

# Predictors of Elevated Blood Lead Level in Thai Children: A Pilot Study Using Risk Assessment Questionnaire

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**Introduction:** In the era post leaded-gasoline use, the risk of exposure to environmental lead in Thai children is not well described. This is a pilot study using a risk assessment questionnaire to identify children with elevated blood lead level.

**Material and Method:** Children from 4 communities, 2 in the Bangkok metropolitan area and 2 in Kanchanaburi province, were recruited during their well child visits. Blood lead levels were obtained in all children and parents are asked to fill out a 25-item risk assessment questionnaire.

**Statistical analysis:** The relationship between the blood lead level and dependent variables were tested using linear regression and one-way analysis of variance (ANOVA) as appropriate.

**Results:** There were 296 children included in the study; 33 from Klong Toey and 114 from Siriraj community in Bangkok while 149 were from two different communities in Kanchanaburi province. The average blood lead level was  $5.65 \pm 3.05$  mcg/dL. The overall prevalence of children with blood lead level  $> 10$  mcg/dL was 8.1%, while that of the Klong Toey community was 12.5%. The questionnaire identified 3 independent predictors of elevated blood lead levels; the presence of peeling paint in or outside the house, eating paints chips, and the geographic location of children.

**Conclusion:** Using a risk assessment questionnaire, together with obtaining blood lead level has proven effective in identifying key environmental features associated with elevated blood lead level in children from sampled Thai communities. The challenge now is to conduct a larger epidemiological study of a similar type in order to guide the screening and preventive efforts.

**Keywords:** Lead poisoning, Risk assessment, Environmental health

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In recent decades, environment and its effects on the health of Thai children has been an issue of great interest among not only health professionals, but

also educators and policy makers. There is little doubt that exposure to toxic sources in our environment can have detrimental results on our children's development, behavior, and other long-term health outcomes. Up until 1997, exposure to environmental lead, namely that from leaded gasoline, has been associated with elevated blood lead levels in Thai children<sup>(1, 2)</sup>. Indeed, after the complete phase out of

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leaded gasoline, several Thai researchers have shown that blood lead levels of Thai children and the general population experienced a drastic decrease<sup>(3)</sup>. Still, other less-publicized sources of lead continue to threaten our children's environment, such as leaded house paints and existence of cottage industries. Since the movement toward a universal lead screening effort in children in general has been dubbed as costly, ineffective and poses an unnecessary burden on the already strained health system, a targeted screening system, whereby only those children with risk factors are screened, can prove a more economical and cost-effective measure for the present time<sup>(4, 5)</sup>. Therefore, finding risk factors for low level lead exposure in Thai children becomes the priority in the continuing campaign against lead poisoning in our children.

## Material and Method

### Recruitment

Children ages 6 months to 4 years who received their medical care at Primary Care Units were recruited to join the study. Children were recruited from Primary Care Units (PCU) of two major provinces namely Bangkok and Kanchanaburi provinces. Those recruited in Bangkok were from two metropolitan communities of Klong Toey (KT) and Siriraj (SI). Those recruited from Kanchanaburi were from the urban center of Pahol Bholpayuhasena Hospital (PB) and a rural hospital of Tong Bha Pume (TBP). Risk assessment questionnaire for lead exposure in the environment were administered to caretakers of these children.

### Risk assessment questionnaire

The questionnaire assesses the potential for lead exposure inside the home of each child by addressing 4 potentially associated factors i.e., excessive hand-to-mouth activity manifested by eating paint chips, lead contamination from an adult's workplace, the existence of cottage industry in the homes, and the presence of house paints inside and outside the home. For each child with a completed questionnaire, a blood lead level was obtained by venous sampling and collected using a heparinized vacutainer tube.

### Blood lead analysis

The samples were analyzed using the graphite furnace and atomic absorption method.

### Statistical method

The relationship between the blood lead level and dependent variables were tested using linear

regression and one-way analyses of variance (ANOVA) as appropriate. To stabilize variance or normalize skewed distributions, dependent variables underwent logarithmic transformation whenever necessary. Statistical significance was accepted as  $p < 0.05$ .

## Results

There were 307 children recruited, of whom, 296 had both the completed questionnaires and blood lead levels done. Their distributions among the 4 communities were, 69 from BP, 41 from KT, 83 from Tong Bha Pume, and 114 from SI. Other characteristics of the participants are described in Table 1 and 2.

There was no difference in age between both sexes in our study. The average blood lead level (BLL) was  $5.65 \pm 3.050$  mcg/dL in the over all population. Average blood lead levels of all four communities were as described in Table 3. There were significant differences in blood lead levels among the different geographical locations from the ANOVA. By multiple comparisons, children sampled from the Klong Toey community in Bangkok had significantly higher blood lead levels than do children from the other 3 communities.

To normalize a skewed distribution, logarithmic transformation of the blood lead levels was performed. By univariate regression analysis, we found that the child's age, the presence of peeling house paints and a history of eating paint chips had significant relationship to the log-transformed blood lead level. The multiple linear regressions gave the following equation (Table 6):

$$\text{Natural Log (blood lead level)} = 0.369 + (0.115 \text{ peeling paint}) + (0.510 \text{ eating paint chips}) + (0.067 \text{ child age}).$$

### Potential predictors for elevated blood lead concentration

When asked whether the child lived in painted homes, 58% of the population report living in homes that were painted, with the majority (71.7%) being painted both inside and out. Of these, 6.8% report having witnessed their children eating peeling paint chips. Univariate regression analysis showed that living in homes with peeling paint and observing children eating paint chips were independent predictors of elevated blood lead level.

While the child's age in our study was young, averaging at  $1.66 \pm 1.39$  years of age, the univariate analysis showed that increasing age was an independent predictor of increasing blood lead levels.

**Table 1.** Participant characteristics (N=307)

Child age (year)	1.66±1.39	
Sex	52% male, 48% female	
Blood Lead level (mcg/dL)	5.65±3.05	
- Family income (Baht/month)	N (number answered)	% of total
< 5,000	92	30.00
5,000-10,000	128	41.70
10,000-20,000	54	17.60
20,000-30,000	22	7.10
>30,000	11	3.60
- Type of homes		
House	215	70.10
Commercial building	7	2.30
Temporary structure	17	5.60
Apartment/ condominium	34	11.20
Rented house	1	0.30
Homeless	32	10.50
- Duration of residence (years)		
< 5	125	40.72
5-10	51	16.61
> 10	131	42.67
- Where does house paint exist in the home		
Inside only	47	15.30
Outside only	40	13.00
inside and outside	220	71.70
- Community		
Tong Bha Phume (TBP)	69	22.50
Klong Toey (KT)	41	13.40
Pahol Bholpayuhasena (PB)	83	27.00
Siriraj (SI)	114	37.10

**Table 2.** Prevalence of environmental characteristics from the risk assessment questionnaire (N=296)

Characteristics	Number answered	%
Painted house (inside or out)	128	41.7
House with peeling paint	79	25.7
Eating paint chips	11	3.6
House near the traffic	73	18.3
Smell of automobile exhaust fume in the house	59	14.8
Residence member working in a factory with lead-related jobs	48	15.6
Cottage industry at home	38	12.8

In our population, 18.3% lived near a major traffic intersection, 14.8% reported being able to smell automobile fume exhaust from their homes, 15.6% reported working in lead-related industries (Table 2). Other factors such as proximity to a major traffic

intersection or history of parents working in factory did not show significant correlation with increasing blood lead level (Table 4).

Average blood lead levels from different communities differ greatly in our study. Children from

**Table 3.** Average blood lead levels between the 4 communities

	PB	TBP	KT	SI	Total
Number of cases	82	67	33	114	296
Average blood lead levels(mcg/dL)	5.56 ± 2.56	5.57 ± 3.10	7.89 ± 2.15	5.11 ± 3.31	5.65±3.05
Number of cases with BLL > 10mcg/dL	7	3	5	9	24
% of elevated BLL *	8.5	4.5	15.2	7.9	8.1

\* defined as BLL > 10mcg/dl

**Table 4.** Univariate regression analysis summary for independent factors predicting the blood lead level\*\*\*

Variable	Coefficient	confidence limits
Painted house	0.075	-0.041, 0.191
House with peeling paint	0.322	0.214, 0.430**
Eating paint chips	0.679	0.563, 0.795**
House located near the traffic	-0.111	-0.253, 0.231
Smelling traffic in the house	-0.017	-0.105, 0.071
Residence member working in a factory	-0.013	-0.148, 0.122
Working in the house	0.1	-0.060, 0.260
Child s history of anemia	0.156	-0.004, 0.316
Child age	0.078	0.038, 0.119**
Sex	0.046	-0.069, 0.161

\*\* p < 0.01

\*\*\* Blood lead concentrations were transformed by applying the natural log

**Table 5.** One-way analysis of variance for BLL on dependent variables

Variable	df	F
Household Income	4	1.04
Type of home	5	0.97
Duration of residence	3	1.77
Painted surface	3	0.61
Location of patient sampled	3	11.55*

\* p < 0.05

**Table 6.** Multiple regression analysis for blood lead concentration\*\*\*

	Coefficient	confidence limits
Peeling paint	0.115*	0.001,-0.229
Eating paint chips	0.510**	0.356,-0.664
Child s age	0.067**	0.032,-0.102

\* p < 0.05, \*\* p < 0.01

\*\*\* Blood lead concentrations were transformed by applying the natural log.

The intercept of the model was 0.369.

the Klong Toey community had the highest average blood lead level of 7.89 mcg/dL, while those from Siriraj community had the lowest average blood lead level among the four communities in our study. The location of children in our study was a significant predictor of elevated blood lead levels (Table 5). The overall prevalence of blood lead level being above 10 mcg/dL was 8.1% across the 4 sampled communities, a number well below 12% which universal blood lead screening had been recommended. However, when examined individually, we found that 15.2% of the population from Klong Toey had blood lead level greater than 10mcg/dl, the proposed action limit for children (Table 3).

## Discussion

Screening for elevated blood lead levels within a population has been the focus of numerous studies through out the medical literature. With the age of utilization management and medical economics, preventive health measures are sometimes sacrificed for cost-effectiveness. The American Academy of Pediatrics guideline recommends universal screening only when the prevalence of elevated level is greater than 10 mcg/dl. Otherwise, targeted screening with risk assessment questionnaire is recommended for screening of the general population. In our study, as in many other studies conducted in Thailand after the complete eradication of leaded gasoline<sup>(3)</sup>. We found the average blood lead level of children to be well below the 10 mcg/dl range and the prevalence of elevated blood lead level is also less than the that mentioned in the AAP guideline.

Thus, the need to identify community-specific risks for exposure to lead in the environment, leading to elevated blood lead level, becomes the key issue in the prevention effort in children. The use of a standard, none population-specific risk assessment questionnaire has been proven ineffective in screening for potential risks of lead exposure in specific communities and the standard Center for Disease Control (CDC) questionnaire may not target the right risk factors in Thai communities<sup>(6-11)</sup>.

The targeted screening performed in our study identifies three key independent risk factors associated with increased blood lead level in our population of children, the presence of peeling paint in the homes, the habit of eating paint chips and the association of increasing blood lead level with increasing age. Contrary to the popular theory that lead poisoning in children is a result of indiscriminate hand-to-mouth activities of young children, the positive association of blood lead level with increasing age suggests that lead exposure is a continuous threat through out childhood and its presence in our children's environment ubiquitous. Thus, making screening and prevention issues more urgent and pressing than ever. The association between blood lead level and house paint is also extremely poignant. Even in the United States where content of lead in household paint has been regulated for several decades, interior and exterior paint is still identified as one of the major contributor to lead found in household dust and soil, leading to inadvertent exposure of young children<sup>(12-15)</sup>. As a result, environmental remediation is targeted at reducing lead dust in children's environment, as well

as finding effective measures for lead paint abatement.

Furthermore, the association between increasing lead level and increasing age is an issue worth exploring. Although the adverse effects of lead on the neurocognitive, behavioral and psychological development of very young children is well known, more and more evidence suggest that continuous low-level exposure can also have impact far into adulthood. Such evidence serves to reiterate the importance of primary prevention of lead exposure and the value of screening questionnaire in identifying children who are at risk so that blood lead levels can be obtained and monitored while the comprehensive health assessment commences<sup>(4, 16-19)</sup>.

Finally, the differences in the prevalence of elevated blood lead levels, from 4.5% in Bahol Pholpayuhasena community to 15.2% in Klong Toey community, is an important issue to address especially when referring to lead exposure screening and prevention in our children's population. Although targeted, screening is effective in most communities, the US Center for Disease Control endorses universal screening when prevalence of elevated lead level is higher than 12% in any given community in order that all the cases with elevated blood lead level be detected and appropriate intervention begun<sup>(20)</sup>.

## Conclusion

Despite phasing out leaded gasoline use, environmental lead exposure is still posing significant health risks to children in the Thai communities. The development of the population-specific questionnaire and its use by the vigilant and conscientious physician can help to delineate individuals in different communities who possess differences in health practices and environment, yielding varying degrees risk for the exposure to lead. Such measures can help to abate the prolonged exposure to lead that can result in morbidities to our children. A large scale epidemiological study should be undertaken to determine the prevalence of elevated blood lead levels in various communities in Thailand so that the information can be used to re-evaluate the need for a more comprehensive and universal screening plan for Thai children.

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## ปัจจัยทางสิ่งแวดล้อม และ สังคม ที่มีผลต่อการมีระดับตะกั่วสูงในเด็กไทย: การศึกษานำร่อง เพื่อใช้แบบสอบถามในการประเมินความเสี่ยงต่อการมีระดับตะกั่วสูง

จุฬิธา โฉมฉาย, ฉันทนา ผดุงทศ, สัมมน โฉมฉาย

**คำนำ:** การศึกษาระดับตะกั่วในเลือดของเด็กไทย ในยุคหลังจากการหยุดใช้น้ำมันที่มีตะกั่วเป็นสารกันหืนยังคงขาดความชัดเจน โครงการนำร่องนี้มีจุดประสงค์เพื่อนำแบบสอบถามประเมินความเสี่ยงในการสัมผัสสารตะกั่วในเด็กมาใช้ เพื่อดูความสัมพันธ์ระหว่างคำตอบในแบบสอบถามและระดับตะกั่วในเลือด

**วัตถุประสงค์และวิธีการ:** กลุ่มตัวอย่างคือเด็กอายุ 6 เดือน ถึง 4 ปีที่มารับบริการที่หน่วยบริการสุขภาพปฐมภูมิในชุมชน 4 แห่ง คือ เขตคลองเตยและชุมชนใกล้เคียงโรงพยาบาลศิริราช กรุงเทพมหานคร อำเภอทองผาภูมิ และโรงพยาบาลพหลพลพยุหเสนา จังหวัดกาญจนบุรี ผู้ปกครองจะเป็นผู้ตอบแบบสอบถาม โดยแบบสอบถามมีคำถามทั้งหมด 25 ข้อ ซึ่งเกี่ยวข้องกับสภาพแวดล้อมและสถานภาพทางสังคมของเด็กและครอบครัว เด็กทุกคนจะได้รับการตรวจระดับตะกั่วในเลือดที่เจาะจากหลอดเลือดดำ แล้วนำไปทำการวิเคราะห์ตะกั่วทำโดยวิธี atomic absorption

**ผลการศึกษา:** มีผู้เข้าร่วมโครงการทั้งสิ้น 296 ราย โดยมาจากหน่วยบริการสุขภาพปฐมภูมิเขตคลองเตย 33 ราย จากหน่วยบริการสุขภาพปฐมภูมิเขตบางกอกน้อย 114 ราย และ 149 รายจากสองชุมชนในจังหวัดกาญจนบุรี ระดับตะกั่วในเลือดเฉลี่ยคือ  $5.65 \pm 3.05$  ไมโครกรัม/เดซิลิตร มีเด็กที่มีระดับตะกั่วสูงกว่า 10 ไมโครกรัม/เดซิลิตรอยู่ร้อยละ 8.1 โดยชุมชนคลองเตยมีความชุกสูงสุดคือร้อยละ 12.5 จากการตอบแบบสอบถามพบว่าข้อมูลที่ได้จากคำถามเกี่ยวกับการมีสีลอกหลุด และคำถามเกี่ยวกับพฤติกรรมการหยิบชิ้นสีเข้าปาก และภูมิฐานะของเด็กเป็นปัจจัยที่มีความสัมพันธ์กับระดับตะกั่วในเลือดอย่างมีนัยสำคัญ

**สรุป:** จากการศึกษาพบว่าการใช้แบบสอบถามเพื่อคัดกรองปัจจัยทางสิ่งแวดล้อมเป็นวิธีการที่ได้ผลในการสืบค้นปัญหาทางสิ่งแวดล้อมที่มีผลต่อระดับตะกั่วในเลือดของเด็กในชุมชน การศึกษาขั้นต่อไปจึงควรเป็นการใช้ข้อมูลดังกล่าวเพื่อคัดกรองกลุ่มประชากรเด็กทั่วไปเพื่อการศึกษาถึงความชุก และการกระจายของปัญหาตะกั่ว อันจะนำมาซึ่งแนวทางการคัดกรอง ป้องกันแก้ไข ที่มีผลกว้างไกลต่อไป

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