Factors Affecting Blood Lead Level of Students in Chonburi Province

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Abstract

Lead is a highly toxic heavy metal which causes intellectual abnormalities in children. This study is a survey research using cross-sectional method to evaluate the effects of heavy metal exposure and the possible factors in students between June and July, 2010. Heavy metals were monitored using both environmental and biological indicators. Ninety students in 4^{th} and 6^{th} grade from three schools located in industrial area of Chonburi province were inquired and interviewed. The average value of lead in blood was 6.35 ± 3.84 µg/dl and was not significantly different. Drinking and supplied water from studied area were collected and analyzed. Eight heavy metals including Al, Fe, As, Mn, Zn, Cd, Cu and Hg were found in all samples (n = 15), but Cr, Ni and Pb were not found. Factors that correlated with lead levels in the blood with statistically significant difference were the time that the students take from home to school (p = 0.029) and the refinery plant that is located near residential areas (p = 0.040). In conclusion, there was no correlation between lead levels in the blood and its exposure. Lead exposure from other sources should be further studied and health-monitoring procedure should be established for other heavy metals found in drinking water.

Keywords: Blood, Child, Chonburi, Lead

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ปัจจัยที่มีผลต่อระดับตะกั่วในเลือดเด็กนักเรียน จังหวัดชลบุรี

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บทคัดย่อ

ตะกั่วเป็นโลหะหนักที่มีพิษสูงต่อเด็ก การรับสัมผัสตะกั่วจะส่งผลกับการพัฒนาทางด้านสติปัญญา การศึกษานี้เป็นการวิจัยเชิงสำรวจ เก็บข้อมูลแบบตัดขวาง ทำการประเมินผลกระทบจากการรับสัมผัสโลหะหนัก และปัจจัยที่มีอิทธิพลต่อการรับสัมผัสของเด็กนักเรียน ในช่วงเดือนมิถุนายน ถึง กรกฎาคม 2553 โดยการตรวจกำกับในสิ่งแวดล้อมและตัวบ่งชี้ทางชีวภาพ การสอบถามและสัมภาษณ์เด็กนักเรียนระดับประถมศึกษาปีที่ 4 ถึง 6 จำนวน 90 ราย จากโรงเรียน 3 แห่ง ในเขตพื้นที่อุตสาหกรรม จังหวัดชลบุรี ผลการศึกษาพบระดับตะกั่วในเลือดเด็กนักเรียนทั้ง 3 แห่งมีค่าเฉลี่ยเท่ากับ 6.35 ± 3.84 ไมโครกรัมต่อเดซิลิตร และไม่มีความแตกต่างทางสถิติ ตรวจพบโลหะหนัก 8 ชนิด ได้แก่ อลูมิเนียม เหล็ก สารหนู แมงกานีส สังกะสี แคดเมียม ทองแดง และปรอท แต่ไม่พบโครเมียม นิกเกิล และตะกั่ว ในตัวอย่างน้ำดื่มน้ำใช้บริเวณโรงเรียนทุกตัวอย่าง (n = 15) พบปัจจัยที่สัมพันธ์กับระดับตะกั่วในเลือดอย่างมีนัยสำคัญทางสถิติ ได้แก่ ระยะเวลาที่เด็กใช้เดินทางจากบ้านมาโรงเรียน (p = 0.029) และการมีโรงกลั่นอยู่ใกล้บ้าน (p = 0.040) ไม่พบความสัมพันธ์ระหว่างระดับตะกั่วในเลือดและการรับสัมผัสตะกั่ว ซึ่งแสดงให้เห็นว่าได้รับสัมผัสตะกั่วมาจากแหล่งอื่น จึงควรมีการศึกษาเพิ่มเติม และติดตามเฝ้าระวังสุขภาพเด็กจากการรับสัมผัสโลหะหนักชนิดอื่นที่ตรวจพบในน้ำดื่ม

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Introduction

Heavy metals are very stable and non-degradable substances which tend to remain at the bottom of the sediment or pass through the food chain. Lead is a highly toxic heavy metal used in several industries and for manufacturing goods for many years. It is classified as one of the hazardous pollutants because of the adverse effects on human health, organs and systems. There are many sources of lead exposure including the exposure from car batteries, some plastics or semi-plastic and protective coatings and paint as well as from lead contaminated food and water, house and vehicles dust, paint chips, soil and air[1]. Even at a small amount but lead and its compounds may harm to young children and pregnant by ingestion or inhalation[2,3]. Furthermore, other heavy metals can be found in every modern product used in daily life such as plastic or semi-plastic, colored cloth, tools, food and cosmetics.

In Chonburi province, many manufacturing companies and factories use heavy metals for producing electronics, auto parts, and metal smelters. Additionally, heavy metals are used in the agricultural sectors through the application of chemical pesticide and fertilizer. In the medical industry, heavy metals are applied in medicines, medical devices and cosmetics. Thus, the wastewater released from these industries is a major cause of water pollution[4,5].

Children are sensitive to heavy metal exposure in many ways including breathing and ingestion. Since children have a higher respiratory rate than adults at 2.3 times, they are more prone to be exposed to heavy metals. Drinking water is a potential source of lead exposure in children[3]. Their water intake and food consumption are 4.8 and 6.1 times higher than adults, respectively[6]. The chronic effects occur when children received a large amount of heavy metals from drinking water. These chronic effects includes lowered abilities to learn, slowed growth and development, and brain developmental disruption due to heavy metal absorption directly into the nervous system[7]. Therefore, heavy metals, especially lead, posses harmful effects on a children's intellectual abilities[8].

Thus, the objective of this study was to evaluate the factors affecting lead level in the blood of students in 2010. Chonburi province was selected as the study site since it has many industries and manufacturing factories which poses higher risk of exposure. Lead and other heavy metal contaminations were assessed by measuring their concentrations in drinking and supplied water as well as in children's blood. Moreover, other factors affecting children's health were also considered as database and guidance to improve the healthcare program.

Materials and Methods

Population and samples

School children: Students aged between 9 to 13 years old from three public schools in Chonburi province were specifically selected and interviewed. The criteria used in sample selection included 1) the school must locate in Chonburi province and 2) its location is near manufacturing factories or industrial estate and heavy metal point source. Additionally, GIS position of each studied area was recorded for further distance calculation.

Drinking and supplied water: Five water samples were collected in each school (Total 15 samples) for further heavy metals measurement.

Sampling and analysis

Blood sampling and lead analysis: Three millilitres of blood from students were collected and filled in EDTA-containing plastic tube, and then immediately shaked to prevent blood clot. Blood samples were kept at 4ºC until analysis. For blood analysis, 100 µl of blood sample and 900 µl of modifier (0.2 g of ammonium di-hydrogen phosphate dissolved in 0.5 ml of Triton –X and 100 ml of deionized water) were completely mixed and then applied to Graphite Furnace-Atomic Absorption Spectrometer[9] for lead concentration analysis.

Drinking and supplied water sampling and lead analysis: The hydrant was cleaned and fully opened for 2 min, then two litres of water were collected in rinsed plastic bottle and filled with 10 ml of concentrated nitric (suprapure) for heavy metal preservation. The method used for analyzing metals (aluminium, arsenic, cadmium, copper, chromium, iron, mercury, manganese, nickel, lead and zinc) in this study was conducted according to standard methods for the examination of water and waste water[10] using Inductively Coupled Plasma-Emission Spectrometer (ICP-ES).

Data analysis

The data were collected from questionnaires, survey, observation and interviews. Qualitative analysis method was used for analyzing the data. On the other hand, quantitative data were analyzed using descriptive statistic such as frequency, percentage, age, average, standard deviation, mean, maximum and minimum. Inferential statistic was performed by linear correlation.

Results

Lead concentration in blood

The results of blood analysis indicated that average lead concentration was 6.35 ± 3.84 µg/dl. The highest average level of lead was found in the first school at 7.53 ± 4.95 µg/dl. While in the second and third schools were 5.70 ± 3.75 and 5.74 ± 2.00 µg/dl, respectively (Fig. 1). However, there was no statistically significant difference ($p > 0.05$).

Most students (89.89%) had lead level in blood equal to or lower than 10 µg/dl. The percentages of students in the first and second school were 77.42% and 89.66%, respectively. For the third school, all children's blood contains lead equals to or lower than 10 µg/dl.

Overall, out of the total number of students tested, 11.11% of students had lead in their blood higher than threshold limit set by Centers for Disease Control and Prevention (10 µg/dl). Specifically, about 22.58% of students from the first school and 10.34% of students from the second school had lead levels in their blood higher than the threshold, while no students had lead levels in their blood above the limit for the third school (Table 1).

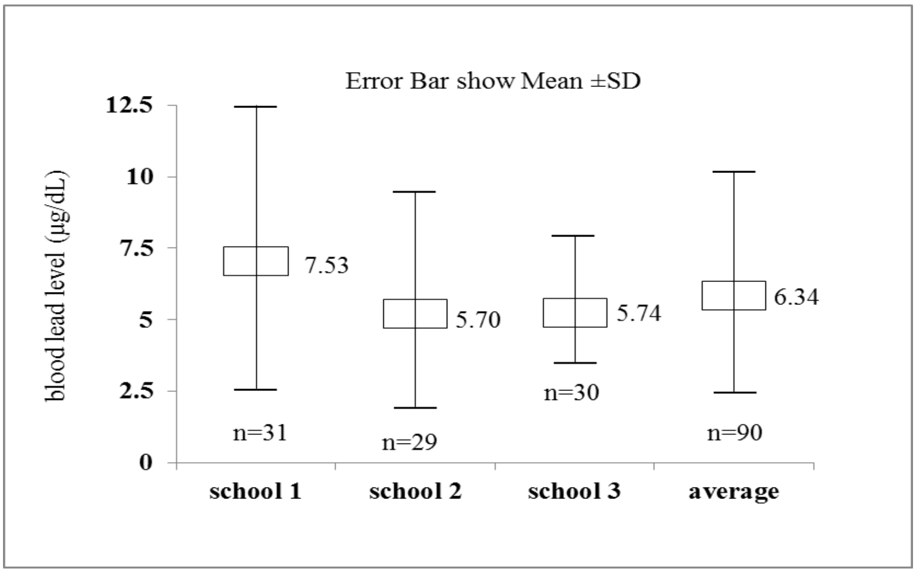

Figure 1 Lead concentration in the blood of students from 3 schools in Chonburi province

Heavy metal concentration in drinking and supplied water

Fifteen samples of drinking and supplied water were collected from three schools in Sriracha district. All samples contained heavy metals, such as aluminium, iron, arsenic, manganese, zinc, cadmium, copper, and mercury. However, chromium, nickel, and lead were not found. Among them, aluminum was the most commonly found (93.33%), followed by iron (80.00%), arsenic (66.67%), manganese (60.00%), zinc (20.00%). For cadmium, copper and mercury was found at 6.67% (data not shown).

Potential factors that leads to heavy metal exposure in school children

Based on interpreted questionnaire answers (Table 2), it indicated that many students (64.4%) were second hand smokers. About half of them (47.1%) were exposed to very high level of second hand smokes (family member smokes > 10 cigarette/day). Some students (35.6%) were in non-smoking environment. There was no active smoker in this study.

The results of univariate linear regression analysis (weighted/adjusted data) indicated that there were only two factors that correlated with level of lead in the blood: the time that the students take to get to school and oil refinery plants nearby their residents as shown in Table 3. The relation between the time and lead level in the blood were statistically significant (p = 0.029). The presence of lead in the blood of students that take less time to get to school was lower than students that take a longer time to get to school. The relationships of distance from residents to oil refinery plants and blood lead level were also statistically significant (p = 0.040). Student living nearby the plants had lower lead levels in their blood as compared to student living far away from it. As for other factors such as the location of gas station, garage, and printer shops, no correlation was found with lead levels in the blood.

Discussion

Exposure to lead can occur from many channels. The relationships of contributed sources remained unclear for

Table 1 Number and percentage of blood samples containing lead (classified by concentration range)

Blood lead concentration (µg/dl)	Number of sample (percentage)			
	School 1	**School 2**	**School 3**	**Total**
0-5	12 (38.71)	14 (48.28)	10 (33.33)	36 (40.00)
> 5-10	12 (38.71)	12 (41.38)	20 (66.67)	44 (48.89)
> 10-15	5 (16.12)	2 (6.90)	0 (0)	7 (7.78)
> 15-20	1 (3.23)	1 (3.44)	0 (0)	2 (2.22)
> 20-25	1 (3.23)	0 (0)	0 (0)	1 (1.11)
Total	31 (100)	29 (100)	30 (100)	90 (100)
Mean ± SD	7.53 ± 4.95	5.70 ± 3.75	5.74 ± 2.00	6.35 ± 3.84
Median (Max-Min)	6.82 (23.42-n.d.)	5.08 (19.04-n.d.)	5.65 (9.01-n.d.)	5.44 (23.42-n.d.)

Table 2 Personal factors which may influence lead exposure

Demographic and Social characteristic	Number (percentage)			
	School 1	School 2	School 3	Total
1. passive smoking				
• Non-exposure	10 (32.3)	12 (41.4)	10 (33.3)	32 (35.6)
• Low exposure	4 (14.3)	-	3 (10.0)	7 (8.1)
• Moderate exposure	1 (3.6)	2 (6.9)	4 (13.4)	7 (8.1)
• High exposure	13 (46.4)	15 (51.7)	13 (43.33)	41 (47.1)
2. Resident				
• Nearby the road	21 (67.7)	11 (37.9)	19 (63.3)	51 (56.7)
• Far off	10 (32.3)	18 (62.1)	11 (36.7)	39 (43.3)
3. Factory nearby the resident				
• yes	18 (58.1)	23 (79.3)	25 (83.3)	66 (73.3)
• no	13 (41.9)	6 (20.7)	5 (16.7)	24 (26.7)
4. Type of factory				
• Oil refinery	4 (11.4)	16 (25.8)	21 (51.3)	41 (29.7)
• Gas station	4 (11.4)	11 (17.7)	16 (39.0)	31 (22.5)
• Garage	6 (17.2)	12 (19.4)	2 (4.9)	20 (14.5)
• Printing house	2 (5.7)	1 (1.6)	-	3 (2.2)
• Construction	4 (11.4)	3 (4.8)	1 (2.4)	8 (5.8)
• Metal smelting foundry	4 (11.4)	8 (12.9)	-	12 (8.7)
• Battery shop	3 (8.7)	2 (3.2)	-	5 (3.6)
• Incinerator	2 (5.7)	6 (9.7)	-	8 (5.8)
• Other	6 (17.1)	3 (4.8)	1 (2.4)	10 (7.2)
5. Getting to school				
• Walking	1 (3.2)	2 (6.9)	4 (13.3)	7 (7.8)
• Bicycle	-	13 (44.8)	1 (3.3)	14 (15.6)
• Motorcycle	8 (25.8)	6 (20.7)	15 (50.0)	29 (32.2)
• Bus	12 (38.7)	7 (24.1)	6 (20.0)	25 (27.8)
• School bus	5 (16.1)	-	-	5 (5.6)
• Personal car	5 (16.1)	1 (3.4)	4 (13.3)	10 (11.1)
6. Time spent on traveling from resident to school (min)				
• 5-15	17 (54.8)	21 (72.4)	25 (83.3)	63 (70.0)
• >15-30	9 (29.0)	4 (13.8)	5 (16.7)	18 (20.0)
• >30-45	5 (16.1)	2 (6.9)	-	7 (7.8)
• >45-60	-	2 (6.9)	-	2 (2.2)
7. Hobby				
• Sale / delivery	3 (9.1)	4 (10.8)	6 (12.8)	13 (11.1)
• Housekeeping/playing computer game	5 (15.2)	17 (46.0)	7 (14.9)	29 (24.8)
• Sport	20 (60.6)	8 (21.6)	21 (44.67)	49 (41.9)
• Animal caring	4 (12.1)	8 (21.6)	13 (27.67)	25 (21.34)
• Selling newspaper	1 (3.0)	-	-	1 (0.89)
8. Air conditioner				
• use	6 (19.4)	1 (3.4)	4 (13.3)	11 (12.2)
• not use	25 (80.6)	28 (96.6)	26 (86.7)	79 (87.8)

children living in urban area. However, this study investigated the exposure channels from oral ingestion via water sources from schools, but no considering the exposure from skin or respiratory systems. The study found that lead levels in the blood of children from three schools were not significantly different. About 11.11% of school children have lead levels in their blood above WHO standard (10 µg/dl). The major contributing factors could result from consuming lead contaminated food or using lead contaminated containers to cook. It also might occur from hygiene habits such as not washing hands before eating or hand-to-mouth behaviors[11,12]. Satheantananon[13] found that age had an influence on lead accumulation in the blood. The measurement of lead levels in the blood from people living in the high risk areas of lead exposure in Kanchanaburi province, Thailand was observed. The result showed that 10-14 years old children had higher lead levels in their blood as compared to 5-9 years old, because they were likely to do mischievous romp and playing around in the rain which may be contaminated with lead.

Table 3 Univariate linear regression analysis of personal and environmental factors, which may influence lead exposure

Variable	Coefficient	95% Confident Interval		*p*-value
School location	1.27	0.97	1.66	0.080
Period of living in the resident	1.04	0.99	1.02	0.097
Time spent on traveling from resident to school	1.39	1.04	1.85	0.029*
Family member who smokes	0.65	0.41	1.03	0.065
Oil refinery plant nearby the resident	2.05	1.27	3.30	0.040*
Gas station nearby the resident	1.40	0.85	2.26	0.193
Car shop/garages nearby resident	0.90	0.53	1.52	0.676
Printing house nearby resident	1.09	0.33	3.50	0.880
Construction nearby the resident	0.41	0.44	1.92	0.814
Metal smelting foundry nearby the reside	0.14	0.44	1.53	0.533
Battery shop nearby the resident	0.26	0.35	2.18	0.771
Incinerator nearby the resident	1.37	0.65	2.86	0.398

This result confirmed the study of Schutz, et al.[14] which found that 2-14 years old children had lead levels in their blood in the range of 4.7-19.1 µg/dl and 36% of them had lead levels in their blood above the standard. Etchevers, et al.[15] measured lead levels in the blood samples of 6 months to 6 years old children in France (2008-2009) and found that the average was 1.49 µg/dl. Only 0.09% of children have presence of lead level above the standard.

However, 60% of children (in all three schools) had high level of lead in their blood and was above the "level of concern" by the Centers for Disease Control and Prevention (CDC)[16] which is at 5 µg/dl. As the level of lead in the blood increased, the harmful effects of lead in children also increased. Lead can affect many systemic organs in the body depending on a dose-related continuum of toxic effects. For instance, if lead level in the blood is lower than 10 µg/dl, it may affect growth and development of children such as decreasing in IQ level, hearing loss, decreased growth, and impaired peripheral nerve function[17].

The assessment of heavy metal contamination is very important especially in drinking water. In this study, eight heavy metals (Al, Fe, As, Mn, Zn, Cd, Cu, Hg, Cr, Ni and Pb) were found in drinking water. Since lead was not found in drinking water, this finding indicated that lead presence in school children's blood might be from the other sources. The finding confirmed the study of Kruawala, et al.[4] which also did not find lead in supplied water in Bangphra district, and Srichung Island, Chonburi province. For other heavy metals, it was found that manganese level in one of five drinking water samples collected from second and third school, and mercury level from the first school were over the standard for drinking water of the Ministry of Public Health, Thailand (more than 0.5 and 0.001 mg/l, respectively[18]. However, arsenic level in all drinking water samples (from three schools) was over the standard of the World Health Organization (0.01 mg/l)[19]. The level was in the range of 0.0133-0.049 mg/l (data not shown).

From the questionnaire, the interpreted results indicated that most school children lived in cigarette smoking environment. They also lived nearby manufacturing factories, oil refinery plants, and gas stations, therefore they may be exposed to heavy metals as they are going to school from home. Swaddiwudhipong, et al.[2] found that children lived nearby solar energy conversion system had 43.3% higher chance to be exposed to lead than the average. Health risk of children was higher than adults because they are more likely to have nutritional deficiencies that lead to increased absorption of lead and they spend more time in a single environment such as the home[17]. In 2010, WHO[20] indicated that major sources of lead exposure for children were active industries, paints and pigments, solder in food cans, drinking water systems with lead solder and lead pipes, electronic waste, lead contaminated food, contaminated soil, contamination in the former industrial sites.

Genes of children exposed to lead in early stage of life might be re-programmed, which then alters gene expression and further increases the risk of disease[17,21]. Gastrointestinal absorption of lead is quite high in childhood; about 50% of ingested lead is absorbed by children comparing to 10% in adults[17]. Thus, the effects from being exposed to lead or mercury might occur in children more than in adult, which causes the increased susceptibility to diseases. The appropriate way to reduce this effect is to reduce the chance of exposure to lead in the environment or ingestion of lead contaminated food. Moreover, the monitoring program should be established for better prevention.

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