Towards Prenatal Biomonitoring in Eastern Nigeria: Assessing Lead Levels and Anthropometric Parameters of Newborns

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Abstract: The purpose of this study is to measure maternal blood lead level (BLL) and cord BLL in Nigeria and to compare Nigerian data with other data. We investigated the association among maternal and cord BLLs, and some anthropometric parameters of their babies. BLL was measured in the umbilical and maternal blood samples (using inductively coupled plasma / mass spectrometry (ICP-MS)) of 119 women who delivered at three different hospitals in Nnewi, South Eastern Nigeria. Anthropometric variables of the babies (head circumference, abdominal circumference, birth weight, birth length, crown rump length) were measured. Lead was detected at >10 μg/l in 10.9 percent of the maternal and 3.4 percent of the cord blood samples. The maternal BLL was 6.19 ± 2.77 (mean ± SD) μg/dl while cord BLL was 4.75 ± 2.59 (mean ± SD) μg/dl. With the exception of cord BLL and crown rump length positive correlation (R=0.204, P=0.026), neither the maternal nor the cord BLL showed any significant association with any of the children’s anthropometric parameters.

Keywords: maternal blood, cord blood, blood lead level, monitoring, anthropometric.

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Introduction

Preventive public health measures have been undertaken in many high-income countries in the last two decades to decrease lead exposure; consequently, the average blood lead levels (BLLs) have significantly decreased in the last twenty years among the general population. Developmental exposures to environmental chemicals have become an important public health concern because of their possible toxic impact on sensitive development and programming of organ functions [1]. In utero environmental exposures can have long term consequences on health and development. Prenatal life is considered to be the most sensitive stage of human development due to the high degree of foetal cellular division and differentiation [2]. Also, due to the differences compared to the adult in many biochemical pathways, foetuses are highly susceptible to teratogens, typically at low exposure levels that do not harm the mother [3].

Lead is a pervasive neurotoxicant, and young children and foetuses are at particular risk of exposure [4].

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BLLs are related to diverse health effects, presumably because there are exchanges with lead in critical target tissues, such as the brain, bone, erythroblasts and kidney. Lead interferes with signal transmission at the synapse and with cellular adhesion molecules, causing disruption in cell migration during critical times of the nervous system development [5]. In Zamfara State, northwest Nigeria, the death of at least 400 children was associated with lead poisoning, a tragedy which Human Rights Watch (HRW) described as the “worst lead poisoning epidemic in modern history”[6]. In view of the ubiquity of lead in various environmental matrices [7] and the public health importance in Nigeria [8–10], the recognition and inclusion of lead assay in the diagnosis of metabolic disorders has been advocated.

Studies have demonstrated that lead is released from the maternal skeleton during pregnancy and lactation in humans [11–12]. These toxins are transferred to the infants via the placenta during pregnancy and breast milk during lactation, and most severely affect the newborns at a time of rapid development of the central nervous system [13]. Recent epidemiological studies have emphasized the importance of continued monitoring of BLLs prenatally and during early infancy because of the link between BLLs (at even moderate and low concentrations) and neurological effects [14–18]. High cord blood lead has been reported to be a negative predictor of a child’s birth weight, length and head circumference, indicating that lead might have a negative influence on growth in children even at very low exposure levels [19]. Lead intoxication during organogenesis exhibits a significant decrease in the fetal crown-rump length in an animal model [20]. Several studies have shown an association between high BLLs and poor pregnancy outcome [21, 22]. It has been suggested that during pregnancy there is no threshold for the adverse consequences of lead on the subsequent mental development of the child [7].

The purpose of this study is to measure and compare the maternal and cord BLLs with a view to comparing the Nigerian data with other data. We have also investigated the association between maternal and cord BLLs and some anthropometric parameters of their babies. Understanding the extent and correlations of current prenatal exposure to lead is a key step in designing and implementing targeted public health actions to protect fetal health.

**Subjects and Methods**

**Study population**

The study population was 119 pregnant women who agreed to participate in the project. The eligibility criteria to participate in the present study were as follows: living in the study area Nnewi, South Eastern Nigeria for at least 5 years; aged 18 to 40 years; singleton; and no report of diabetes, hypertension, or preecclampsia. Women were recruited at the 3rd trimester of pregnancy and followed up until delivery. Nnewi is situated in the south of Eastern Nigeria and is a semi-urban settlement estimated to have a population of 204,000 inhabitants. Although government records show about forty medium-scale industries, virtually all motor and motorcycle parts of all brands can be repaired or reconstructed in this city in make-shift cottage factories.

**Sampling**

**Lead exposure**

Maternal and cord blood were collected by midwives following a common aseptic procedure from August 2010 to August 2011. Maternal and cord blood (10 ml) were collected by adequately trained nurses - in the act of phlebotomy - via venepuncture, using metal free syringes into a trace metal-free cryovial that contained ethylenediaminetetraacetic acid (EDTA) as anticoagulant. Blood samples were processed, separated into aliquots of 1 ml, then frozen to −80°C and transported by trained personnel to the laboratory at the University of Michigan, USA. The one hundred and nineteen women who participated in this study signed informed consent forms of the University of Michigan’s School of Public Health and Nnamdi Azikiwe University Teaching Hospital Ethical Committees.

All blood samples were stored at −80°C and then thawed and stored at 4°C until analysis. Prior to analysis, 250 μl of blood samples were digested with 500 μl of concentrated nitric acid (70% nitric acid; Optima grade, Fisher Scientific) overnight at room temperature. The following morning, 250 μl hydrogen peroxide (30% Suprapur grade, Sigma-Aldrich) was added to each digest and allowed to sit overnight at room temperature before diluting to 5 ml into acid washed propylene sample vials (13 mm × 100 mm). Quality
Control samples, Institut national de santé publique du Québec (INSPQ; QMEQAS09 blood), were thawed and stored at 4°C until analysis.

**Laboratory methods**

The blood samples were analyzed by the method described previously [23]. One milliliter aliquot of each sample was diluted to a known volume with a mixture containing 0.1% aqueous Triton X-100, 0.1% ammonium phosphate (NH₄H₂PO₄), and 1 mg/ml of sodium heparin. The dilution and handling of the samples was done following the ultra-clean lab procedure developed for water samples with very low lead levels [24]. In particular, all the lab-ware that came into contact with the sample was carefully decontaminated using the procedure described by Nriagu et al [24]. The lead content of each sample was determined using an Agilent 7500c series inductively coupled plasma/mass spectrometer (ICP-MS) equipped with a collision cell.

Instrumental operating conditions recommended by the manufacturer were used. The blood samples diluted with the chemical cocktail in the sample tubes were injected into the instrument without further modification. Each batch of 12 blood samples analyzed included a reagent blank (diluent with no blood), a duplicate sample and a standard reference blood sample (NIST) 1640 mixed with the diluent. The day-to-day acceptance criterion for the precision of instrumental measurement was set at 73%.

The method detection limit, calculated as three times the standard deviation for the reagent blanks, was 0.2 μg/dl. Lead was detected in all the blood samples analyzed by the instrumental method used in the study. Replicate analyses of several samples indicate the range of error to be ± 10% for all the blood lead data presented.

**Measurement of anthropometric parameters**

Standard instruments (weighing balance and fiberglass measuring tape) were used for the anthropometric assessment. Anthropometric variables (head circumference, abdominal circumference, birth weight, birth length, crown rump length) were measured on the newborns.

**Statistical analysis**

Distribution of all variables was examined for normality. The correlations between lead levels and variables were examined by calculating Pearson’s correlation coefficient. Bivariate and multivariate analyses were conducted to examine the associations between anthropometric parameters and maternal and cord BLLs.

**Results**

The lead concentrations in the cord and maternal blood samples, and the percentage prevalence of BLL above maximum permissible level 10 μg/dl are shown in Table 1. The maternal BLL was 6.19 ± 2.77 (Mean ± SD) μg/dl while the cord BLL was 4.75 ± 2.59 (Mean ± SD) μg/dl. Using an independent sample t-test, we compared the mean lead concentration in the maternal blood with that in the cord blood samples. The result indicated that the maternal mean blood lead value was significantly higher (P < 0.001) than that of the cord. There was a 10.9% and 3.4% prevalence of BLL above maximum permissible level 10 μg/dl in both the maternal and cord BLLs, respectively.

The bivariate correlations between the maternal blood lead concentration and the children’s anthropometric parameters, and the bivariate correlations between the cord blood lead concentration and the children’s anthropometric parameters at birth are shown in Tables 2 and 3, respectively. No significant associations were observed between the mothers’ lead concentration and all the children’s anthropometric variables at birth. There were also no significant associations (P < 0.05) between the cord blood lead concentration and the children’s anthropometric variables (head circumference, abdominal circumference, weight, length) at birth. However, the cord blood lead concentration indicated a significant association with crown rump length at birth (R = 0.204, P = 0.026), as shown in Table 3. The comparative analysis of cord BLLs in the literature (μg/dl) with values obtained in the present study are shown in Table 4. The mean and geometric mean cord BLLs in the 119 women were found to be 4.75 ± 2.59 and 4.26 μg/dl, with median, min and maximum levels of 4.27, 1.09, and 21.0 μg/dl, respectively.
Table 1. Lead concentrations in cord and maternal blood samples

<table>
<thead>
<tr>
<th>Blood sample</th>
<th>Number of subjects</th>
<th>Lead concentration (µg/dl)</th>
<th>Range (µg/dl)</th>
<th>Median (µg/dl)</th>
<th>% Prevalence of BLL above maximum permissible level 10 µg/dl</th>
<th>t-Stat</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cord</td>
<td>119</td>
<td>4.75 ± 2.59 (4.26)</td>
<td>1.09-4.27</td>
<td>4.27</td>
<td>16.52</td>
<td>-4.41</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mother</td>
<td>119</td>
<td>6.19 ± 2.77 (5.68)</td>
<td>2.17-5.58</td>
<td>5.58</td>
<td>15.25</td>
<td>-0.024</td>
<td>0.798</td>
</tr>
</tbody>
</table>

Data are Mean ± Standard Deviation. Number in parenthesis represent geometric mean. BLL: blood lead level

Table 2. Bivariate correlations between maternal blood lead concentration and the children’s anthropometric variables at birth

<table>
<thead>
<tr>
<th>Mothers’ lead concentration vs.</th>
<th>Correlation coefficient (R)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head circumference at birth</td>
<td>-0.024</td>
<td>0.798</td>
</tr>
<tr>
<td>Abdominal circumference at birth</td>
<td>-0.015</td>
<td>0.870</td>
</tr>
<tr>
<td>Birth weight</td>
<td>-0.048</td>
<td>0.605</td>
</tr>
<tr>
<td>Birth length</td>
<td>-0.061</td>
<td>0.510</td>
</tr>
<tr>
<td>Crown rump length at birth</td>
<td>-0.059</td>
<td>0.523</td>
</tr>
</tbody>
</table>

Table 3. Bivariate correlations between cord blood lead concentration and the children’s anthropometric variables at birth

<table>
<thead>
<tr>
<th>Cords’ lead concentration vs.</th>
<th>Correlation coefficient (R)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head circumference at birth</td>
<td>0.031</td>
<td>0.738</td>
</tr>
<tr>
<td>Abdominal circumference at birth</td>
<td>0.028</td>
<td>0.763</td>
</tr>
<tr>
<td>Birth weight</td>
<td>-0.028</td>
<td>0.762</td>
</tr>
<tr>
<td>Birth length</td>
<td>0.019</td>
<td>0.838</td>
</tr>
<tr>
<td>Crown rump length at birth</td>
<td>0.204</td>
<td>0.026</td>
</tr>
</tbody>
</table>
Discussion

The present study investigated the prenatal burden of exposure to lead at delivery by measuring the maternal and cord blood levels of lead. The maternal BLL was 6.19 ± 2.77 (mean ± SD) μg/dl while cord BLL was = 4.75 ± 2.59 (mean ± SD) μg/dl. This result indicated that the maternal mean blood lead value was significantly higher (P < 0.001) than that of the cord, with a 100% prevalence of BLL above maximum permissible level 10 μg/dl in both the maternal and cord BLLs. With the exception of a positive association of cord BLL and crown rump length positive correlation, neither the maternal nor the cord BLL showed any significant association with any of the children’s anthropometric parameters (head circumference, abdominal circumference, weight, length) at birth.

The Centre for Diseases Control [25] recommended a follow-up of children above a BLL threshold of 10.0 μg/dl, and a concentration of 10.0 μg/dl is defined as the threshold for which a medical intervention is required. According to the French National Institute of the Health and the Medical Research [26], prevention and medical follow-up should be envisaged from a BLL of 10.0 μg/dl. There is currently a growing concern about the threats to pregnancy outcome or adverse

Table 4. Comparative analysis of cord blood lead levels in the literature

<table>
<thead>
<tr>
<th>Country</th>
<th>Sampling dates</th>
<th>N</th>
<th>Analytical method</th>
<th>LOD (μg/dl)</th>
<th>Mean (SD)</th>
<th>Geometric mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Shanghai, China</td>
<td>1993</td>
<td>348</td>
<td>AAS with graphite furnace</td>
<td>NA</td>
<td>– – –</td>
<td>9.2</td>
<td>1.6</td>
<td>17.5</td>
<td>–</td>
<td>[41]</td>
</tr>
<tr>
<td>3. India</td>
<td>1993-1997</td>
<td>148</td>
<td>Differential pulse anodic stripping voltammetric (DPASV) technique</td>
<td>0.001</td>
<td>– – –</td>
<td>5.1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>[42]</td>
</tr>
<tr>
<td>4. Israel</td>
<td>1994-1995</td>
<td>70</td>
<td>AAS</td>
<td>NA</td>
<td>3.53 (1.6)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>[43]</td>
</tr>
<tr>
<td>5. Canada (Inuit )</td>
<td>1995-2002</td>
<td>110</td>
<td>AAS (Perkin Elmer model ZL4100)</td>
<td>1.04</td>
<td>4.64 –</td>
<td>3.52</td>
<td>0.52</td>
<td>17.8</td>
<td>–</td>
<td>[45]</td>
</tr>
<tr>
<td>6. Italy</td>
<td>1996</td>
<td>159</td>
<td>AAS with graphite furnace</td>
<td>NA</td>
<td>4.87 (3.60)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>[46]</td>
</tr>
<tr>
<td>7. Turkey</td>
<td>1998</td>
<td>104</td>
<td>AAS (Perkin Elmer SIMAA6000)</td>
<td>0.01</td>
<td>1.69 (0.91)</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>4.07</td>
<td>[47]</td>
</tr>
<tr>
<td>8. Krakow, Poland</td>
<td>2001-2004</td>
<td>457</td>
<td>Inductively coupled plasma mass spectrometry CLIA88 method</td>
<td>NA</td>
<td>– – –</td>
<td>1.21</td>
<td>0.44</td>
<td>4.6</td>
<td>–</td>
<td>[48]</td>
</tr>
<tr>
<td>9. Flanders, Belgium</td>
<td>2002-2006</td>
<td>1107</td>
<td>High resolution-inductively coupled plasma-mass spectrometry</td>
<td>0.2</td>
<td>1.92 –</td>
<td>1.31</td>
<td>1.41</td>
<td>0.1</td>
<td>17.76</td>
<td>[49]</td>
</tr>
<tr>
<td>10. France</td>
<td>2003-2004</td>
<td>1021</td>
<td>AAS</td>
<td>NA</td>
<td>2.32 (2.43)</td>
<td>1.66</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>[50]</td>
</tr>
<tr>
<td>11. Pakistan</td>
<td>2005</td>
<td>540</td>
<td>AAS with graphite furnace</td>
<td>NA</td>
<td>10.8 –</td>
<td>9.6</td>
<td>9.7</td>
<td>1.8</td>
<td>48.9</td>
<td>[51]</td>
</tr>
<tr>
<td>12. Tanzania</td>
<td>NA</td>
<td>150</td>
<td>AAS with electrothermal atomization</td>
<td>NA</td>
<td>4.1 –</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>18</td>
<td>[44]</td>
</tr>
<tr>
<td>13. Yunnan, China</td>
<td>NA</td>
<td>100</td>
<td>AAS (Perkin-Elmer Analyst 300)</td>
<td>NA</td>
<td>5.31 (2.79)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>[52]</td>
</tr>
<tr>
<td>14. Spain</td>
<td>2004-2008</td>
<td>1466</td>
<td>AAS (Perkin-Elmer Analyst 800)</td>
<td>2</td>
<td>1.1 (0.7)</td>
<td>1.1</td>
<td>1</td>
<td>1</td>
<td>19</td>
<td>[53]</td>
</tr>
<tr>
<td>15. Belgium</td>
<td>2008</td>
<td>2</td>
<td>AAS (Perkin Elmer SIMAA6000)</td>
<td>NA</td>
<td>– – –</td>
<td>–</td>
<td>2.3</td>
<td>52.7</td>
<td>–</td>
<td>[54]</td>
</tr>
<tr>
<td>16. Kuwait</td>
<td>48</td>
<td>(Varian, Spectra AA 220)</td>
<td>NA</td>
<td>15.10 (12.30)</td>
<td>– – –</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>[55]</td>
</tr>
<tr>
<td>Present study, Nigeria</td>
<td>2010-2011</td>
<td>199</td>
<td>Inductively coupled plasma mass Spectrometry</td>
<td>–</td>
<td>4.75 (2.59)</td>
<td>4.26</td>
<td>4.27</td>
<td>1.09</td>
<td>21.0</td>
<td></td>
</tr>
</tbody>
</table>

AAS: Atomic Absorption Spectrophotometry, NA: not available, SD: standard deviation, LOD: limit of detection, Undetected levels were counted with a LOD/2
effects in children at levels lower than the international guidelines [27, 28]. High lead levels are known to cause neurobehavioral effects in infants and children, and the cumulative effects of low levels of lead exposure in utero and after birth can have similar detrimental effects [29]. Jedrychowski and co-workers showed that a prenatal cord BLL below 16.7 μg/dl could result in a development delay in infants by about 20% at age 6 months [15]. The children of the women who participated in this study may be observed for developmental delays and require medical assistance. Since this practice of observance of developmental delays is seldom, especially in semi-urban areas, these children born to mothers with high cord BLL in this community may be left to grow up with deficits. Mattison suggested that the impact of environmental exposures on pregnancy outcome or development may have no threshold, and the only reasonable approach is to keep exposure as low as possible [30].

The present result indicated that there were no significant associations between cord BLL and some anthropometric variables such as head circumference, abdominal circumference, birth weight and birth length, but there was a significant association with crown rump length at birth \((R = 0.204, P = 0.026)\). Lead administered through drinking water from the 6th to the 14th day of gestation in iron-deficient rats resulted in a significantly reduced crown-rump length [31]. In a study conducted on a group of 106 Swedish women, the median placental concentration of lead was 26 nmol/kg (range 0–630 nmol/kg). The lead levels in the cord blood were almost the same as in the maternal blood. Statistically significant negative associations were found between cord blood lead on one hand, and child’s length and head circumference on the other [19]. Cord blood lead has been shown to be a negative predictor of a child’s birth weight, length, and head circumference, indicating that lead might have a negative influence on growth in children even at very low exposure levels [19].

In pregnant women and fetuses, it is established that lead reduces fertility [32] and readily crosses the placental barrier, provoking spontaneous abortion, stillbirth [33–35], preterm delivery, and low birth weight [32, 36]. It has been found that cord BLLs were significantly and negatively associated with a newborn’s head circumference. However, maternal BLL has also been found to show no association with birth weight, recumbent length, or head circumference, as in our study [37].

The 100% presence of lead in maternal and cord blood seen in this study is similar to a study conducted on 1578 women who delivered at the Al-Kharji King Khalid Hospital in Saudi Arabia between 2005 and 2006, where lead was detected in all cord and maternal blood and in 96% of placental tissues [2]. Durska [38] reported the detection of cord and maternal BLL in 78 and 33% of mothers, respectively, while Butler and his colleagues reported that lead was detected in 95% of cord blood samples in 407 cord blood samples analyzed [39].

The cord BLLs found in other countries such as China, Mexico, India, Israel, Pakistan, Tanzania, Turkey, Spain, Belgium and indeed other countries were in general lower than the levels obtained in the present study [40–55].

Endogenous lead exposure is an important independent predictor of adverse health outcomes, such as: cognitive decline [56, 57], cardiovascular disease [58, 59], and decreased fetal growth [22, 60, 61]. Jedrychowski and coworkers [15] showed that a prenatal cord blood lead level below 16.7 μg/dl could result in a development delay in infants by about 20% at age 6 months.

In a Belgian study involving migrant mothers from Sub-Saharan Africa, increased risk of lead exposure and high cord blood lead concentration similar to our study have been reported [54]. The weaknesses of our study are the non-inclusion of factors associated with lead exposure and the lack of follow-up of women who had elevated lead levels by investigating the details related to their diet, lifestyle and cultural habits.

In Nigeria, human exposure to lead can occur through various sources such as leaded gasoline, industrial processes such as lead smelting and coal combustion, artisanal mining, electronic wastes, lead-based paints, lead-containing pipes or lead-based solder in water supply systems, battery recycling, grids and bearings, herbal medications, etc [62].

Lead inhibits the cytosolic δ-aminolevulinic acid dehydratase (ALAD), mitochondrial aminolevulinic acid synthetase (ALAS), and ferrochelatase [63], but its effect on ALAD is more profound and its inhibition has been used clinically to gauge the degree of
lead poisoning. Inhibition of ALAD results in the accumulation of aminolevulinic acid, detectable in the plasma and urine even at BLLs of less than 10 μg/dl. Although ALAD inhibition is first noted at BLLs of 10–20 μg/dl, heme biosynthesis does not decrease until the activity of ALAD is inhibited by 80–90%, which occurs at a much higher blood lead concentration of about 55 μg/dl [64]. Renal dysfunction occurs mostly at high levels of lead exposure (> 60 μg/dl) but damage at lower levels has also been documented (~10 μg/dl) [65]. Chronic and acute lead intoxication cause cardiac and vascular damage with likely lethal consequences, including hypertension and cardiovascular disease [59]. Low level lead exposure can contribute to hypertension in both animals and humans [66]. The reproductive health implications of lead tend to be more pronounced in women, with infertility, miscarriage, premature membrane rupture, pre-eclampsia, pregnancy hypertension and premature delivery as likely signs [67, 68]. The high maternal and cord BLLs seen in this study may lead to increased incidence and prevalence of pregnancy hypertension in Eastern Nigeria, as has been reported by other workers [69]. Although exposure to low or moderate lead levels does not produce a marked loss of immune cells, subtle lead-related changes in the immune cell population can be functionally harmful. Jedrychowski et al 2011 [70] showed that it is prenatal exposure rather than the postnatal BLLs that is more important in enhancing sensitization to common aeroallergens.

Epidemiologic observations on urban, industrial pollution across eastern Germany strongly suggest that the exposure to metal-rich pollutants may largely account for regional differences in prevalence of allergic sensitization in children [71]. The differences correlate with several-fold higher levels of these metal presences in fine particulate matter [72].

The appropriate State Ministry of Health should forward all blood lead test results from City residents to Local Government Areas, which should conduct follow-up interviews and case investigations for adults identified with BLLs ≥10 μg/dl. Identification and removal of the lead source is the main priority. Women in the second half of pregnancy with BLLs 45-69 μg/dl are considered for chelation therapy. Pregnant women with BLLs ≥70 μg/dl are considered for chelation regardless of trimester. Pregnant women with lead encephalopathy should receive chelation regardless of trimester [68].

One limitation of this study is that we were unable to collect biological specimens from the fetuses or babies. Future studies should examine maternal as well as fetal serum levels. Further, it would have been preferable to have additional information about potential exposure sources of lead, e.g., dietary consumption, house dust levels of lead, and selenium, and additional measures of nutritional status, especially iron, calcium and zinc.

The presence of lead in both maternal and cord blood in excess of 10 μg/dl is of public health importance. The safety threshold proposed by the WHO is a subject of debate [68] since adverse neurological effects at low level lead exposure below10 μg/dl have been described. Hence, the importance of conducting prospective studies has been suggested by other workers [53].

Biomonitoring of blood lead in pregnant women in Nigeria should be considered relevant in healthcare management, public health decision making, and possible primary prevention activities. There is a need to study the toxicological implications of chronic low-level exposure to heavy metals from African markets. A multidisciplinary approach composed of pediatricians, physicians, toxicologists, chemists and social workers is recommended to address metal pollution in Nigeria. This specialized centre managed by this team of experts will handle all cases of people with blood lead level more than 20 μg/dl. They will study the residential environment, possible sources of lead exposure and socioeconomic and housing conditions. As acceptance of human biomonitoring as a vital tool in assessing and evaluating the past, current and future influence of the environment on human beings, it is essential that these biomonitoring studies be performed in a fast, reliable and cost-effective manner. In Nigeria, patchy human biomonitoring (HBM) data amidst absence of national reference values, mainly in areas polluted with lead, has been collected over the last few years. The future of biomonitoring in Nigeria lies in extending such programs to measuring exposures in the general population, increasing international collaboration in this field, developing analytical capacity and expertise, and increasing the use of human biomonitoring studies in forming and evaluating...
environmental health policy, as is obtainable in the US and other developed nations.

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東部ナイジェリアにおける出生前バイオモニタリングに向けて：新生児の鉛濃度および人類学的計測値の評価

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要旨：この研究は、ナイジェリアにおいて、母親および臍帯血の血中鉛濃度(BLL)を測定し、他の地域と比較することを目的とする。我々は、母親の血液および臍帯血のBLLと、新生児の人類学的計測値との関連性の調査を行った。ナイジェリア南東部ンネウィの別の3病院で出産した119人の女性から採取した、臍帯血および母親の血液サンプルを用いてBLLを測定した(誘導結合プラズマ質量分析法(ICP-MS)を使用)。新生児の人類学的計測（頭囲・腹囲・出生体重・出生身長・頭臀長）を行った。母親の血液サンプルの10.9％、臍帯血サンプルの3.4％から、10 μg/lより多い鉛が検出された。母親のBLLは6.19 ± 2.77 μg/dl（平均±標準偏差）、臍帯血BLLは4.75 ± 2.59 μg/dl（平均±標準偏差）であった。臍帯血BLLと頭臀長の明確な関連性(R = 0.204, P = 0.026)を除けば、子どもたちの人類学的計測値と、母親の血液および臍帯血BLLには有意な関連性は見られなかった。

キーワード：母体血、臍帯血、血中鉛濃度。

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