Temporal Fluctuation of the Lead Level in the Cord Blood of Neonates in Taipei

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ABSTRACT. From August 1985 to September 1987, 9 502 cord blood samples were obtained from the Taipei Municipal Maternal and Child Hospital. A total of 205 cord blood samples chosen randomly from newborns without parental exposure to lead were analyzed by flameless atomic absorption spectrophotometry. The average blood lead level was .36 ± .11 μmol/l (7.48 ± 2.25 μg/dl). A similar analysis was performed on samples obtained from 160 newborns whose fathers had occupational lead exposure. In both groups, the average concentration of lead in cord blood in the summer was statistically greater than that in the winter. Air lead and total amount of lead in gasoline consumed in Taipei appeared to be associated with this seasonal fluctuation in the average lead level of cord blood. After considering alternative sources, we conclude that the seasonal fluctuation of cord blood lead is probably influenced by air lead produced from the combustion of gasoline.

LEAD is not an essential element for the human body,[1] and its toxicity, which results from high levels of exposure, has long been recognized. In the past 10–20 y, however, investigators noticed hematologic and neurologic damage in children who had relatively low levels of lead in their blood and teeth.[2,3] More recently, a lead level greater than 10 μg/dl in newborns was associated with a mild impairment of mental development and behavioral performance.[4] Such studies draw attention to redefining the safe level of blood lead in newborns and to searching for effective ways to reduce blood lead levels.[5–8] Because atmospheric lead is one of the primary environmental sources of lead, and because unleaded gasoline has been used in Western countries for more than 10 y, there is great interest in possibly reducing blood lead in newborns in developing countries by replacing leaded gasoline with unleaded gasoline. In this study, we report a temporal fluctuation in the lead level of the cord blood of newborns in the Taipei area and discuss lead sources potentially related to this fluctuation.

Materials and methods

All women who received prenatal examinations between August 1985 and September 1987 at the Taipei Municipal Maternal and Child Hospital (TMMCH) were invited to participate in this study. A total of 9 502 (86%) women were enrolled, and they gave birth to one baby each. For each delivery, 5–10 ml of umbilical cord blood were collected in metal-free tubes (SARSTEDT MONOVETTE,® containing EDTA) and stored at −20 °C until analysis.

Mothers were interviewed during their prenatal visits by three specially trained and mutually standardized interviewers. We collected standard demographic data; reproductive and medical histories; and information on exposure to: lead in the workplace, medicines, alcohol, and tobacco, etc. After excluding 225 blood samples from newborns whose fathers and/or mothers were occupationally exposed to lead, we randomly selected 205 samples for analysis. Because lead exposure of the father may be less associated with blood lead of newborns, we also analyzed 160 blood samples (of the 225) from newborns with only paternal exposure to lead for comparison. Each sample was assayed in duplicate by an Instrument Laboratory (IL)® 12E and an IL® 755 graphite furnace atomizer. The discrepancy between each pair of duplicates was less than 10% in all cases. The analytical system was calibrated with a mixture of aqueous standards of known lead concentration using pooled blood as a matrix. To ensure intralaboratory consistency, each batch of samples was accompanied by blood samples of known lead concentration. We also participated in the interlaboratory or external quality control program of the Centers for Disease Control (CDC).[9]

Gasoline lead content and sales data were obtained from the China Petroleum Company (CPC), which is the only gasoline wholesaler in Taiwan. Monthly average atmospheric lead measurements were obtained from the Environmental Protection Bureau (EPB) of Taipei. The EPB monitors air lead using 24-h high-volume samplers at 21 different monitor sites in Taipei distributed according to population density; the samples were then analyzed by atomic absorption spectrophotometry. Univariate analyses, Student's *t* tests, and linear regressions were performed by the Statistical Analysis System (SAS) package.[10]

Results

Of the 205 randomly selected blood samples, 9 were discarded because of clotting, which left 196 samples for analysis. The average lead concentration in the cord bloods was .36 ± .11 μmol/l (7.48 ± 2.25 μg/dl). Whereas average lead concentration decreased in the second year, the difference was not statistically significant. However, the mean level of blood lead in the summer (.38 ± .11 μmol/l [7.94 ± 2.23 μg/dl], June through August) was significantly higher than that in the winter (.33 ± .12 μmol/l [6.84 ± 2.40 μg/dl], December through February, $p = .002$; see Fig. 1). A similar trend was also found in cord blood taken from newborns with paternal exposure. From an analysis of questionnaire information, we found that Huang-Lian, an herbal medicine containing the highest dosage of lead among the herbal medicines, was taken by 19% of the mothers. The average lead concentrations of cord blood from newborns whose mothers used and did not use Huang-Lian were .37 ± .10 μmol/l (7.60 ± 2.04 μg/dl) and .36 ± .11 μmol/l (7.45 ± 2.31 μg/dl), respectively; the difference was not statistically significant. Figure 2 shows the total lead in gasoline consumed per day (i.e., the amount of gasoline sold daily multiplied by the lead content) in Taipei during the study period. Because the CPC reduced the lead content in September 1986 and January 1987 from 0.32 g/l to 0.20 g/l, respectively, and finally down to 0.15 g/l, the total lead in gasoline consumed dropped abruptly during this period. However, the temporal fluctuation of total lead in gasoline consumed is in accordance with the seasonal change of the lead levels of cord blood in this study. The average monthly air lead concentration in Taipei during the period fluctuated with the total lead in gasoline consumed (correlation coefficient of .6832, $p = .001$).

Discussion

Before assay, 9 of 205 blood samples (4.4%) were discarded because of clotting. Fortunately, these samples were distributed randomly according to demographic variables and should not have influenced the results.

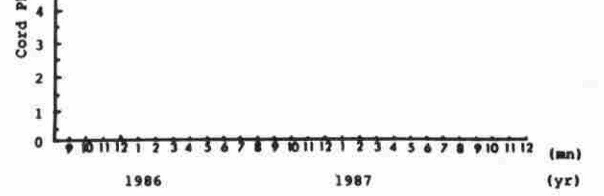

Fig. 1. Seasonal fluctuation of the cord blood lead (PbB) by month.

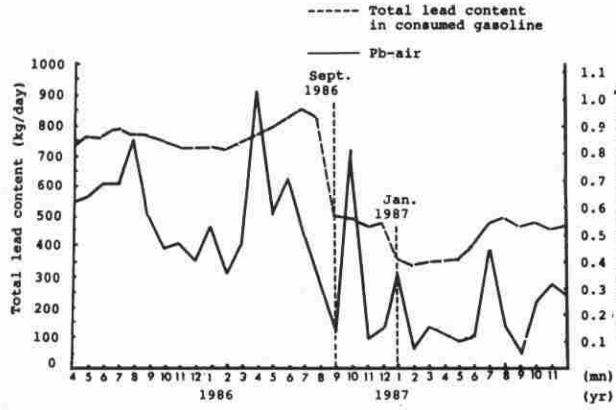

Fig. 2. Seasonal fluctuations of the total amount of lead in gasoline consumed and average air lead concentration (Pb-air) in the Taipei area.

Lead analysis was performed by a single researcher who was blind to the characteristics of the samples. Intra- and interlaboratory controls ensured that blood lead measurements were reliable and consistent with other credible laboratories.

Although there is a significant difference between the lead levels of cord blood from neonates born in summer and in winter, it does not necessarily follow that this variation is caused by one source of lead exposure, e.g., air. Alternative explanations must also be considered, such as lead in: drinking water, food, cosmetics, herbal medicines, working environment, and air.

Drinking water. Data from the Taipei Tap Water Company (TTWC) has shown that the lead level in tap water is usually undetectable (less than 5 μg/l).[11] Another independent water survey of lead content, executed by the Environmental Protection Agency in 1987, demonstrated that the lead content of tap water used by 92% of the households in Taipei was less than 10 μg/l.[12] According to Moore et al., the lead content of tap water is usually constant and too small to influence the fluctuation of blood lead.[13]

Food. We have shown previously that lead content in canned foods is not associated with blood lead in traffic policemen in Taipei[14]; it therefore appears unlikely to affect the results of this study. Food and Drug Bureau (FDB) data for dietary lead intake show that the estimated amount of lead absorbed by the average person in Taipei is probably as high as that estimated by the World Health Organization (WHO), i.e., 20–30 μg/person · day,[1,15] but generally the amount of lead in consumed diet does not vary considerably among the seasons.

Cosmetics. Data from the FDB show that in almost all of the cosmetics surveyed, lead content was under the safety level of 20 ppm and always part of an inorganic compound,[15] and therefore it is not easily absorbed through the skin. Hence, lead in cosmetics probably contributed very little to the blood lead levels of pregnant women and their newborns.

Herbal medicines. In accordance with Chinese tradition, pregnant women are advised to take herbal medicines for nourishment. Chinese herbal medicines frequently contain lead, and their consumption among pregnant women is usually greater than the consumption of Western medicines. In this study, we found that Huang-Lian was taken by 19% of the mothers, and that of all the herbal medicines it was taken in the highest dosage. The average lead concentration of cord blood among newborns of mothers using Huang-Lian (.37 ± .10 μmol/l [7.60 ± 2.04 μg/dl]) was not significantly higher than that of mothers not using Huang-Lian (.36 ± .11 μmol/l [7.45 ± 2.31 μg/dl], p = .73). Because Huang-Lian had the highest lead content among herbal medicines surveyed by the FDB,[15] and did not affect the cord blood lead of neonates in this study, we expect that herbal medicine consumption by pregnant women was probably not an important factor contributing to the seasonal fluctuation of cord blood lead.

Occupational exposure. According to one of our previous studies, occupational lead exposure of the parents of neonates increases the lead content of cord blood.[16] In this study, both the neonates without parental exposure and with paternal lead exposure only showed the same seasonal variation. The average lead concentration of cord blood in the summer was significantly higher than that in the winter (Fig. 1). Because parents with occupational exposure represented a variety of occupations (Table 1), and their workloads usually did not vary seasonally, we conclude that occupational lead exposure does not explain the seasonal fluctuation of lead levels in cord blood.

Air lead from gasoline. During the last decade, there have been many studies to determine the contribution of leaded gasoline to human exposure to lead. Although some studies concluded that no association existed between lead in gasoline burned and blood lead,[17] others provided evidence to the contrary.[7,18] This issue has always been controversial.[19–22] In general, gasoline lead emissions in the air are either directly inhaled by people or fall onto dirt, dust, and foliage, which represent other avenues of lead ingestion. In this study, the monthly average lead level of cord blood of newborns without parental exposure was significantly associated with the monthly average lead content of consumed gasoline before the lead content of gasoline decreased to 0.15 g/l in September 1986 (r = 0.5377, p = .0067). After the lead content decreased to 0.15 g/l, the concentration of lead in cord blood generally decreased, although there was not a significant difference (t = 1.709, p = .089). Even though the data cited above do not prove the existence of a cause-effect relationship between the use of leaded gasoline and human exposure, the concordance of these trends is notable. From the discussion above, we conclude that the consumption of leaded gasoline is the most important explanation for temporal fluctuations in the lead levels of the cord blood of neonates in Taipei.

Table 1.—Distribution of Newborns without Parental Exposure to Lead and Newborns with Paternal Exposure Only according to Paternal Occupation

Occupation of father	Nonexposed*	Father-exposed
Professionals, technicians and allied workers	27	15
Administrators and executives	23	37
Supervisors and adminstrative workers	43	6
Marketing and sales workers	41	9
Service workers	15	4
Agricultural, forestry, and fishing workers	1	1
Manufacture and allied workers, transportation equipment operators, and laborers	53	88
Military	1	

*Two cases were discarded becaused there was a lack of occupational data.

Because 10.7% of newborns without parental exposure to lead in Taipei have a blood lead level that exceeds 10 μg/dl, there is concern that action be taken to protect future generations. Moreover, because there is some indication that the average blood lead level in cord blood decreased as the lead content of gasoline dropped, we strongly recommend that action be taken to reduce further exposure to lead due to gasoline. Ninety percent of gasoline lead is emitted into the air, part of which is directly or indirectly absorbed by the public.[1] Assuming that the daily volume of air inhaled by a healthy man is 20 m^3 and the efficient rate of lead absorption is 30%,[1] then approximately 3 μg of lead is absorbed by the man if the air lead is 0.5 $\mu g/m^3$. This accounts for about 8% of the total amount of lead absorbed by an average person in 1 d, as estimated by WHO. Including lead absorbed via indirect routes, the percentage attributable to gasoline lead is actually greater. Both direct and indirect absorption of gasoline lead is inevitable. Even as trace quantities, the lead amounts are sufficient to raise the lead levels in the cord blood of neonates and perhaps even to damage the mental development of fetuses.[4] It is, therefore, necessary to limit exposure to lead, especially from unavoidable sources like lead in the atmosphere produced by the combustion of leaded gasoline.

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