Lead levels in milk and blood from donors to the Breast Milk Bank in Southern Brazil

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A B S T R A C T

Brazilian scientific literature on the adverse effects of lead on the general population is still very limited. Lead, a potentially toxic substance, has become a public health problem due to its effects, mainly those affecting the central nervous system and on the synthesis of heme. The aim of this study is to evaluate the level of lead exposure of donors to the Breast Milk Bank in the city of Londrina, Parana, by estimating the levels of that metal in milk and blood samples. This is a cross-sectional study conducted during the period between January and July 2007. All mothers enrolled as donors in the Breast Milk Bank were included in this study. A total of 92 volunteers presenting the following inclusion criteria were evaluated in the project: volunteers who were healthy, without any chronic disease, full-term pregnancy, breastfeeding between the 15th and 210th day after giving birth, and living in the city of the study. Lead in milk and blood was quantified using the inductive coupled plasma mass spectroscopy (ICP-MS) technique. All mothers signed a consent form approved by the Research Ethics Committee from Londrina State University. The median lead concentration in milk samples was 3.0 μg/L, varying from 1.0 to 8.0 μg/L. The median of lead in blood was of 2.7 μg/dl, varying from 1.0 to 5.5 μg/dl. In Spearman correlation analysis, significant but modest correlations could be observed between the concentration of lead in blood and in milk ($r_s=0.207, p=0.048$), hemoglobin and ALAD activity ($r_s=0.264, p=0.011$), level of lead in blood and mother’s age ($r_s=-0.227, p=0.029$). However, for hematocrit and hemoglobin, the correlation was higher ($r_s=0.837, p<0.001$). No statistically significant associations were found between concentrations of lead in milk and blood and demographic variables studied, obtained through interviews and validated questionnaire. The mean of milk/blood lead ratio was equal to 0.11. In general, the values found in the present study are similar to those obtained in populations in other countries, and are within background levels.

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1. Introduction

Environmental exposure to lead and its absorption by the body, even in low levels, constitute a severe public health problem due to the absence of safe concentration levels of this metal (Schnaas et al., 2006; Lanphear et al., 2005; Tong et al., 2000) and also to its ability to accumulate in the body for a long period of time (Gulson et al., 2003; Li et al., 2000; Al-Saleh et al., 1996).

Studies have suggested that breast milk is a potential source of lead exposure in children (Gulson et al., 2003, 1998; Hallén et al., 1995; Silbergeld, 1991). However, data evaluating and quantifying the relationship between breast milk and the exposure of children to lead are still scarce (Ettinger et al., 2004a).

There are experimental evidences suggesting that the fetal brain presents greater sensitivity to the toxic effects of lead when compared to a more mature brain. They also suggest that the encephalic barrier of fetuses are immature and do not promote protection against the metal (Schnaas et al., 2006; Oskarsson et al., 1998; Coyer, 1990). Fetus vulnerability can occur even if the mother’s exposure had ceased many years earlier (UNEP, 2006; Bellinger, 2005; Manton et al., 2003, 2000; Gulson et al., 2003, 1997; Li et al., 2000).

The neurotoxicity of lead is a special concern, since prospective studies present evidence that neural–behavioral effects, such as
loss in academic performance and motor abilities, can persist even if the levels of this metal in the organism return to their reference values (Needleman et al., 1990). There is also the hypothesis that these effects are irreversible or at least lasting up to adulthood (ATSDR, 2007; UNEP, 2006; Bellinger et al., 1992; Needleman and Weiss, 2002).

Among the difficulties observed by several authors, the lack of standardized methodology to evaluate the chemicals in breast milk can be noted, which makes the comparison of data from different studies challenging (Ettinger et al., 2004b; Gulson et al., 2003, 1998; Solomon and Weiss, 2002). Such facts hinder an standardized methodology to evaluate the chemicals in breast milk from the Breast Milk Bank in a municipality in the south of Brazil.

Economic Classification Criteria (ABEP, 2005). This tool estimates the purchase power of people and families living in urban areas concerning the possession of goods and the level of instruction of the family’s breadwinner, on a scale from A to E. Class A corresponds to the class with greater consumption power and class E to the one with less consumption power.

2. Material and methods

2.1. Study population

This is a cross-sectional study developed in the municipality of Londrina. This city is located in the northern region of the Paraná State, in Brazil. It presents an estimated population of 473,741 inhabitants (DATASUS, 2004), and approximately 97% live in the urban area. The subjects of this study are mothers who are donors to the Breast Milk Bank of the University Hospital from the State University of Londrina. All breastfeeding mothers enrolled in the referred Milk Bank during the period between January and July, 2007 were recruited for this study. Inclusion criteria were: healthy mothers without chronic diseases, with term babies, in breastfeeding period between 15 and 210 days, living in the referred city. From a total of 120 mothers included in the study, eight donors were beyond the breastfeeding period stipulated for the study, and two did not live in the city of Londrina. Therefore, a total of 10 exclusion cases (8.4%) were registered. Moreover, 18 losses (16.5%) were observed, being three cases of absence of the mother in scheduled visits, six cases of changes in address or insufficient address, as well as nine refusals in taking part of the study. Therefore, the population of this study was considered as a total of 92 mothers.

A standardized data collection form was pre-tested in a trial in October, 2006, in a Lactation Unit of the region. The collection of data, milk and blood samples from the volunteers was conducted in a visit to their households, being this visit previously scheduled. The information obtained was: demographic data (age, skin color; economic class, schooling level; number of children; time of lactation; daily consumption of milk; place and time of dwelling; proximity to any source of lead contamination; occupational activity; smoking habit; alcohol consumption; leisure activities, among others.

For the variable schooling, the subjects were classified according to the last year they finished.

Cigarette smoking habits were recorded as following: never smoked, former smoker and current smoker. Mothers classified as having never smoked were those who had never smoked or who had smoked up to five cigarettes a day. Former smokers were those who used to smoke more than 5 cigarettes per day in the past, and those currently smoking more than 5 cigarettes per day were included in the smoking group.

In the category alcohol consumption, mothers who ingested at least one bottle of beer and/or one glass of wine and/or one glass of spirits daily were considered “consumers”. The category “non-consumers” comprised all the mothers who had never consumed alcohol or who ingested it only occasionally.

In this study, the average amount of milk consumed per week day was considered by multiplying the number of glasses drank by day by the number of days in a week. This total was then divided by seven to reach an average. From this variable, two different categories were created: ≥ two glasses, and < two glasses of milk consumed daily. For the variable daily consumption of milk, a consumption of two glasses of milk per day was established, corresponding to approximately 600 mg calcium.

The variable economic class was established according to the classification by the Brazilian Association of Research Companies by means of the Brazilian Economic Classification Criteria (ABEP, 2005). This tool estimates the purchase power of people and families living in urban areas concerning the possession of goods and the level of instruction of the family’s breadwinner, on a scale from A to E. Class A corresponds to the class with greater consumption power and class E to the one with less consumption power.

As well as the researcher, two undergraduate students and a technician from a clinical analysis laboratory helped in the collection of data and biological material. The students have undergone training, discussions on communication and interviewing techniques in order to conduct the interview, as well as training on filling the forms so to guarantee the information quality control.

The present study was approved by the Ethics and Research Committee of the State University of Londrina. The donor mothers included in this study signed a proper informed consent form in which the objectives of the research were described and highlighted the voluntary nature of their participations.

2.2. Collection of samples

In order to determine the levels of lead, milk samples containing between approximately 15 and 20 ml were collected by the mothers themselves, using polyethylene tubes previously rinsed and prepared. Blood samples were decontaminated using 20% nitric acid baths for 24 h and then rinsed in deonized water.

For the hematocrit and hemoglobin analyzes, samples of approximately 3 ml blood were obtained by vein puncture, with vacutainer containers and EDTA as anticoagulant. Samples were stored between 4 and 8 °C until reaching the laboratory and the analyzes were performed in the same day of collection. In order to determine the δ-aminolevulinic acid dehydratase (ALAD) activity, samples of approximately 2 ml blood were obtained by vein puncture, with heparinized vacutainer containers, and the analyzes were performed within 24 h after collection.

All samples were obtained during house visits which had been previously scheduled, and the blood samples were collected by the researchers themselves. The polyethylene tubes for the collection of milk had been previously decontaminated using 20% nitric acid baths for 24 h and then rinsed in deonized water.

2.3. Analytical procedures

The determination of lead in human blood and milk samples was conducted in the Specialized Equipment Section of the Adolfo Lutz Institute, São Paulo. Aliquots of 5 ml from the samples were mineralized in a muffle furnace at 400 °C, after drying at 105 °C. Ashes were dissolved in 5 ml HNO₃ at 5% (v/v). The result for each sample was obtained by the mean of 3 replicates. In order to determine lead in blood, an aliquot of 100 µl total blood, previously homogenized, was diluted in 1900 µl of a solution of TritonX 100 (0.05%) diluted in HNO₃, 0.1% (v/v). Lead concentrations were determined using the inductively coupled plasma mass spectrometry technique (ICP-MS), using the ELAN DRC II Perkin Elmer equipment. For the calculation of the concentration, the mean of the three isotopes (206, 207 and 208) was used. As internal pattern, a solution of 5 µg/ml rhenum was used. In order to verify the precision of the methods, the reference material NIST 8435–Whole Milk Powder and the certified reference materials NIST 955b levels 1 and 2–Whole Blood were used. Recoveries obtained for the three reference materials were of 91%, 105% and 100%, respectively.

Limits of detection (LOD) and quantification (LOQ) of methods were calculated as 3- and 10-fold the standard deviation from the concentrations of 6 independent blank replicates. In order to determine lead in milk, LOD and LOQ were 0.3 and 2.0 µg/L, respectively; in order to determine lead in blood, the values were 0.02 and 0.05 µg/dl, respectively.

Precision of methods, calculated as variation coefficient, was of 10% for a concentration of 1.0 µg/L in determining lead in milk, and of 7% for a concentration of 0.05 µg/dl, in determining lead in blood. The samples were handled in an ISO class 6 clean room.

The activity of ALAD was determined by the European Standardized Method (Berlin and Schaller, 1974), which is based on the incubation of the enzyme with excess of δ-aminolevulinic acid. The results are expressed in units/ALA liter/min/erythrocyte liter, with hematocrit being determined in an automated cell counter.

2.4. Statistical analysis

Information registered in the interview forms was entered twice in an Epi Info database, version 3.4 for Windows.

In the descriptive stage of the results analysis, the frequency distribution of the variables was verified and the central tendency and variability means were calculate.

The quantitative variables were presented under the form of means and standard deviation, minimum and maximum values and percentiles 25 and 75.

Comparison of lead levels in milk, lead in blood and ALAD activity between two different groups, and with the Kruskall–Wallis test to compare among more than two groups. Correlation between the quantitative variables was evaluated by
means of Spearman’s correlation coefficient for data with non-Gaussian distribution.

Tests were conducted considering a significance level of 5% and processed using the program Statistical Analysis System version 8.2 (Inst. Inc., Cary, NC, USA).

3. Results

3.1. General characterization

For the present study, a total of 92 donors with average age equal 28.1 years (16–45 years old) was considered. General characterization of the population studied can be observed in Table 1.

No participant was characterized as a consumer of alcoholic beverages. Approximately 36% of the volunteers declared to be occasional consumers (only one glass and/or dose per week) of any kind of beverage, and therefore, this variable could not be measured.

3.2. Lead concentrations in milk and blood

As it can be observed in Table 2, the lead concentration means in milk and blood samples were equal 2.9 ± 1.1 and 2.82 ± 0.94 μg/dl, respectively. This table also presents the mean values for haematocrite, haemoglobine and ALAD activity, as well as minimum and maximum values.

In the present study, the means of milk/blood ratio from the 92 samples was equal 0.11, and 91.3% presented interval from 0.04 to 0.15 and 8.7% ranging from 0.20 to 0.31.

As it can be observed in Table 3, there is a statistically significant association between the lead level in milk and the variable skin color. For the other variables included in this study, no significant association could be observed between these and Pb blood. For the variables hemoglobin and ALAD, this association was close to statistically significant (p=0.052).

Table 4 presents a comparison between lead levels in milk and blood obtained in this study and those found in other studies.

According to the Spearman correlation analysis, significant correlations could be observed, despite being low, between the variables Pb blood and Pb milk (r_s=0.207, p=0.048), hemoglobin and ALAD activity (r_s=−0.264, p=0.011), Pb blood and mother’s age (r_s=0.227, p=0.029). However, for hematocrit and hemoglobin, the correlation was very high (r_s=0.837, p<0.001). For the other variables, no significant correlation was observed.

4. Discussion

In the present study, the means and median in the concentration of lead in milk from donors to the Breast Milk Bank of the University Hospital from the State University of Londrina are shown in Table 2, which may indicate low environmental exposure to lead.

In a study also conducted in Brazil by Anastacio et al. (2004), the results were very close to those in this research, even though it had been conducted in the municipality of Rio de Janeiro, which is considered more industrialized than the city of Londrina (Table 4).
Factors associated to levels (median) of lead in milk, blood and ALAD from volunteers of the Breast Milk Bank in Londrina, Brazil (n=92).

<table>
<thead>
<tr>
<th>Variables</th>
<th>n</th>
<th>Pb milk (µg/l)</th>
<th>Pb blood (µg/dl)</th>
<th>ALAD (µmol ALAD min⁻¹ L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>Median</td>
<td>Median</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p</td>
<td>p</td>
<td>p</td>
</tr>
<tr>
<td>Mother's age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 30</td>
<td>57</td>
<td>3.0</td>
<td>0.885</td>
<td>2.7</td>
</tr>
<tr>
<td>≥ 30</td>
<td>35</td>
<td>3.0</td>
<td></td>
<td>2.9</td>
</tr>
<tr>
<td>Smoking habit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smoked</td>
<td>75</td>
<td>3.0</td>
<td>0.428</td>
<td>2.7</td>
</tr>
<tr>
<td>Former smoker</td>
<td>13</td>
<td>3.0</td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>Current smoker</td>
<td>94</td>
<td>3.0</td>
<td></td>
<td>2.9</td>
</tr>
<tr>
<td>Milk consumption (≥2 glasses/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>42</td>
<td>3.0</td>
<td>0.189</td>
<td>2.8</td>
</tr>
<tr>
<td>No</td>
<td>50</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Lactation time (days)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–30</td>
<td>16</td>
<td>3.0</td>
<td>0.438</td>
<td>2.8</td>
</tr>
<tr>
<td>&gt; 30 e ≤ 120</td>
<td>55</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>120–210</td>
<td>21</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Skin color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>66</td>
<td>2.5</td>
<td>0.023</td>
<td>2.7</td>
</tr>
<tr>
<td>Non-white</td>
<td>26</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Number of children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>62</td>
<td>3.0</td>
<td>0.923</td>
<td>2.7</td>
</tr>
<tr>
<td>Two or more</td>
<td>30</td>
<td>3.0</td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Economic class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A+B</td>
<td>46</td>
<td>3.0</td>
<td>0.347</td>
<td>2.8</td>
</tr>
<tr>
<td>C+D</td>
<td>46</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Living near contamination source</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (up to 100 m)</td>
<td>21</td>
<td>3.0</td>
<td>0.786</td>
<td>2.9</td>
</tr>
<tr>
<td>No (&gt; 100 m)</td>
<td>71</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Living with people exposed to lead</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>14</td>
<td>3.0</td>
<td>0.620</td>
<td>2.9</td>
</tr>
<tr>
<td>No</td>
<td>78</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Hematocrit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 40</td>
<td>70</td>
<td>3.0</td>
<td>0.432</td>
<td>2.7</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>22</td>
<td>3.0</td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 12</td>
<td>19</td>
<td>3.0</td>
<td>0.431</td>
<td>2.8</td>
</tr>
<tr>
<td>&gt; 12</td>
<td>73</td>
<td>3.0</td>
<td></td>
<td>2.7</td>
</tr>
</tbody>
</table>

A multi-centric study conducted by the World Health Organization (WHO, 1989) estimated mean concentrations of lead in breast milk in some countries, where concentrations varied from 2.0 to 16.8 µg/l. The study concluded that concentrations between 2.0 and 5.0 µg/l were within reference values. Abadin et al. (1997), in a review study, concluded that the lead concentrations in milk would range between 2.0 and 5.0 µg/l in a population, which had not been occupationally exposed to lead. The results observed in the present study are comparable to those of Chien et al. (2006) and Hanning et al. (2002), which obtained similar concentrations of lead in mature milk. Ettinger et al. (2006) obtained lower mean values than those in the present study, although in approximately 91% samples the ratio ranged between 2.0 and 5.0 µg/l in a population, which had not been occupationally exposed to lead. The results of the present study are within the reference values proposed by the referred studies.

The results observed in the present study are comparable to those of Chien et al. (2006) and Hanning et al. (2002), which obtained similar concentrations of lead in mature milk. Ettinger et al. (2006) obtained lower mean values than those in the present study, while Sowers et al. (2002) obtained higher levels when compared to this study (Table 4).

According to Ettinger et al. (2004b), researchers found concentrations of lead in milk ranging in three magnitude levels (< 1.0 µg/l, from 1.0 to 10.0 µg/l and > 100.0 µg/l). These differences could be partly attributed to true differences in exposure distributions across populations and over time. However, such variations also reflect several other factors that might interfere in the final result, for instance, absence of analytical precision and the great potential of contamination of the samples. Some failures are also observed in the design of the research, in the description of sampling methods, choosing non-representative samples, among others (Ettinger et al., 2004b; Landrigan et al., 2002; Solomon and Weiss, 2002; LaKind et al., 2001; Gulson et al., 1998).

Needham and Wang (2002) state that the presence of fat in milk must also be considered as a complicating factor in determining lead in this matrix. It has become a challenge to find methods that will provide precise and exact results and also digest samples with 100% efficiency (Ettinger et al., 2004b). In the present study, to overcome the issue of fat in milk samples, some digestion procedures were previously tested, and the process which is described in Section 2 was selected.

Gulson et al. (1998) affirm that a way that enables verification of the accuracy of analytical results would be the comparison of the concentrations of lead in milk and blood. In reason of protein-binding properties of lead and not to fat, blood presents greater concentration in relation to milk. Dorea (2004) affirms that lead has a low transfer coefficient from blood to milk, due to the protein-binding properties.

According to Gulson et al. (2003, 1998), the ratio expressed as percentage of lead concentration in milk to the concentration in the mother’s blood should not be higher than 15%. If this is the case, it may indicate either a possible contamination during collection or a problem during the analysis of the samples. In the present study, although in approximately 91% samples the ratio expressed as a percentage of the mean concentration of lead in milk (2.9 µg/l) to the mean concentration in blood (2.8 µg/dl) was equal to 11%, some samples presented a ratio above this value. In the revision study conducted by Dorea (2004), the milk/blood ratio ranged from 1% to 97% with the exception of one only study, presenting a ratio greater than 100%.

The colostrums samples normally have higher levels of lead than those from mature milk in that they have higher proteic and...
lower fat content (Rothenberg et al., 2000; Silbergeld, 1991). However, colostrums samples tend to present higher variability in the levels of this metal, since the fat content also varies, and only stabilizes after 2–6 weeks into lactation (Needham and Wang, 2002). For this reason, mature milk presents more stable concentrations of this metal, contributing for its choice as exposure indicator in the present study.

Studies such as Ettinger et al. (2006), Sowers et al. (2002), and Sternowsky and Wessolowski (1985) have observed the influence of different lactation stages in the concentration of lead in milk (Table 4). However, the present study is a cross-sectional analysis and cannot evaluate changes in breast milk over the course of lactation.

Considering that the environmental exposure of the population, as a general rule, derives from industrial contaminant discharges, among other factors, the results obtained in the present study seems to be compatible with the characteristics of the city studied, presenting low industrialization, with a strong potential in the service providing areas. This reinforces the idea that higher levels of lead in blood, and consequently in human milk, are found in population living in more industrialized regions (Sharma and Pervez, 2005; Kulkybaev et al., 2002; Turan et al., 2001).

Some studies have found that occupational exposure to lead constitutes an important variable in the increase of lead levels in milk (Sharma and Pervez, 2005; Li et al., 2000) (Table 4). In the present study, one of the donors referred working with the welding of electronic component plates. However, this exposure did not influence the concentrations of metal in milk and blood, which did not differ from the other samples analyzed.

Spearman’s correlation analysis in the present study showed a modest correlation between the levels of lead in milk and in blood.

### Table 4

Comparison of lead concentrations in milk samples of different countries.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Lactation stage</th>
<th>n</th>
<th>Pb milk (µg/l)</th>
<th>Pb blood (µg/dl)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koyashiki (2008)</td>
<td>Brazil</td>
<td>Mature milk</td>
<td>92</td>
<td>2.9 ± 1.1^a</td>
<td>2.82 ± 0.94^a</td>
<td>Non-occupational exposure to lead</td>
</tr>
<tr>
<td>Chien et al. (2006)</td>
<td>China</td>
<td>All Colostrum</td>
<td>72</td>
<td>7.7 ± 8.2^c</td>
<td>–</td>
<td>All (chinese herbs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>35</td>
<td>8.6 ± 10.9^a</td>
<td>–</td>
<td>Consumption group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>37</td>
<td>6.8 ± 2.7^a</td>
<td>–</td>
<td>Consumption group</td>
</tr>
<tr>
<td>Ettinger et al. (2006)</td>
<td>Mexico</td>
<td>Mature milk</td>
<td>310</td>
<td>1.4 ± 1.1^a</td>
<td>9.3 ± 4.5^a</td>
<td>1 month after delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>9</td>
<td>2.34^a</td>
<td>–</td>
<td>Control group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>7</td>
<td>2.36^a</td>
<td>–</td>
<td>Control group</td>
</tr>
<tr>
<td>Sowers et al. (2002)</td>
<td>USA</td>
<td>Mature milk</td>
<td>15</td>
<td>6.1 ± 1.0^a</td>
<td>1.4^a</td>
<td>1.5 months after delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>5</td>
<td>5.6 ± 1.1^a</td>
<td>1.6^a</td>
<td>3 months after delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>12</td>
<td>5.9 ± 1.0^a</td>
<td>1.7^a</td>
<td>6 months after delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>4</td>
<td>4.3 ± 1.6^a</td>
<td>1.4^a</td>
<td>12 months after delivery</td>
</tr>
<tr>
<td>Sharma and Pervez, 2005</td>
<td>India</td>
<td>Colostrum</td>
<td>5</td>
<td>3.5 ± 2.0^a</td>
<td>13.2 ± 5.8^a</td>
<td>Occupational exposure to lead (workers in metal foundry industry)</td>
</tr>
<tr>
<td>Hanning et al. (2003)</td>
<td>Canada</td>
<td>Mature milk</td>
<td>25</td>
<td>2.1 ± 1.7^a</td>
<td>22.9 ± 12.5^a</td>
<td>Ingestion of wild animal meat containing fragments from lead bullets</td>
</tr>
<tr>
<td>Sowers et al. (2002)</td>
<td>USA</td>
<td>Mature milk</td>
<td>15</td>
<td>6.1 ± 1.0^a</td>
<td>–</td>
<td>Non-occupational exposure to lead</td>
</tr>
<tr>
<td>Li et al. (2000)</td>
<td>China</td>
<td>Colostrum</td>
<td>165</td>
<td>6.8 ± 3.3^a</td>
<td>–</td>
<td>Non-occupational exposure to lead</td>
</tr>
<tr>
<td>Sternowsky and Wessolowski (1985)</td>
<td>Germany</td>
<td>Colostrum</td>
<td>38</td>
<td>2.8 ± 2.5^a</td>
<td>6.3 ± 2.0^a</td>
<td>Non-occupational exposure to lead</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>10</td>
<td>9.1 ± 2.5^a</td>
<td>–</td>
<td>Rural area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Colostrum</td>
<td>10</td>
<td>12.5 ± 4.1^a</td>
<td>–</td>
<td>Rural area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mature milk</td>
<td>10</td>
<td>8.0 ± 2.1^a</td>
<td>–</td>
<td>Rural area</td>
</tr>
</tbody>
</table>

^a Mean.  
^b Median.  
^c Geometric mean.  
^d Below limit detection.
A higher correlation was expected, but these results can be explained due to the low concentration range of this metal in these biological samples. Ettenger et al. (2004a) also observed a modest correlation \((r_s=0.32, p<0.000)\) between the concentrations of lead in mature milk and blood, just as Anastacio et al. (2004) in mothers not occupationally exposed to the metal \((r_s=0.49, p<0.020)\). The results obtained in the research by Chien et al. (2006) have indicated that the half-lives of lead in breast milk and in blood were the same \((t_{1/2}=35 \text{ days})\).

In the present study, a modest correlation between the levels of lead in blood and the age of the mother \((r_s=0.227, p<0.029)\) could be observed. However, no such correlation between age and lead levels in milk could be observed.

A high correlation among the variables hemoglobin and hematocrit \((r_s=0.837, p<0.001)\) could be observed, which was expected. However, no correlation between these indexes and concentrations of lead in milk and blood could be noted.

Mean and median for ALAD activity observed in the present study (Table 2) are compatible to the values available in the literature for healthy and non-exposed individuals (De Siqueira et al., 2003; Mezzaroba et al., 2000), indicating low exposure to lead. No correlation between ALAD activity and lead concentration in blood and milk could be observed.

Regarding the consumer classes A–B and C–D, in which the distribution of donors was homogeneous in the two categories, no association could be made to the levels of lead in milk (Table 3). Azcona-Cruz et al. (2000) affirm that women from less favorable economic classes would be exposed to a higher number of contaminants as they have less access to medical information and treatments and reduced choices related to the way of living (living conditions and locations).

In the present study, the daily consumption of two glasses of milk, which corresponds to approximately 600 mg calcium (minimum calcium dose necessary to shield the absorption of the metal, according to some authors), was not associated to the levels of lead in milk. Leotsinisidis et al. (2005) and Gundacker et al. (2002) have also not found significant effects of calcium supplementation.

Some authors have observed mild negative associations between dietary calcium intake through the consumption of milk and the levels of this metal in the mother’s blood (Ettenger et al., 2004b; Anastacio et al., 2004).

Primiparous mothers present elevated lead levels in milk when compared to women with a higher number of children (Hertz-Piciotto et al., 2000), which can be seen as a risk factor. In the present study, 67.4% of the volunteers reported breastfeeding the first child although there was no difference in the levels of metal in milk or blood between primiparous and multiparous mothers (Table 1). Other authors also have not observed this association (Ettenger et al., 2004b; Frkovic et al., 1997).

In the present study, few women reported having used hair dye, ingesting mineral supplements, and engaging in leisure activities with exposure to metal. Therefore, no association could be established between the levels of lead in blood or milk and these variables. Hertz-Piciotto et al., 2000 did not observe such associations for the same limitations, or else, few women during pregnancy reported such activities. Leotsinisidis et al. (2005) did not observe significant effects between supplementation and lead levels in milk during pregnancy.

5. Final considerations

The present study allows the conclusion that milk donors in the municipality of Londrina presented low lead concentration in milk and blood, compatible with exposure to the metal in a low industrialized city.

Mature milk can be considered an appropriate biological matrix for determining lead because it can be collected using non-invasive methods, as well as presenting a good correlation with the lead levels in blood, according to most scientific publications analyzed. In the present study, despite the levels of lead in blood and milk being low, a modest correlation could be observed.

In the absence of safe exposure limits of children to lead, a great interest in the evaluation of adverse effects of this metal in low concentrations can be observed. This study contributes for the monitoring of breastfeeding women in several geographical locations and also from several socio-economic and demographic backgrounds.

The harmonization of collection protocols and the analysis of human milk with the aim of improving the comparison between the information obtained is suggested so that they become relevant, in order to reflect the different exposure scenarios. According to some authors, although the weight of the scientific evidence of data indicate that the advantages of breastfeeding overcome any risk of human milk contamination, it is important to identify exposed populations and contamination tendencies in order to implement public health measures aiming to eliminate or lower the breast milk xenobiotics.

References


