Original Article

Environmental Investigation for Mass Lead Poisoning among Children in Industrial Area of Samut Sakhon, Thailand

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Background: A girl with blood lead level [BLL] of 166 mcg/dL was admitted in hospital due to status epilepticus. A high level of lead dust and contamination in environment was detected in her living area. All the children in a school that was located around 100 meters from the recycling factory were examined. Among these group of children, the prevalence of high BLL (10 mcg/dL or more) was 44.2% (75 from 165 children).

Objective: To find the associations of demographic, risk behaviors, and external or internal environmental factors in children with high BLL (10 mcg/dL or more) who lives in area of industrial community. A second objective is to study the effects of high BLL (15 mcg/dL or more) on IQ level and learning disability [LD] among these children.

Materials and Methods: A case control study was conducted with 43 cases of school children (BLL of 10 mcg/dL or more), and 43 children as a control group in same school by matching of classroom and gender with 1:1 matched ratio. The baseline characteristics, behavioral, and environmental risk factors (internal and external), and collected samplings of the household environment were sent to standard laboratory to identify lead contamination and the association among the environmental risk factors with high BLL (10 mcg/dL or more) by multiple logistic regression analysis, and looking for the prevalence of low IQ and LD among children who were detected BLL of 15 mcg/dL or more.

Results: The study found statistically significant association between high level of BLL and school duration (more than four academic years) (odds ratio 4.86, 95% CI 1.81 to 13.04, *p*-value 0.002), the distance between home and the factory (less than 500 meters) (odds ratio 2.98, 95% CI 1.12 to 7.94, p-value 0.029), and father's occupation (odds ratio 2.75, 95% CI 1.03 to 7.37, p-value 0.044). In the group of children who high BLL (15 mcg/dL or more), the studied found the prevalence of 25% in low IQ, 5% of mental retardation, and 66.7% of LD were detected.

Conclusion: This study found positive association of high BLL among children living around the industrial community. The most important factors were related with the duration of living in the place related with lead contamination, father's occupation, and the distance between the housing and the factory. The prevalence of low IQ and LD among children with BLL of 15 mcg/dL or more was higher than average of Thai children. There is a need for blood lead screening for these children and prompt care and prevention if high blood levels of lead is detected.

Keywords: Lead, Lead poisoning, Blood lead level, Learning disability, Industrial community

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Lead is a heavy metal that is hazardous to children. The symptoms depend on the amount of lead in the patients' blood and the duration of contact(1-3). High lead level in blood will negatively affects every body system. Furthermore, through genetics polymorphism, such as early toxicity, affects the mind as being cramped and senseless. Additionally, even small amount of lead that is continuously taken would cause being pale and having a slow growth. In the worst cases, it negatively influences the central nervous system [CNS], especially in intellectual development. Once the CNS is affected from lead, it cannot heal and return to the normal stage(4-9).

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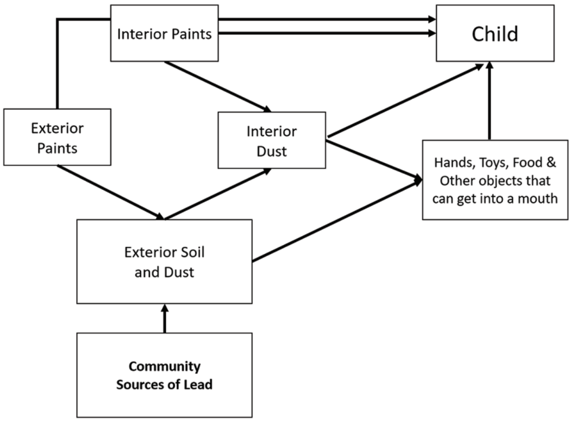

Figure 1. Pathway of lead exposure in the residential environment of Samut Sakhon modified from Bornschein et al[11,12], and Binns et al[9].

Center Disease of Control [CDC] and American Academy of Pediatrics [AAP] defined the level amount of lead contamination in blood that is an acceptable level for children to less than 10 mcg/dL. In 2012, CDC has announced a new lower acceptable level of lead contamination of 5 mcg/dL. This implied that they have realized the greater danger of lead[10].

There are two common pathways of lead contamination in children, internal and external factors. Bornschien's theory claims that lead that contaminates the community can enter the house through air circulation. It also can become exterior and interior soil dust. Those contaminants will merge to internal factors that are coming from paint, household products, toys, and others equipment and facilities (Figure 1). All of these exposures convert to significantly influence the lead level contamination in blood of children who lives in this residential environment[11-14].

In Thailand, the government have reported mass lead poisoning affecting residents in some communities. Tantanasrikul et al (2002) chose the sampling population of the residents in Klity Village, Kanchanaburi Province, Thailand[15]. Moreover, Mitchell et al (2009)[16] have reported the effect of lead contamination in Thai-Burma Border. Nonetheless, there is no report showing the consequences of mass lead poisoning among children who lives in or around the industrial factory community areas/industrial neighborhoods[16].

Recently, an 8-month girl with status epilepticus was transferred to Pediatric Intensive Care Unit, Ramathibodi Hospital, Mahidol University. The definite cause of this critical illness was coming from the high level of lead in her blood, which was measured as 166 mcg/dL. The blood lead level [BLL] was more than 16 times over the standard cut-off level. According to the guidelines on how to handle a community when a patient in that community has a high blood lead contamination over 15 mcg/dL is to complete an urgent environmental investigation to find out the causes and prevent its recurrence.

The Child Safety Promotion and Injury Prevention [CISP], Thailand and Pediatric Department, Ramathibodi Hospital, Mahidol University did a community research focused on the girl's living community. The researcher found that she lived in an area with nearby factories that stores large amount of heavy metals. After examining those metals, it was found that most contained lead.

From indexed case tracing, the researcher did a survey at Ban Nong Hat Yai School, which is located nearby factories on the industrial community, and not far from the indexed case's home. The researcher team collected blood samples of all the students in this school to check the level of lead contamination. The result showed that 73 out of 165 students (44.2%) had BLL of 10 mcg/dL or more, and 11 students had a BBL of 20 mcg/dL or more as shown in Table 1.

According to the data, the objective of this study is to find the causes of high BLL, which could be the external or internal factors that positively influence the level of lead contaminated in children's blood. A secondary objective is to study the level of intellectual quotient [IQ] and the prevalence of learning disability [LD] among children with over 15 mcg/dl of lead contamination in their blood.

Table 1. Results of BLL sampling from student in Ban Nong Hat Yai School, Samut Sakhon Province

Education level	BLL (mcg/dL)			Total (subjects)	Students with lead contamination ≥10 mcg/dL (%)
	≥20	10 to 19.9	<10		
K1	0	5	12	17	29.41
K2	0	7	13	20	35.00
Grade 1	4	2	11	17	35.29
Grade 2	0	7	14	21	33.33
Grade 3	1	12	9	22	59.09
Grade 4	4	15	7	26	73.08
Grade 5	2	8	13	23	43.48
Grade 6	0	6	13	19	31.58
Teachers	0	0	11	11	0.00
Total	11	62	103	176	44.20*

BLL = blood lead level; K1 = kindergarten 1; K2 = kindergarten 2

* Percent was calculated from total 165 students

Materials and Methods

The case-control study was conducted and collected data directly from subjects in community, Ban Nong Hat Yai School located nearby an industrial community area not far from area of the indexed case report. The environmental survey, clinical exam, blood investigations, and structural questionnaire interview were used as a tool for collecting the data. The authors assigned as cases the students who have a level of lead contamination in blood of 10 mcg/dL or more. The student who have level of lead contamination in blood of 10 mcg/dL or lower served as control group. The matching done by school level, which are kindergarten, first primary schools and second primary schools, and gender between Case and Control (1:1). The inclusion criteria were students of Ban Nong Hat Yai School (level K1-2, G1-6) who resided in Tambon Bang Nam Chuet. The students were tested for BLL and the information of potential risk factors related to lead contamination was collected. The exclusion criteria were children with disability including impairments in body functions and structures, children who recently migrated to live in Tambon Bang Nam Chuet for less than three months.

In the first phase, the researcher team introduced the research to the headmaster of the school, teachers, students, and parents. They explained the objectives of the research including education on the harm of lead to engage everyone at the school. Then, the authors matched the case and control sampling of population by gender and level of education (6, 16, and 21 pairs for Kindergarten, first primary school, and second primary school, respectively), and 18 males and 25 females were paired. Some of the data was missing because the sampling population either was not available, or the home address could not be found. Additionally, some students may have moved out or graduated. The data of grade-6 students was discarded because they were moving out of the school the following year.

In the second phase, a direct structured questionnaire interview was done and included demographic data, and data related to potential confounders consisting of family income, housing characteristics, child activities and play area, nutritional status, underlying disease, and migration. It also included the occupation, types of work that related with lead contamination in parent or other family members, anemia status measured by capillary hematocrit, and pica behavior in a child. The contaminated environment factors such as lead-based paint, enamel or plastic paint with paint dust or paint chip, highly decorated dishes/toys or bright colors and decorations inside dish surfaces that touch food, drink or toy surfaces, lead contaminated cooking pot or water cooler-tank-pipe were collected by questionnaires interview. Lead content analysis was done for potential sources of lead paint or lead dust exposure in the home including two samples of exterior dust, two samples of interior dust, one sample of exterior paint, and one sample of interior paint.

In the the third phase, the environmental investigations and survey were collected such as some of items in the house to analyze by Lead Paint Handheld XRF Analyzer. Moreover, all of students found with BLL over 15 mcg/dL were sent to measure IQ level and screening for LD in the last steps.

Statistical analysis

The descriptive statistics are reported as number, percent, mean ± SD, and median (ranges) depending on data distribution. The normality of continuous data was examined by using the Shappiro-Wilk test. The statistically significance of continuous variables was tested by Student t-test or Mann-Whitney U test depending on whether the data had normal or non-normal distribution. Chi-square statistic was used for nominal scales. The associations between the BLL and the influential factors were done in three domain group.

First domain was the basic information of the patients, duration of stay in the school, duration of stay in current house, parents' occupation that is related to lead etc. The second domain are information of external risk factors such as playground with old paint, garage in the community, lead contaminated environment in household such as exterior dust, interior dust, exterior paint, and interior paint. The third domain group is the distance between house and the industrial factories, which will be analyzed by univariate analysis.

The variable that had a *p*-value of less than 0.10 were enrolled into multiple logistic regression analysis. Some of continuous variables were transformed to be categorized based on statistical approach or clinical cut-off. Then logistic regression analysis was performed in backward and forward stepwise method. The comparisons were considered as statistically significant at *p*-value of less than 0.05. Students with a BLL over 15 mcg/dL were analyzed for evidences of low IQ level and abnormal LD by Chi-square statistic, looking for statistical association (Figure 2). All statistical analyses were performed using the Stata 15.0 software package (College Station, TX, USA).

This study was approved by the Ramathibodi Hospital, Institutional Review Board [IRB], Faculty of

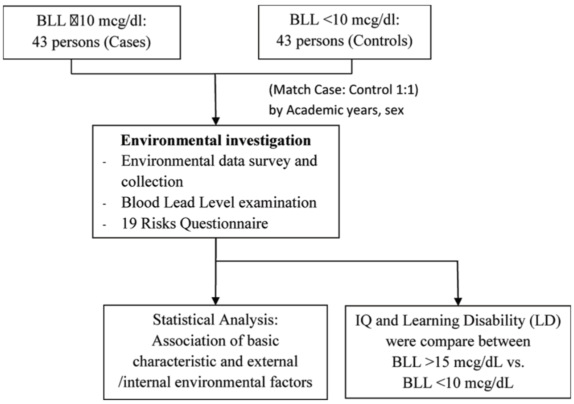

Figure 2. Flow of data flow, investigation domains, and analytical plans.

Medicine Ramathibodi Hospital, Mahidol University. All investigations were conducted in accordance with the principles set forth in the Declaration of Helsinki and all of its subsequent amendments.

Results

According to data collection among case and control groups, the results will be shown in 43 pairs of samplings by matching of case and control 1:1 with academic years and sex. The mean ± SD level of lead contamination were 16.70±5.11 mcg/dL in cases group, 6.36±1.63 mcg/dL in control group. The median and ranges were 15.13 (11.10, 33.68) and 6.04 (3.68, 9.95) in case and control groups respectively (*p*-value smaller than 0.001). From Univariate analysis, the researcher found the trend of exposure years are likely to be more positive with age but did not reach statistical significance (OR 2.16, 95% CI 0.66 to 7.12 for age 5 to 10 years, and OR 1.72, 95% CI 0.57 to 5.21 for age more than 10 years, respectively, *p*-value 0.409). For education level, the present study found an increase of odds ratio when children were higher class level for kindergarten and primary school (OR 1.37, 95% CI 0.28 to 6.58, *p*-value 0.69), and have the same trend of grades level that increasing with higher odds ratio of BLL, see Table 2.

Other results from univariate regression analysis showed that three important risk factors, duration in school (OR 3.95, 95% CI 1.51 to 10.35, *p*-value 0.002), duration in house (OR 2.97, 95% CI 1.17 to 7.56, *p*-value 0.016), and father occupation (OR 1.91, 95% CI 0.75 to 4.87, *p*-value 0.049) strongly related with high BLL of children, see Table 2.

For internal and external risk factors of environment, the questionnaire was used to explore the risk factors that influence the level of lead in the blood. The medical staffs used the structural risks questionnaire to interview. The result showed that those 19 risk factors, the risk from oil paint storage, peeling oil paint on internal or external wall, architraves or pillars did not demonstrate to statistically significantly affecting high BLL (*p*-value greater than 0.05). Only peeling oil paint on architraves or pillars have a trend of association but is still not statistically significant (OR 2.15, 95% CI 0.88 to 5.22, *p*-value 0.08). For distance from the factory, the studied found that the house within 500 meters of industrial factories was statistically significant associated with high BLL (OR 2.71, 95% CI 1.07 to 6.84, *p*-value 0.027), see Table 3.

We analyzed of the level of lead and the environment factors via six household appliances in the house of children with BLL of 10 mcg/dL or more. These specimens were analyzed by Lead Paint Handheld XRF Analyzer. The result showed no significant association. However, in the environment survey of oil paints that contain over 100 ppm of lead, 51.2% of children had lead contamination. Additionally, when the area dust

Table 2. Univariate analysis among interested demographic factors and BLL of children

Factors	BLL (mcg/dL), n (%)		Odds ratio (95% CI)	*p*-value
	≥10	<10		
Age				0.409
<5 years	8 (38.1)	13 (61.9)	1	
5 to 10 years	16 (57.1)	12 (42.9)	2.16 (0.66 to 7.12)	
>10 years	19 (51.4)	18 (48.6)	1.72 (0.57 to 5.21)	
Education				0.690
Kindergarten	4 (57.1)	3 (42.9)	1	
1st school	39 (49.4)	40 (50.6)	1.37 (0.28 to 6.58)	
Grade				0.066
1	2 (40.0)	3 (60.0)	1	
2	7 (41.2)	10 (58.8)	1.05 (0.13 to 8.41)	
3	4 (40.0)	6 (60.0)	1.00 (0.10 to 9.66)	
4	9 (75.0)	5 (25.0)	4.50 (0.40 to 50.74)	
5	13 (72.2)	5 (27.8)	3.90 (0.43 to 35.16)	
6	8 (33.3)	16 (66.7)	0.75 (0.10 to 5.64)	
School duration				0.002
<4 years	12 (31.6)	26 (68.4)	1	
≥4 years	31 (64.6)	17 (35.4)	3.95 (1.51 to 10.35)	
Duration in house				0.016
<6 years	12 (34.3)	23 (65.7)	1	
≥6 years	31 (60.8)	20 (39.2)	2.97 (1.17 to 7.56)	
Fathers' occupation				0.049
Non-lead related	18 (46.2)	21 (53.8)	1	
Lead related	23 (62.2)	14 (37.8)	1.91 (0.75 to 4.87)	
N/A	2 (20.0)	8 (80.0)	0.29 (0.05 to 1.65)	
Mothers' occupation				0.883
Non-lead related	29 (48.3)	31 (51.7)	1	
Lead related	12 (54.6)	10 (45.4)	1.28 (0.48 to 3.44)	
N/A	2 (50.0)	2 (50.0)	1.06 (0.14 to 8.22)	

BLL = blood lead level; N/A = not available

Table 3. The univariate analysis among 19 risk of internal/external factors from questionnaires interviews with outcome (high BLL ≥10 mcg/dL)

Factors	BLL (mcg/dL), n (%)		Odds ratio (95% CI)	*p*-value
	≥10	<10		
1. Oil paint for internal wall				0.138
No	57 (47.4)	41 (52.6)	1	
Yes	6 (75.0)	2 (25.0)	0.30 (0.06 to 1.63)	
2. Oil paint for architraves/pillars				0.490
No	12 (44.4)	15 (55.6)	1	
Yes	31 (52.5)	28 (47.5)	0.72 (0.29 to 1.82)	
3. Oil paint for external wall				0.46
No	38 (48.7)	40 (51.3)	1	
Yes	5 (62.5)	3 (37.5)	1.75 (0.39 to 7.96)	
4. Oil paint for fence				0.40
No	39 (48.8)	41 (51.2)	1	
Yes	4 (66.7)	2 (33.3)	2.10 (0.36 to 12.35)	
5. Peeling oil paint on internal wall				0.65
No	28 (48.3)	30 (51.7)	1	
Yes	15 (53.6)	13 (46.4)	1.24 (0.50 to 3.07)	
6. Peeling oil paint on architraves/pillars				0.08*
No	20 (41.7)	28 (58.3)	1	
Yes	23 (60.5)	15 (39.5)	2.15 (0.88 to 5.22)	
7. Peeling oil paint on external wall				0.83
No	27 (50.9)	26 (49.1)	1	
Yes	16 (48.5)	17 (51.5)	0.91 (0.38 to 2.17)	
8. Peeling oil paint on the door				1.00
No	41 (50.0)	41 (50.0)	1	
Yes	2 (50.0)	2 (50.0)	1.00 (0.13 to 7.53)	
9. Peeling coated colorful toys				0.38
No	24 (46.2)	28 (53.8)	1	
Yes	19 (55.9)	15 (44.1)	1.48 (0.61 to 3.56)	
10. Peeling coated colorful tables				0.50
No	37 (48.7)	39 (51.3)	1	
Yes	6 (60.0)	4 (40.0)	1.58 (0.41 to 6.12)	
11. Colorful toothbrushes				1.00
No	40 (50.0)	40 (50.0)	1	
Yes	3 (50.0)	3 (50.0)	1.00 (0.19 to 5.31)	
12. Playground				
No	-	-	No difference	-
Yes				
13. Colorful food containers				0.747
No	5 (45.5)	6 (54.5)	1	
Yes	38 (50.7)	37 (49.3)	1.23 (0.34 to 4.43)	
14. Lead-smelled from tank				
No	-	-	No difference	-
Yes				
15. Lead-bung containers				1.00
No	42 (50.0)	42 (50.0)	1	
Yes	1 (50.0)	1 (50.0)	1.00 (0.06 to 16.79)	
16. Lead-smelled drinking water				0.69
No	40 (50.6)	39 (49.4)	1	
Yes	3 (42.7)	4 (57.1)	0.73 (0.15 to 3.52)	
17. Lead Garbage				0.155
No	33 (46.5)	38 (53.5)	1	
Yes	10 (66.7)	5 (33.3)	2.30 (0.70 to 7.58)	
18. Distance from house to industrial factories <500 meters				0.027
No	12 (35.3)	22 (64.7)	1	
Yes	31 (59.6)	21 (40.4)	2.71 (1.07 to 6.84)	
19. Garage in community				1.00
No	36 (50.0)	36 (50.0)	1	
Yes	7 (50.0)	7 (50.0)	1.00 (0.32 to 3.16)	

BLL = blood lead level

has over 400 ppm of lead, then 27.8% of that group of children had lead contamination as shown in Table 4.

Using multiple logistic regression analyses, three domain risk factors in the baseline and family characteristic were analyzed (baseline demographics, internal, and external risk factors questionnaires). The factors with *p*-value smaller than 0.10 from univariate analysis were picked up to further analysis. As the results, the present study found that duration of study in school with longer or equal to four years (OR 4.86, 95% CI 1.81 to 13.04, *p*-value 0.02), the father's occupation (OR 2.75, 95% CI 1.03 to 7.37, *p*-value 0.044), and the distance between the house and the industrial factories that is less than 500 meters (OR 2.98, 95% CI 1.12 to 7.94, *p*-value 0.029) are significantly associated with high BLL in students, see Table 5.

For association of IQ and high BLL, regarding the 20 students who have a BLL over 15 mcg/dL. They show that one fourth of students had IQ below 90, below normal (five students from 20 students who had BLL of 15 mcg/dL or greater). Four students had an IQ of 80 to 89 and one student had an IQ of less than 69, which is regarded as mental retardation. When the authors compared average IQ of all students in Ban Nong Hat Yai School, it found that average IQ was 103.73, which was lower than the average IQ of students among Bangkok's suburban districts collected by Department of Mental Health and has been reported as 119.7±14.7.

To evaluate the LD, the researcher chose language disability among grade 3 to 6 students. The results showed that 17 students categorized as LD had BLL

Table 4. Univariate analysis between lead contamination of external/internal factors in environment (ppm) and BLL in children

Lead contamination	BLL (mcg/dL), n (%)		Odds ratio (95% CI)	*p*-value
	≥10	<10		
Painting >100 ppm	22 (51.2)	18 (41.9)	1.34 (0.63 to 2.83)	0.387
Dust >400 ppm	12 (27.9)	14 (32.6)	0.79 (0.35 to 1.81)	0.639
Soil >400 ppm	2 (4.7)	1 (2.3)	1.50 (0.24 to 9.35)	0.557

BLL = blood lead level

Table 5. Multiple logistic regression analysis between BLL and significant of risk factors of environment

Factors	Coefficient	OR	95% CI	*p*-value
Duration of school ≥4 years	1.58	4.86	1.81 to 13.04	0.002
Father's occupation	1.01	2.75	1.03 to 7.37	0.044
Distance between house and industrial factories (<500 meters)	1.09	2.98	1.12 to 7.94	0.029

BLL = blood lead level; OR = odds ratio

over 15 mcg/dL. Among this group, nine students (53.0%) were diagnosed with language disability. Those nine students were categorized into three disabilities, six (35.0%) with reading disability, nine (53.0%) with writing disability, and seven (41.2%) with calculating disability. The authors compared these results to the average LD research conducted in 2009. It can be demonstrated that the diversity rate among each community is 29.31%. These children in industrial area showed significant over-average prevalence of LD of Thailand.

Discussion

The present study conducted to find associated risk factors causing high BLL among children in Ban Nong Hat Yai School, a primary school that is located near the industrial community factories in Samut Sakhon Province, Thailand. The results showed that there are 73 students with BLL higher than 10 mcg/dL, which was 44.2% of the 165 students in this school. The researcher was matching 43 pairs of subjects based on basic information of case and control groups of population (academic years, sex) to analyze the association among high BLL and risk factors (demographic, behaviors, parent's occupational) as well as internal/external environmental factors.

Regarding to the statistical analysis, the present study found the risk and behavior factors that have shown significantly association were duration in school that is over four years (OR 4.86, 95% CI 1.81 to 13.04, *p*-value 0.02), parents' occupation that was working related to lead contamination or exposure, and the distance from the factories (OR 2.75, 95% CI 1.03 to 7.37, *p*-value 0.044). For the distance diameters, the authors drew circles using the factory as the center. If

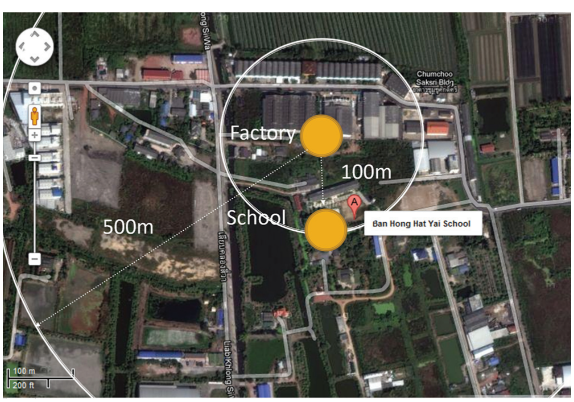

Figure 3. Distance diameter by GPS demonstrated around factory to school or houses which is less than 500 meters.

the distance between the house and industrial factories was less than 500 meters, then it was directly associated with high BLL of children (OR 2.98, 95% CI 1.12 to 7.94, *p*-value 0.029).

An interesting question is why the students in this school have different lead level in blood and trending higher than other children in other areas. According to Pathway of lead exposure by Bornschein, it mentioned the factors influencing the level of lead and focuses on the accommodation factors. However, this research found that the duration of stay in the school over four academics years, the parents' occupation, and the distance from factories (Figure 1, 3) have positive influence, which are not mentioned in Bornschein's theory.

Recently, Zhejiang, China (2011) showed high BLL in poison worker[17,18]. In Uruguay (2001) researches[19-22] demonstrated the main factor is the parents' occupation. In Sichuan, China (2010) the study demonstrated significantly that distance of 800 meters from a factory influenced a high BLL where seven children had dangerously high BLLs and were hospitalized. In Chengdu, China (2015)[23], a study indicated that the sex, time of exposure, and distance to the toxic have a have a significant influence, which is similar to the present study. Recently, a meta-analysis by Li et al (2015)[24,25] reported that the lead poisoning rate among population living around mining area was 70% (95% CI 62.7 to 77.3), industrial area was 57.5% (95% CI 28 to 86.9), and urban area was 9.6% (95% CI 7.1 to 12.1). They found that most of the high BLL was in school age (6 to 12 years old) children. They reported 6.7% (95% CI 4.7 to 8.6) in school age group, which is a much lower rate than in our study (44.2%). For gender, they showed that the male population, aged 0 to 18-year-old, had a high BLL in about 10% (95% CI 7.0 to 13.0) while the female had 7.7% (95% CI 5.0 to 10.4). Nevertheless, these studies did not specify and explore the exact distance of the possible contamination. Moreover, no research mentioned the exact duration of stay in school or household, which can influence the lead level.

The result also shows that student who had BLL level higher than 15 mcg/dL were associated with lower IQ and an abnormal LD when compared with the average level of Thai children. Those factors should be explored and studied further. This would be fundamental information to help other researchers interested to conduct research on this developmental field.

From the nineteen items of internal/external risk associated environment and behavior questionnaires, most items were not significantly associated with our interested risks or behavioral risk factors of high BLL. The author found that only one item, which is the distance of less than 500 meters between the factories and the house, shows positive statistical association (OR 2.98, 95% CI 1.12 to 7.94, *p*-value 0.029). There may have been some recall bias when the questionnaires were filled, even after the authors employed well trained staff to interview.

Conclusion

An environment with lead contamination results with higher BLL to the children who live in Bang Nam Chuet Industrial Community and went to the Ban Nong Hat Yai School. The standard cut-off BLL level of 10 mcg/dL (CDC and AAP) has been used for many years in western countries(10). The risk factors that influences the BLL are either external or internal environmental contamination. If those risk factors are not solved, the students or children in affected community will be continuously building toxic lead exposure, which will affect their long-term health. A blood check-up program and child developmental evaluation should be implemented and focused on children who live near industrial communities.

Mass lead poisoning can be found in industrialized and developing countries and the causes and factors are not too different. This research should raise awareness among people around industrial areas to check their blood more often. The effects of lead on children lowers IQ and creates higher rate of LD than normal children. Therefore, it is crucial that blood examination be supported as public policy.

Children living in industrial areas should get blood examination periodically. There should be standard measures to prevent lead spread to the community. Public policies should sanction manufactures to eliminate risks to the outlining communities.

The limitation of this study is that the selected sampling group studied in IQ and LD were the patients with BLL over 15 mcg/dL, which is different from the group with less than 10 mcg/dL. Moreover, because of the limited number of psychologists, it was not possible to examine all the patients with over 10 mcg/dL. Even though the staff were well-comprehended on the questionnaire, the recall bias could have occurred. We were limited in the evaluation of the industrial factories in this area, such as lead dust, working relating to lead, and lead contamination in environment. This limitation due to these factories were protected by law and the researchers cannot get samples without permission.

What is already known on this topic?

The authors know that lead is harmful to health. Especially in children residing in industrial communities. They are exposed to these heavy metals and contaminants, from inhaling and breathing out these lead metal droplets. In many countries, research focus on the children living around industrial area with direct and indirect exposure to lead. Recent reports have shown that lead causes harm to all systems of the body including CNS systems to the cognitive and learning environments.

What this study adds?

This study explored association of demographic factors, risk behaviors, and external or internal environmental factors related with lead exposure and contamination in high BLL (10 mcg/dL or more) neighborhood area surrounding an industrial community. High BLL (15 mcg/dL or more) affects the IQ level and LD in children.

Potential conflicts of interest

The authors declare no conflict of interest.

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