspensions were obtained after a 15-minute centrifugation at 2500 rpm. Decanted supernatants were used to extract residues, which were then purified according to the protocol. After that, the two supernatants were mixed. For chromatographic analysis, a 1.5 mL sample was filtered according to Vallant et al. [13].

Metal analyses

Toxic elements determination in this study was done using Inductively Couples Plasma Mass Spectrometry (PerkinElmer ELAN ICP-MS DRC II), PIN 5989-559 IEN. This method is provided to determine Pb , Hg and other heavy metals in biological samples using plasma ionisation and quadruple mass spectrometer.

For the determination of serum Pb and Hg , the serum samples were diluted with an equal volume of deionised water (1:5). The dilution ratio was adjusted to ensure that concentration falls within a suitable absorbance range. of Pb and Hg in serum samples: The samples after dilution were injected into Inductively Couples Plasma Mass Spectrometry (ICP mass) and the calibration curve for each metal was plotted. We used th corresponding curve of each metal to estimate the concentration of pb and Hgl in each sample .

Statistics

The data were assessed using SPSS Windows 23.0 (SPSS Inc, Chicago, IL, USA).$P < 0.05$ was accepted as statistical significance

Less than LOD (Hg) values were imputed with the default value of 1/2 LOD. Maternal Hair-Hg values were obtained using hair samples from trimesters 1–3. Data on Pb and Hg were not frequently reported . It is less than 0.05 in the Lilliefors test. It is less than 0.05 in the Lilliefors test. It was picked to perform non-parametric tests to assess bivariate correlations and group comparisons. The Chi-Square test and the Fisher's Exact Test were applied to examine the contingency tables when subgroups had low sample numbers. On dichotomized data (Noverall median vs. median values), The Cochran and Mantel–Haenszel statistics were used to examine the links between BW, BL, and HC and the Pb and Hg loads, the height of the mother, and the length of the pregnancy. The FPRP definition used by Wacholder et al. [15] necessitated this correction due to the large number of tests that were run simultaneously. We used categorical regression analysis (CATREG) to find out how much of an impact this had on newborn anthropometry. The newborn anthropometry factors associated to Pb less than 0.1 are now included in the CATREG model. The Pratt-coefficient of relative significance was used as an exclusion criterion in CATREG analysis to account for the explanatory variables' collinearity. A estimated component ranking was calculated from these coefficients. Non-significant and insignificant components of the regression models were gradually deleted. Exclusion criteria in this series were the PN0.1 and a Pratt coefficient less than 0.05,

Results

Table 1. Characteristics of study subjects.

	Value (N = 70)
Women	
Pregnancy body mass index (Kg/m^2)	25.3 ± (2.5)
Gestational length (w)	40 ± (3.6)
Infants	
Gender	
Male	45 (64.3%)
Female	25 (35.7%)
Birth weight (g)	3345 ±(156) gm
Birth length (cm)	52 ± (3.6) cm
Head circumference (cm)	36 ± (3.2) cm

Data represented as mean (SD) or number (Percentage)

Pregnancy BMI mean was 25.3 Kg/m2, mean gestational length was 40 weeks with SD of 3.6. Most infants (64.3%) were males and 35.7% were females. Mean birth weight was 3345 g with SD of 156. Mean birth length was 52 cm with SD of 3.6. Mean Head circumference HC was 36 cm with SD of 3.2.

Table 2. Lead (Pb) and mercury (Hg) concentrations in maternal and infant compartments.

	MIN	MAX	25th	50th	75th	N< LOD (%)
Pb						
Maternal blood (pg/L)	11.14	86.4	16.8	24.9	34.7	0
Placenta (pg./kg)	11.03	77.1	22.3	25.8	36.8	0
Cord blood (pg./L)	0.2	63.82	7.81	13.4	24.1	0
Meconium (pg./kg)	2.04	108	10.28	15.5	27.9	0
Hg						
T-Hg Maternal blood (pg/L)	0.12	5.3	0.32	0.7	1.2	0 (0)
T-Hg Placenta (pg/kg)	0.11	12.2	0.71	1.9	3.7	40 (57.1%)
I-Hg Placenta (μg/kg)	0.11	4.2	0.6	0.9	1.4	9 (12.9%)
Me-Hg Placenta (pg/kg)	0.12	9.4	0.1	0.8	1.3	20 (28.57%)
T-Hg Cord blood (pg/L)	0.2	7.2	0.4	1.1	1.9	7 (10%)
T-Hg Meconium (pg/kg)	0.4	118	1.1	4.0	9.3	11 (15.7%)
I-Hg Breast milk (pg/L)	0.1	2.0	0.1	0.2	0.3	29 (41.4%)
T-Hg Maternal hair (pg/kg)	50	765	103	178	421	0 (0)

T-Hg: total mercury, I-Hg: inorganic mercury, Me-Hg: methyl mercury.

Minimum lead concentrations in maternal blood, placenta, cord blood and meconium were 11.14, 11.03, 0.2 and 2.04 respectively and maximum lead concentrations were 86.4, 77.1, 63.82 and 108 pg. per unit respectively. Regarding mercury concentrations, minimum concentrations of T-Hg Maternal blood, T-Hg Placenta, I-Hg Placenta, Me-Hg Placenta, T-Hg Cord blood, T-Hg Meconium, I-Hg Breast milk and T-Hg Maternal hair were 0.12, 0.11, 0.11, 0.12, 0.2, 0.4, 0.1 and 50 pg. per unit respectively. Maximum concentrations were 5.3, 12.2, 4.2, 9.4, 7.2, 118, 2.0 and 765 pg. per unit respectively.

Table 3. Correlation coefficients for Hg contents in maternal and infant compartments.

		Mat-Bl T-Hg	Mat-Hair T-Hg	Plac T-Hg	Plac I-Hg	Plac Me-Hg	Mec T-Hg
Mat-Hair (pg/kg)	R	0.463**					
	P	P < 0.01					
Plac-T-Hg (pg/kg)	R	0.325*	0.368*				
	P	P < 0.05	P < 0.05				
Plac-I-Hg (kg/kg)	R	-0.004	-0.008	0.365*			
	P	P > 0.05	P > 0.05	P < 0.05			
Plac-Me-Hg (pg/kg)	R	0.426**	0.365*	0.4342**	-0.106		
	P	P < 0.01	P < 0.05	P < 0.01	P > 0.05		
Mec-T-Hg (pg/kg)	R	0.100	0.126	0.231	0.485**	0.000	
	P	P > 0.05	P > 0.05	P > 0.05	P < 0.01	P > 0.05	
CordBI-T-Hg (kg/L)	R	0.526***	0.413*	0.354*	0.063	0.410**	0.048
	P	P < 0.001	P < 0.05	P < 0.05	P > 0.05	P < 0.01	P > 0.05

T-Hg: total mercury, I-Hg: inorganic mercury, Me-Hg: methyl mercury.
** P<0.01. * P<0.05. *** P<0.001.
P>0.05 non-significant | P< 0.05 significant | P< 0.001 High significance

Hg levels in maternal and fetal tissues were typically associated, with the exception of breast milk and meconium.

Table 4. Factors correlated to birth length (BL), birth weight (BW), and head circumference (HC).

Parameter	BL (cm)	P	BW (g)	P	HC (cm)	P
Maternal height (cm)	0.215	0.035	0.242	0.013	0.323	0.002
Gestational length (weeks)	0.255	0.019	0.306	0.003	0.179	0.112
MatBl-Pb (pg/L)	-0.135	0.178	-0.258	0.007	-134	0.166
Plac-Pb (µg/kg)	0.221	0.095	0.347	0.006	0.142	0.295
Mec-Pb (µg/kg)	-0.265	0.030	-0.171	0.145	-0.169	0.181
Mean MatHair-Hg (pg/kg)	0.404	0.003	-0.054	0.680	0.142	0315

BW, BL, and HC were all substantially associated (P<0.001). Only bivariate analysis revealed a significant relationship between MatHair-Hg and BL. MatBl-Pb and Mec-Pb had inverse relationships with BW and BL. Plac-Pb, on the other hand, was shown to be positively associated to newborn anthropometry.

Discussion

Heavy metal pollution in Egypt is caused by rapid industrial growth, agricultural fertiliser advances, and urban human activities. Heavy metal pollution is a major problem in our environment, exposing pregnant women and children to potentially dangerous toxins.

Prenatal exposure to heavy metals like as lead and mercury has received minimal attention in Egypt. It is a significant outcome for study into the embryotoxic effects of chemicals such as environmental contaminants and pharmaceuticals, as well as a vital end point for monitoring the evolution of reproductive health efforts and their impact on mother and foetal health.

The blood Pb levels in our study group did not reach the current CDC guideline limit of 100 ug/L. It has been suggested that this threshold of concern be lowered because of the negative effects on children's brain development at blood Pb levels of 100 ug/L [16]. The blood Hg levels of the individuals did not transcend the 15 ug/L intervention or the 5 ug/L warning level. Since these recommended statistics failed to take into account changes in I-Hg and O-Hg load, age, or gender subgroups, Drasch et al. (2002) [17] questioned their validity.

The present study's low I-Hg and undetectable Me-Hg findings support a mercury mean in breast milk samples of 1.36 ug/L reported by Dursun et al. [18]. Pb and Hg levels in meconium have barely been investigated [19] [20]. Mercury concentrations ranged from 0.43 to 71.58 g/L, with a median of 3.17 g/L, according to Ostrea et al. [19]. The range of lead concentrations was 8.23 to 60.04, with a 50th percentile of 35.77. Our results were refuted by the 50th percentile meconium mercury levels of 4.0. Ostera had a higher lead level than us, reaching 15.5 during the course of our trial. Most likely as a consequence of Ostrea et al.'s[19] pollution-affected population studies.

Mercury concentrations were substantially greater in Jiang et al. [20] than in earlier studies like ours and a host of others. Approximately 53 percent of the world's mercury emissions are attributed to human activity, with Asia accounting for the bulk of these emissions. According to sensitivity analysis, mercury levels in fish and the frequency with which individuals eat fish may be key aspects in governments delivering risk management advice to safeguard the health of mothers and new-borns.

Bio-accumulation has been found in experiments to permit heavy metals to travel through the placenta and reach the developing foetus. [21] [22]. Fetal meconium collects xenobiotic residues from the placenta and acts as a record of prenatal exposure. Before, this matrix was used to analyse the impact of numerous environmental xenobiotics, such as medications and alcohol and nicotine by products and heavy metals on fetuses. Perinatal levels of lead and mercury were impacted by a variety of factors, according to Ostrea et al. It was found by Polanska et al. [23] that as persons aged, their MatBl-Pb levels rose .

MatHair-Hg levels in our group (50– 765 ug/kg) are substantially lower than those associated with impaired brain development in children, i.e. >12 mg/kg [24].

Because higher Hg levels have been associated to increased fish consumption Women of reproductive age should be encouraged to consume fish since it is high in essential nutrients, but they should pick Me-Hg-free types to minimise undue exposure. Cunha et al. [25] advised against restricting fish intake since it may reduce critical fatty acid levels below those necessary for normal brain development, causing more harm than good.

The presence of dental amalgam fillings and a link between Mec-Hg and I-Hg levels in the placenta show that neonates were exposed to I-Hg during pregnancy. Amalgam fillings are the most prevalent source of Hg vapour exposure for the general purpose [26]. Dissolved vapour may cross the placental barrier. The faeces (meconium) remove it once it is converted to Hg2+ in the cell. The presence of maternal amalgam fillings has been linked to elevated levels of placental I-Hg [27]. We also found a connection between fillings and Mec-Hg. Gundacker et al. found a similar discovery in their research .

Our data suggest that the pathways driving Pb and Hg translocation in the placenta differ. There have been several more studies that show that foetal blood Hg levels are much higher than those seen in mother's blood, including Caetano et al. [28]. It is therefore theoretically feasible that amino acid transporters may actively transfer nutrients to the infant during pregnancy [29]. The placenta did, however, contain significant levels of mercury (I-Hg and Me-Hg in roughly identical ratios). Cord blood levels of Pb were much lower than those of the mother despite the fact that Pb transfer and retention had been observed and verified. This study's results were in accordance with those of Gundacker et al., [14] as well as those of later studies Gundacker et al., [30]. Overall, we discovered a wide range of maternal and foetal exposure levels, indicating that placental transmission varies greatly from person to person. In contrast, the molecular mechanisms behind the absorption, retention, and excretion of Pb and Hg through the human placenta barrier remain poorly known.

Other investigations Vigeh et al., [31] confirmed that mercury levels had no effect on baby anthropometry. Plac-Pb, MatBl-Pb, and Mec-Pb, on the other hand, had a discernible and statistically significant impact on infant anthropometry. Pb exposure affected BW more than gestational length. Surprisingly, Plac-Pb had the opposite effect on newborn anthropometry as MatBl-Pb or MecPb, with Plac-Pb levels being higher than MatBl-Pb and MecPb levels. Pb levels in mothers and newborns have been associated to poor neonatal anthropometry [32] [30].

Plac-Pb and BW studies suggest that the placenta retains more Pb, which may help shield the foetus from the growth-slowing effects of pb exposure. The mechanisms by which Pb accumulates in the placenta and the implications of these for intrauterine development are still a mystery.

Conclusion

Our findings suggest that various mechanisms of action for Pb and Hg placental translocation may occur. We discovered statistical evidence that Pb exposure levels had a substantial effect on infant anthropometry. Even modest levels of Pb exposure may have an impact on intrauterine development. More study is required to investigate the processes of Pb and Hg transmission via the placenta.

Abbreviations

BL : birth lenght
Bl: blood
BCR-397 :technique for detection of Trace elements in human hair
BMI : body mass index
BW :birth weiht
CATREG :categorical regression analysis
CDC: centers for disease control and prevention
CVAAS : Cold Vapor-Atomic Absorption
FPRP : False Positive Report Probability
GF-AAS: Graphite Furnace Atomic Absorption Spectrometry
HC : head circumference
Hg :mercury
HDPE - High Density Polyethylene
HPLC : High-performance liquid chromatography
IRMM : procedure for sequential extraction
ICP-MS : Inductively coupled plasma mass spectrometry
I-Hg: inorganic mercury
LOD : limit of detection
Mat: maternal
Mec: meconium
Me-Hg: methyl mercury.
Pb :lead
Plac-Pb : placental lead
T-Hg: total mercury.

Declarations section

Ethical Approval and Consent to participate

The Faculty of medicine –Al-Azhar university Ethics Research Committee approved the study, which was conducted following the Declaration of Helsinki. Written informed consent was obtained from the pregnant women who enrolled in this study .Also, the study was approved by the pediatric department Ethics Committee.

Consent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available on request from the corresponding author.

Competing interests

The authors declare that they have no competing interests

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