

LOW BLOOD LEAD LEVELS AND THE COGNITIVE DEVELOPMENT OF CHILDREN FROM DIFFERENT LOCALITIES IN MALAYSIA

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Introduction

- Even with the phasing out of lead from gasoline, lead continue to be a widely consumed metal globally in lead acid battery, as pigment in paint and solder alloy.
- Recent studies which point toward the neurotoxic effects of low blood lead level has regenerated renewed interest in the environmental impact of lead on children.
- The objective of this study was to investigate the effect of low blood lead levels below $10 \mu\text{g}/\text{m}^3$ on the cognitive development of $6\frac{1}{2}$ - $8\frac{1}{2}$ year old children from different localities in Malaysia.



Blood Lead Levels in Malaysian Children

- Unleaded gasoline was introduced in Malaysia in 1992 and leaded gasoline was totally banned in 2000.
- Blood lead levels among pregnant women had reduced from 17.3 $\mu\text{g}/\text{dL}$ in 1982 to 7.71 $\mu\text{g}/\text{dL}$ in 1996.
- A study in 1997 indicated that 11.7 % of 7 to 11 year old urban children from Kuala Lumpur had blood lead levels of $> 10 \mu\text{g}/\text{dL}$, compared to 1 % of suburban children (Jamal *et al.*, 2000).
- Urban children are 25 times at greater risk of experiencing high blood lead levels ($> 10 \mu\text{g}/\text{dL}$) when compared to their suburban and rural counterparts, after controlling for age, sex, parents' education and income level. (Jamal *et al.*, 2000).



Low Blood Lead Levels & Cognitive Development

- Children's IQ scores at 3 and 5 years of age declined by 7.4 points as lifetime average blood lead levels increased from 1 to 10 $\mu\text{g}/\text{dL}$ (Canfield *et al.*, 2003).
- Based on data from 7 cohort studies, Landphear *et al.* (2005) found that the estimated IQ point decrements associated with an increase in blood lead from 2.4 to 10 $\mu\text{g}/\text{dL}$, 10 to 20 $\mu\text{g}/\text{dL}$, and 20 to 30 $\mu\text{g}/\text{dL}$ in children below 10 years of age were 3.9, 1.9, and 1.1, respectively.
- An inverse relationship between blood lead concentration and arithmetic and reading scores was observed for children aged 6-16 years with blood lead concentrations lower than 5.0 $\mu\text{g}/\text{dL}$ (Landphear *et al.* (2000).



Methodology

- A cross-sectional study of 431 Malay children aged 6½ to 8½ years from urban (251), industrial (100) and rural (80) areas were studied in 1997 and 1998.
- Blood lead samples were collected using the finger prick method and analyzed with a graphite furnace atomic absorption spectrophotometer.
- Their cognitive development was assessed using the 'McCarthy Scales of Children's Abilities Test' (MSCA).



Table 1 : Respondents' Sex and Age by Study Locality.

Study Locality	Sex No. (%)		Total No. (%)	Age in Years Mean \pm sd
	Male	Female		
Urban	135 (53.8)	116 (46.2)	251 (58.2)	7.59 \pm 0.60
Industrial	48 (48.0)	52 (52.0)	100 (23.2)	7.28 \pm 0.58
Sub-urban	41 (51.2)	39 (48.8)	80 (18.6)	7.90 \pm 0.57
Total	224 (52.0)	207 (48.0)	431 (100.0)	7.57 \pm 0.62

N=431

Table 2 : Blood Lead and MSCA Scores by Study Locality.

Variables	Median (IQR)/Mean \pm sd			Statistics (Kruskal Wallis/ ANOVA)	p value
	Urban (n=251)	Industrial (n=100)	Sub-urban (n=80)		
Blood lead ¹ (μ g/dL)	3.49 (2.58)	3.48 (3.05)	2.86 (1.80)	9.40**	0.009
	4.21 \pm 2.88	3.75 (2.16)	3.04 \pm 1.24	6.91***	0.001
General Cognitive	93.96 \pm 14.30	102.55 \pm 12.41	101.24 \pm 13.68	17.95***	<0.001
Verbal	43.08 \pm 9.63	48.40 \pm 8.00	47.39 \pm 8.70	15.25***	<0.001
Perception- performance	55.10 \pm 9.91	60.22 \pm 8.12	58.73 \pm 8.33	12.79***	<0.001
Quantitative	44.77 \pm 7.62	46.89 \pm 7.36	47.41 \pm 7.46	5.21**	0.006
Memory	42.26 \pm 10.12	44.46 \pm 8.15	47.05 \pm 7.84	8.53***	<0.001
Motor	42.50 \pm 11.35	50.25 \pm 9.03	49.19 \pm 9.78	25.04***	<0.001

¹ 16 (3.7%) of respondents had blood lead \geq 10 μ g/dL)

** Significant at $p \leq 0.01$

*** Significant at $p \leq 0.001$

Table 3: Achievement of General Cognitive according to Location.

General Cognitive Index	Descriptive Classifications	Theoretical percent	MSCA Reference study* n=1032	Urban (%) n=251	Industrial (%) n=100	Sub-urban (%) n=80	All % n=431
≥ 130	Very Superior	3.0	3.1	1.2	1.0	3.7	1.6
120 - 129	Superior	7.5	8.5	2.4	8.0	3.7	3.9
110 - 119	Bright Normal	16.0	15.9	13.5	23.0	16.3	16.2
90 - 109	Average	46.8	46.7	41.8	52.0	55.0	46.6
80 - 89	Dull Normal	16.0	15.7	27.5	12.0	15.0	21.6
70 - 79	Borderline	7.5	7.3	10.4	3.0	6.3	7.9
≤ 69	Mentally Retarded	3.0	2.8	3.2	1.0	0.0	2.1



*McCarthy (1972).

Table 4 : Correlation Between Log₁₀ Blood Lead and MSCA Scale.

MSCA Scale	Log ₁₀ blood lead r value			
	All (N=431)	Urban (n=251)	Industrial (n=100)	Sub-urban (n=80)
General Cognitive	-0.348**	-0.273**	-0.197*	-0.860**
Verbal	-0.285**	-0.250**	-0.080	-0.699**
Perception-performance	-0.274**	-0.218**	-0.153	-0.683**
Quantitative	-0.269**	-0.188**	-0.193	-0.690**
Memory	-0.249**	-0.199**	-0.126	-0.626**
Motor	-0.329**	-0.269**	-0.240*	-0.609**

* Significant at $p \leq 0.05$

** Significant at $p \leq 0.01$



Figure 1 : Correlation between Blood Lead and GCI among All Children

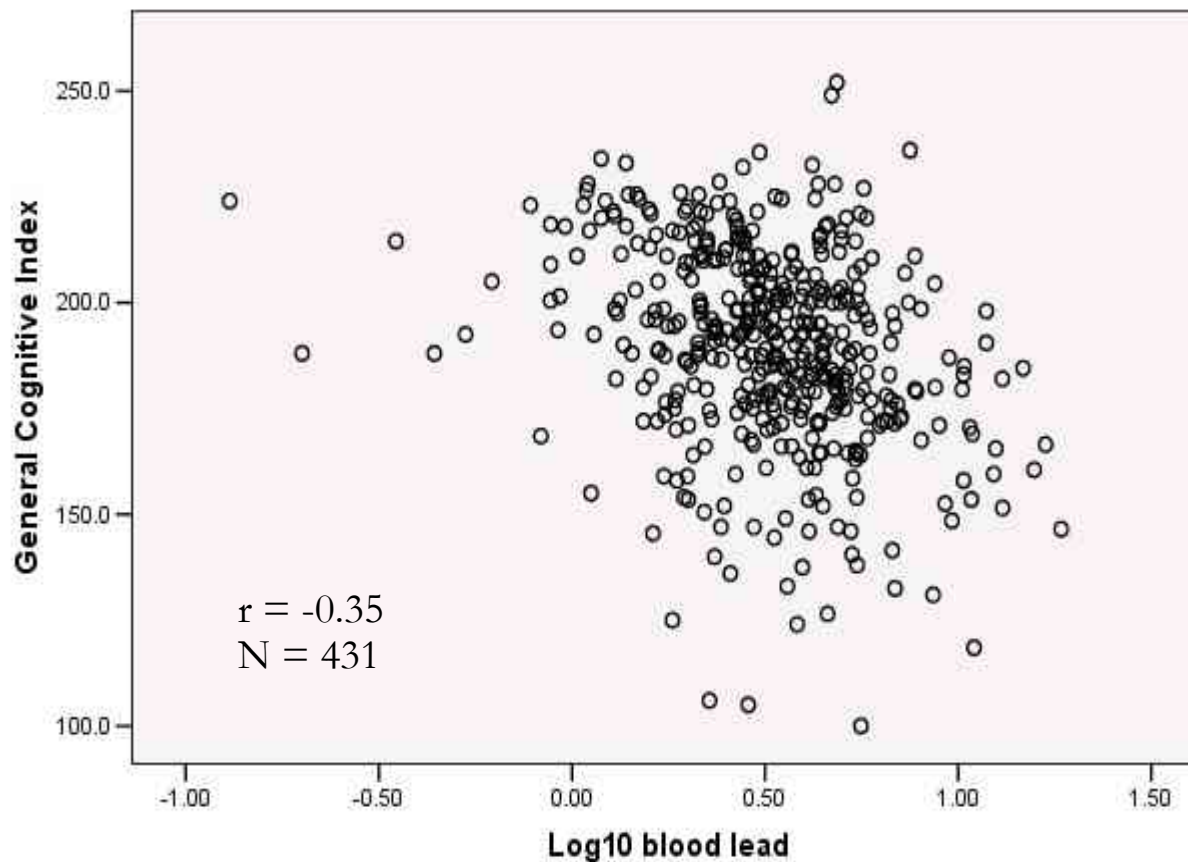


Figure 2 : Correlation between Blood Lead and GCI among Sub-urban Children

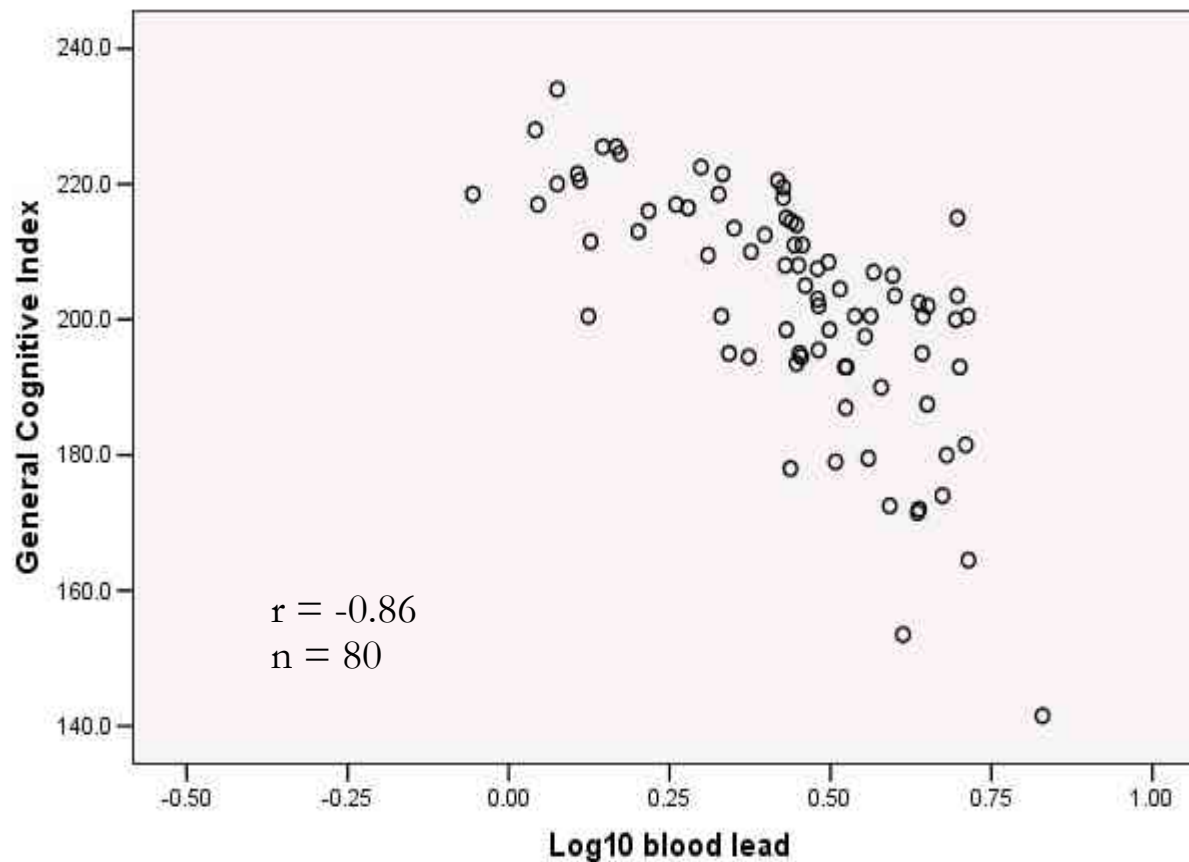


Table 5 : Factors Influencing General Cognitive Index among All Children in the Study Areas.

Dependent variable (General Cognitive Index)	Coefficient Regression (β)	<i>t</i> value	<i>p</i> value
(Constant)	113.776	37.678	< 0.001
Log ₁₀ blood lead	-0.328	-7.311**	< 0.001
Fathers' education	-0.103	-1.527	0.127
Mothers' education	-0.091	-1.392	0.165
Household income	-0.021	-0.394	0.694
Number of siblings	0.019	0.243	0.808
Sequence in family	-0.070	-0.902	0.367
Length of stay	-0.018	-0.408	0.684

N=431

**Significant at $p \leq 0.01$

Regression method : Enter

F value = 11.277, $p < 0.001$

r value = 0.397, $R^2 = 0.144$

Table 6 : Factors Influencing General Cognitive Index among Children in the Urban Area.

Dependent variable (General Cognitive Index)	Coefficient regression (β)	<i>t</i> value	<i>p</i> value
(Constant)	109.879	25.841	< 0.001
Log ₁₀ blood lead	-0.230	-3.738**	< 0.001
Fathers' education	-0.070	-0.782	0.435
Mothers' education	-0.213	-2.467*	0.014
Household income	-0.037	-0.514	0.608
Number of siblings	0.041	0.414	0.679
Sequence in family	-0.070	-0.713	0.476
Length of stay	0.038	0.635	0.526

N=251

**Significant at $p \leq 0.01$

*Significant at $p \leq 0.05$

Regression method : Enter

F value = 5.70, $p < 0.001$

r value = 0.38, $R^2 = 0.117$

Table 8 : Factors Influencing General Cognitive Index among Children in the Industrial Area.

Dependent variable (General Cognitive Index)	Coefficient regression (β)	<i>t</i> value	<i>p</i> value
(Constant)	103.330	16.610	< 0.001
Log ₁₀ blood lead	-0.209	-2.012*	0.047
Fathers' education	0.005	0.038	0.970
Mothers' education	0.071	0.597	0.552
Household income	0.187	1.733	0.086
Number of siblings	-0.026	-0.187	0.852
Sequence in family	-0.068	-0.468	0.641
Length of stay	0.041	0.396	0.693

N=100

*Significant at $p \leq 0.05$

Regression method : Enter

F value = 1.060, $p = 0.396$

r value = 0.273, $R^2 = 0.004$

Table 7 : Factors Influencing General Cognitive Index among Children in the Sub-urban Area.

Dependent variable (General Cognitive Index)	Coefficient regression (β)	<i>t</i> value	<i>p</i> value
(Constant)	127.957	28.211	< 0.001
Log ₁₀ blood lead	-0.800	-14.012**	< 0.001
Fathers' education	-0.139	-1.824	0.072
Mothers' education	0.121	1.613	0.111
Household income	0.181	2.765**	0.007
Number of siblings	-0.329	-2.758**	0.007
Sequence in family	0.286	2.332*	0.022
Length of stay	-0.021	-0.355	0.724

N=80

**Significant at $p \leq 0.01$

*Significant at $p \leq 0.05$

Regression method : Enter

F value = 41.837, $p < 0.001$

r value = 0.896, $R^2 = 0.783$

Discussions

- Blood lead levels higher among urban and industrial children, compared to sub-urban children.
- 41.1 % of urban children had below average IQ (GCI of ≤ 89), compared to 21.3 % of sub-urban children.
- Blood lead and mothers' education influence GCI of urban children.
- Only blood lead influence GCI of industrial children.
- Blood lead, household income, no. of siblings and sequence in family influence GCI of sub-urban children.



Conclusion

- Low blood lead levels below 10 $\mu\text{g}/\text{dL}$ may influence MSCA IQ scores of 6-8 years old Malaysian children, even after controlling for possible socioeconomic confounders.
- Even though sub-urban children show lower blood lead levels, it has a greater influence on their IQ decrement, which concurs with the findings of Landphear *et al.* (2005).



Study Limitations

- Venous blood samples rather than finger prick blood samples would have been a better indicator of children's current blood lead level.
- One time blood lead sampling does not reflect children's lead body burden which may be better associated with their mental performance.

