Blood Lead Level in Bangkok Children

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Abstract

Lead poisoning is one of the most harmful pollulant in children since it permanently effects the growth and intelligence.

Objective : To evaluate the lead problem in Bangkok children and identify risk factors and impact associated with high lead levels (> 10 µg/dL)

Materials and Methods : The longitudinal study (N = 84) followed blood lead levels at birth, 6,12,18 and 24 months of age. Also multiple cross-sectional studies comprising of children under 15 years of age attending the outpatient clinic, Ramathibodi Hospital (N = 511), kindergartens (N = 60) and secondary school students (N = 377) in Bangkok were conducted. The control for under 2 year-old children (N = 188) were those attending Metapracharak Hospital, Nakornprathom Province. Physical examinations were performed by pediatricians. Blood lead levels were assessed by Atomic Absorption Spectrometry. Questionnaires to identify risk factors were completed by parents of under 2-year-old children. Standford Binet tests were performed by psychologists for assessing the IQ in the longitudinal group at 2 years of age.

Results : The mean blood lead levels were increasing with age from 5.57±2.31 µg/dL at birth, to 4.75±3.25 µg/dL at 2 years of age, 6.74±2.02 µg/dL in kindergartens, and 9.03±3.65 µg/dL in secondary school students. They were in the acceptable range. However, the proportion of blood lead higher than 10 µg/dL were increasing from 1 to 6, 10 per cent at birth to 6 per cent at 2 years of age, 10 per cent in kindergartens and 35 per cent in secondary school students. The mean lead level in Bangkok children under 2 years of age was higher than those of the control group in Nakornprathom province, but not statistically singificant. In addition, there was no identified singificant risk factor except that the high lead group had a higher mean age and larger family size than those in the low lead group. In the kindergartens and secondary school, males had higher lead levels than females in the same age group.

Conclusion : The blood lead levels in Bangkok children were not as high as expected. On the contrary, they tended to decrease following the reduction of ambient lead levels due to unleaded gasoline usage.

Key word : Blood Lead Level, Children, Bangkok

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As a result of evolution from agricultural to industrialized country, Thailand is confronted with environmental pollution hazards. Especially in Bangkok, where traffic congestion becomes the most critical problem, lead poisoning is one of the most important pollutants. There is strong evidence that lead has effect on every organ of children(1-8). The Center for Disease Control (CDC), USA. has lowered the acceptable level of blood lead in children to 10 mcg/dL since 1991(9).

Previous studies in Thailand revealed that lead levels in cord blood and school children were much higher than the acceptable level(10). Therefore, this study is conducted to 1) evaluate whether or not lead problem in children living in Bangkok at present is critical, and 2) if possible, identify risk factors and impacts which associate with high blood lead level (> 10 mcg/dL).

MATERIAL AND METHOD

This study was comprised of 5 study groups. The first group was a longitudinal study of children born at Ramathibodi Hospital in January-February 1993 who were followed-up to 2 years of age. Multiple cross-sectional studies in various age groups of children were also conducted during the year 1993 to 1996. Group II was Bangkok children under 15 years of age who visited Ramathibodi Hospital. Group III was children under 2 years of age who visited Metapracharak Hospital, Sampran district, Nakornprathom province. Group IV and V were school-based studies in the kindergartens and secondary schools close to streets and the expressways in Bangkok. Questionnaires, modified from standard questionnaires(11-15), included demographic data, socioeconomic status, housing and residential area, occupation, environment, travelling, leisure, food and water intake, health status and behaviour and were completed by parents. Physical examinations were performed by pediatricians. Blood samples kept in acid washed ion-free tubes were used for measuring lead levels by the Atomic Absorption Spectrometry technique(16,17). Standford-Binet tests was administered by psychologists to assess the intelligence quotient (IQ) in the cohort group at 2 years of age.

Statistical method

Chi-square test, student *t*-test and Mann-Whitney U test were used to test for significant difference ($p < 0.05$) for paired comparisons of proportion, continuous data and non-parametric data, respectively. The determination of correlation was tested by Pearson correlation coefficient.

RESULTS

In group I, the mean lead level in cord blood of the birth cohort of 500 children(18) who were born at Ramathibodi Hospital was 5.1 mcg/dL, of whom 1 per cent had high lead level (> 10 mcg/dL), while that of 500 mothers was 6.1 mcg/dL. Only 84 children were available for follow-up at least once at 6, 12, 18 or 24 months of age. These serial mean blood lead levels were rather constant, ranging from 5.05 to 6.18 mcg/dL (Table 1). The proportion of high lead increased from 0-1 per cent at birth to 10 per cent at 2 years of age.

Simultaneously, the overall mean lead levels of 511 children in group II was 6.03±4.0 mcg/dL, of whom 10.3 per cent had high lead levels (Table 2). The mean level of the under two (4.97± 3.04 mcg/dL) was significantly lower than those of 2-11 years old (9.73±4.74 mcg/dL), with the proportion of high lead levels of 5 per cent and 13.3 per cent, respectively. There was no significant difference between males' and females' lead levels.

Table 1. Mean blood lead level in cohort study.

Age (month)	Number	Blood lead level (mcg/dL) $\bar{X}$	SD	Range	Percentage > 10 mcg/dL
Cord blood	84	5.26	2.31	3 - 20	1
6	63	5.05	1.65	2.1 - 10	0
12	50	6.18	2.51	2.8 - 14.5	9
18	29	4.82	2.61	2.0 - 12	6
24	40	4.75	3.25	0 - 13.3	10

In addition, a control study of group III was conducted in 188 Sampran children aged 6 to 24 months who resided in the suburban area. The mean level was 5.83±5.69 mcg/dL (Table 3). Nine per cent had high lead levels.

Another school-based group, group IV and group V were at a kindergarten and secondary school close to streets and express way in Bangkok which were hypothesized to be one of the sources of lead pollution. The results revealed that the mean levels of 60 children in group IV were 6.61 mcg/dL in under 2-year-old and 6.80 mcg/dL in over 2-year-old group (Table 4). The overall mean level was 6.74±2.02 mcg/dL and of whom 6.7 per cent had high lead levels. It was found that the mean lead level of males (7.69 mcg/dL) was significantly higher than those of females (6.17 mcg/dL) ($p = 0.027$). Lastly, of the 377 students in group V whose ages ranged from 11 to 19 years, the mean blood lead was 9 mcg/dL and 35 per cent had high lead levels (Table 5). The lead levels increased with age but there was no significant difference between the groups aged under and over 15 years. Significantly, the mean blood lead in males (10.2 mcg/dL) was higher than females (7.7

Table 2. Mean blood lead levels in cross-sectional study.

Age		Number	Blood lead level (mcg/dL)			Percentage >10 mcg/dL
			$\bar{X}$	SD	Range	
Month	0 - 6	155	4.95	2.28	0 - 15.0	1.3
	7-12	111	5.11	3.60	0 - 16.0	7.2
	13-18	74	5.25	3.34	0 - 18.5	6.8
	19-24	58	4.42	3.15	0 - 13.3	8.6
Years	2^+-5	61	9.09	4.62	0 - 29.3	32.8
	6^+-11	47	10.32	4.74	0.57 - 28.4	51.1
	> 11	5	12.09	5.78	2.4 - 16.4	80.0
Total		511	6.03	4.0	0 - 29.3	10.3

Table 3. Mean blood lead levels in Sampran group.

Age (month)	Number	Blood lead level (mcg/dL)			Percentage >10 mcg/dL
		$\bar{X}$	SD	Range	
6 – 12	109	6.02	7.09	0 - 54.7	11.0
13 – 18	50	5.64	3.02	0 - 13.7	8.0
19 – 24	29	5.39	2.33	1.65 - 14.3	3.4
Total	188	5.83	5.69	0 - 54.7	9.0

Table 4. Mean blood lead levels of kindergarten.

Age (month)		Number	Blood lead level (mcg/dL)			Percentage >10 mcg/dL
			$\bar{X}$	SD	Range	
25-60	Total	17	6.61	2.10	3.9 - 11.4	11.8
	M	6	8.40	2.31	5.3 - 11.4	33.3
	F	11	5.64	1.21	3.9 - 8.0	0
61-73	Total	43	6.80	2.02	0 - 12.0	4.7
	M	24	7.05	2.37	0 - 12.0	8.3
	F	19	6.48	1.47	4.4 - 9.6	0
25-73	Total	60	6.74	2.02	0 - 12.0	6.7

Table 5. Mean blood lead levels of secondary school students.

Age (Years)		Number	Blood lead level (mcg/dL) $\bar{X}$	SD	Range	Percentage >10 mcg/dL
11 - 15	Total	258	8.69	3.19	1.82 - 21.71	31.3
	M	125	9.84	3.26	3.19 - 21.71	46.4
	F	133	7.61	2.71	1.82 - 16.83	18.0
16 - 19	Total	119	9.79	4.41	2.11 - 22.75	42.1
	M	72	10.84	4.41	3.52 - 22.75	50.0
	F	47	8.18	3.93	2.11 - 17.40	29.8
11 - 19	Total	377	9.03	3.65	1.82 - 22.75	35.0

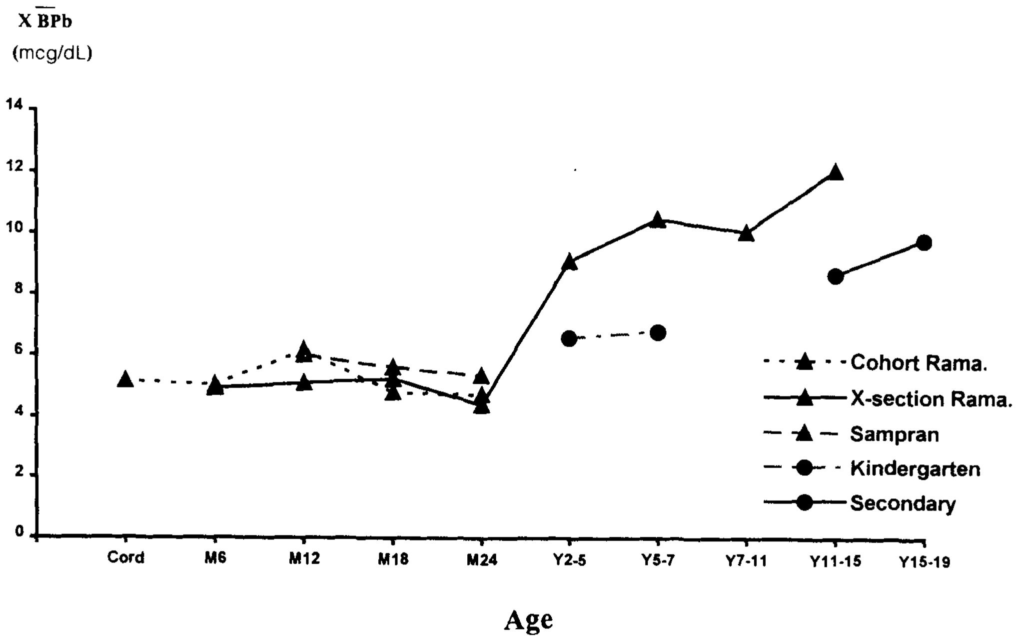

Fig. 1. Mean blood lead levels in Bangkok children compared to Sampran, Nakhon Pathom Province.

mcg/dL) (p = 0.025). The weight and height of the high lead group were not significantly different from those of the low lead group.

When combining the 5 study groups, the blood lead levels of Bangkok children in every age group and the control group are shown in Fig. 1. The mean blood lead levels were increasing with age from 5.19 mcg/dL at birth to 9.79 mcg/dL in secondary school students. Similarly, the proportions of blood lead higher than critical point (10 mcg/dL) also increased from 1 per cent at birth to 35 per cent at 11-19 years of age (Fig. 2).

The mean IQ of 29 children in the cohort group was 110.2±15. Their mean lead level was 3.9±2.5 mcg/dL. The correlation between IQ and blood lead level was not significant (R = 0.14).

Risk factors associated with blood lead level higher than 10 mcg/dL were analysed from questionnaires of children up to 27 months of age in the groups I, II and III. This was because one child postponed his appointment to the age of 27 months. The mean blood lead level of the Bangkok group (6.55±2.97 mcg/dL) was not significantly different from that of the Sampran group (5.82±5.6

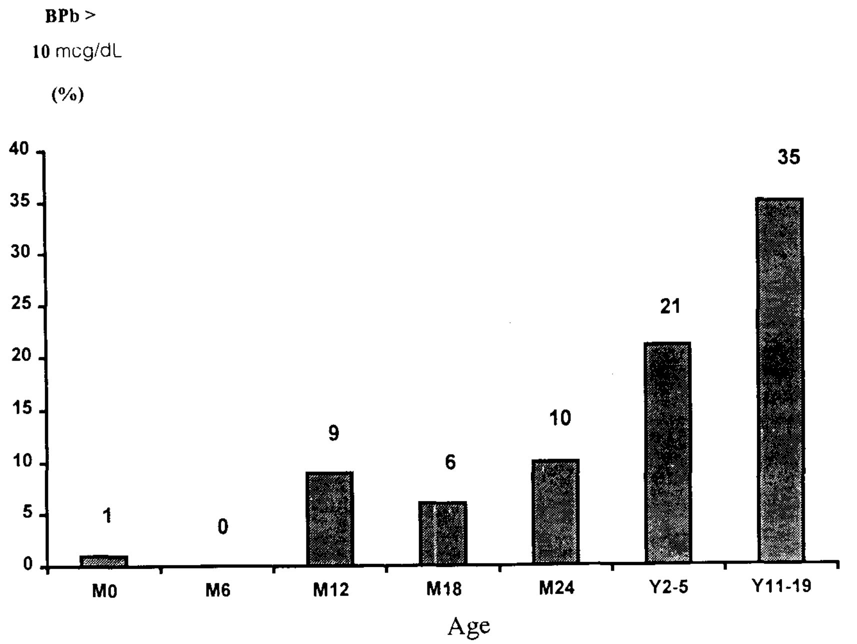

Fig. 2. Percentage of Bangkok children with high blood lead levels.

mcg/dL), p = 0.147. Neither was the proportion of high lead levels, 9.6 per cent and 7.4 per cent, respectively. There was no significant potential risk factor except that the high lead group was significantly older (17.2±7.9 months) than the low lead group (12.4±5.9 months). The high lead group was the higher rank order of child in the family (1.81± 0.75) which represented the family size significantly (p = 0.027), compared to the low lead group (1.42± 0.53).

DISCUSSION

Group 1 of this study was the continuation of a cord blood and maternal blood study[18]. The mean lead level of cord blood in this study (5.19 mcg/dL) was similar to the other studies conducted recently in Chiang Mai (4.94±3.98 mcg/dL)[19] and at Rajvithi Hospital, Bangkok (4.52±1.72 mcg/dL)[20]. This figure was much lower than the previous reports (18.5 mcg/dL in cord blood, 1986)[10] which also showed critical value in 6 to 12 years old Bangkok children (22 mcg/dL in 1989 and 18.8 mcg/dL in 1991). The present study revealed that the mean blood lead level of children living in Bangkok was still within acceptable range of the CDC recommendation. The mean blood lead level of the cross-sectional study from birth to 19 years old was increasing with age. This might suggest that the longer they stayed in Bangkok, the higher the lead levels. Another evidence to confirm that Bangkok might be a location at risk was that the lead level of children in the suburb areas was slightly lower than those living in Bangkok. Since the cohort study had a 2-year follow-up, their serial mean blood lead levels were decreasing from 5.19 at birth to 4.75 mcg/dL at 2 years of age, while the cross-sectional study was collected once at the same time. Among many reasons of improvement of environmental pollution and increased public awareness, the major reason of the decline of blood lead might be explained by the reduction of ambient lead in Bangkok metropolitan which reported the reduction from 2.33 mcg/cumm in 1992 to 0.36 mcg/cumm in 1996 [21]. Although another blood lead study of the authors[22] in the primary school students could not demonstrate the association between the blood lead and ambient lead (R = 0.3). Another study in Bangkok adults in 1998 by Wananukul[23] also showed the reduction of mean blood level to 5.95±2.01 mcg/dL from Chailkittiporanee's study which reported mean level of 27 mcg/dL in 1982[24]. Similarly, Piomelli[25,26] reported the reduction of mean blood lead of children in Manhatton, New York, from 19 to 5 mcg/dL. While Hayes[27] reported those in Chicago of whom blood level reduced from 30 mcg/dL in 1968 to 12 mcg/dL in 1988. They concluded that this happened because the reduction of ambient lead from the use of unleaded gasoline.

The lead level of children in Sampran was slightly lower than those in Bangkok with no statistical significance. This was concordance with the mentioned above study. The mean blood lead in 564 primary school students in Bangkok (9.26 mcg/dL) was significanly lower than those in Singhburi (5.73 mcg/dL), another rural province. The result also revealed that 27.4 per cent of the Bangkok group with blood level more than 10 mcg/dL was significantly higher than 5.7 per cent in the Singhburi group (p = 0.002)[22].

The present study could not identify risk factors or impacts associated with high lead levels. This might be due to the small proportion of high lead level which was only 9-10 per cent. The result in the kindergarten and the secondary school groups showed that male gender was a risk factor. The latter study showed no difference in weight and height. Similarly, the study of Norman[28] in children living in North Carolina in 1993 reported the risk factors and odds ratio (OR) including: living in urban (OR = 1.9), black (OR = 2.4), age older than 2 years (OR = 1.4) and male-gender (OR = 1.2). Whereas Bellinger[29], Pocock[30] and Fulton[31] who studied in Boston (1986), London (1987) and Edinburgh (1987), respectively also showed no significant risk in relation to socioeconomic and demographic data. They suggested that the major source of lead affecting blood lead in children could be environmental lead. However, the study in primary school in Bangkok[22] revealed several significant risk factors with odds ratio shown in the parentheses as followes: location-Bangkok (6.18), male (1.7), mothers who were labourers (1.66), family income less than 3,000 baht (2.12), crowded family of more than 9 members (2.9), occupation of any member in the family related to printing (4.5), previous occupation related to lead smelting (4.85) or printing (4.55), students going to school on foot (2.67), going to school by boat (4.46), and playing close to street (1.7). The primary student study also showed that the high lead group had sigificantly lower weight, height and poorer learning level determined by their teachers. However, the effect of lead on IQ assessed by colored progressive matrices was not shown. The authors concluded that the lead levels in their earlier study affected only physical outcomes but were not high enough to show the effect on intelligence quotient[22].

SUMMARY

This study had demonstrated that the mean blood lead levels in Bangkok children increased with age, starting from approximately 5 mcg/dL at birth to nearly 10 mcg/dL in secondary school students. Eventhough their mean blood lead showed the trend of reduction and were not critical, the proportion of those with high lead was increasing with age from 0 to 35 per cent. Their mean blood levels and proportions of high lead level were also higher than those in rural area. The potential risk factors were older age group, larger family size and males who had significantly higher lead level than the younger children and females, respectively.

Therefore, every effort and mean should be emphasized and intervened to prevent lead hazards in Bangkok children, especially among those with reported risk factors.

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การศึกษาระดับตะกั่วในเลือดของเด็กกรุงเทพฯ

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ตะกั่วเป็นมลพิษจากสิ่งแวดล้อมที่มีผลต่อเด็กเป็นอย่างมาก เพราะจะมีผลต่อการเจริญเติบโต และระดับสติปัญญาของเด็กอย่างถาวร จากการศึกษาในอดีตพบว่าระดับตะกั่วในเลือดของเด็กในกรุงเทพมหานคร (กทม.) ล้วนแล้วแต่สูงกว่าระดับที่ยอมรับ คือ 10 มคก./ดล. ทั้งสิ้น

วัตถุประสงค์ : เพื่อประเมินสถานการณ์ปัจจุบันว่าระดับตะกั่วในเลือดของเด็กที่อาศัยอยู่ใน กทม. ว่าจะสูงถึงขั้นอันตรายหรือไม่ และมีปัจจัยเสี่ยงใดที่จะทำให้มีระดับตะกั่วในเลือดของเด็กเหล่านี้สูง

วิธีการศึกษา : การศึกษาครั้งนี้เป็นการศึกษาแบบ longitudinal และ cross-sectional ในเด็ก 2 กลุ่ม คือ กลุ่มที่ 1 เป็นการศึกษาติดตามเด็กที่เกิดในโรงพยาบาลรามาธิบดีช่วงเดือน มกราคม 2536 จำนวน 84 คน และกลุ่มที่ 2 ประกอบด้วยกลุ่มการศึกษาหลายอายุต่อเนื่องกัน เพื่อให้แสดงถึงสถานการณ์รวมของตะกั่วในเลือดของเด็ก กทม. โดยเป็นเด็กที่มาตรวจแผนกผู้ป่วยนอกของโรงพยาบาลรามาธิบดี 551 คน เด็กนักเรียนตั้งแต่เด็กเล็กถึงอนุบาล จำนวน 60 คน และเด็กนักเรียนมัธยมศึกษาจำนวน 377 คน โดยมีกลุ่มเปรียบเทียบสำหรับเด็กเล็กกว่า 2 ปี ที่อำเภอสามพราน จังหวัดนครปฐม 188 คน

ในเด็กอายุน้อยกว่า 2 ปี ผู้ปกครองต้องตอบแบบสอบถามเกี่ยวกับข้อมูลทั่วไป เศรษฐฐานะ ที่อยู่อาศัย อาชีพ การเดินทาง อาหาร น้ำดื่ม และการเรียนเพื่อหาปัจจัยเสี่ยง ทุกกลุ่มจะได้รับการตรวจร่างกายโดยกุมารแพทย์ และได้รับการตรวจเลือดเพื่อตรวจหาระดับตะกั่วด้วยวิธี Atomic Absorption Spectrometry ในกลุ่มแรกจะได้รับการตรวจ IQ ด้วยวิธี Standford-Binet โดยนักจิตวิทยาเมื่ออายุ 2 ปี

ผลการศึกษา : พบว่าเด็กที่อาศัยอยู่ใน กทม. มีระดับตะกั่วสูงกว่าสามพรานแม้จะไม่แตกต่างกันทางสถิติ เด็กอายุมากจะมีตะกั่วสูงกว่าเด็กอายุน้อยกว่าอย่างมีนัยสำคัญทางสถิติ ค่าตะกั่วในเลือดเฉลี่ยเพิ่มขึ้นตามอายุจาก 5.2 มคก./ดล. ในตอนแรกเกิดเป็น 4.75, 6.61, 6.80 และ 9.03 มคก./ดล. ในเด็กอายุ 2 ปี, อนุบาล, ประถมศึกษา และมัธยมศึกษาตามลำดับ โดยกลุ่มที่มีระดับตะกั่วสูงกว่า 10 มคก./ดล. เพิ่มขึ้นจากร้อยละ 0-1 ในตอนแรกเกิดเป็นร้อยละ 6, 10 และ 35 ตามลำดับเช่นกัน

จากการศึกษาโดยใช้แบบสอบถามไม่พบว่ามีปัจจัยที่มีผลชัดเจนต่อระดับตะกั่วในเลือด ยกเว้นในเด็ก กทม. กลุ่มที่มีตะกั่วในเลือดสูงกว่า 10 มคก./ดล. มีอายุเฉลี่ยสูงกว่ากลุ่มตะกั่วต่ำ และเป็นบุตรลำดับที่มากกว่าอย่างมีนัยสำคัญทางสถิติ ในกลุ่มอนุบาลและมัธยมศึกษา พบว่าเด็กนักเรียนชายจะมีตะกั่วสูงกว่านักเรียนหญิงอย่างมีนัยสำคัญทางสถิติ อย่างไรก็ตาม ข้อมูลนี้แสดงว่าระดับตะกั่วในเลือดของเด็กกลุ่มนี้ไม่สูงอย่างที่คาดคิด และมีแนวโน้มจะลดลง

คำสำคัญ : ตะกั่วในเลือด, เด็ก, กรุงเทพมหานคร

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