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ASSOCIATION OF BLOOD LEAD LEVELS AND WORKING MEMORY ABILITY OF PRIMARY SCHOOL CHILDREN SURROUNDING EX-COPPER MINING AREA IN RANAU, SABAH (MALAYSIA)

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ABSTRACT

A cross sectional study on the association of Blood Lead Levels (BLL) and Working Memory (WMICS) ability of primary school children surrounding ex-copper mining area in Ranau, Sabah was conducted from September 2012 till October 2013. One hundred schools children were selected from 5 schools which consisted of three from Ranau (expose groups, n=60), one each from Pitas and Sipitang (non-expose groups, n=40). The main objective is to study the association of BLL and WMICS ability of Primary School Children in Ranau Sabah. Blood samples were taken by venous blood draw using disposable syringes and collected in plastic sterile tube mixed with K_2EDTA. The samples were maintained at 4ºC and transported to University Malaysia Sabah laboratory. BLL was tested using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Perkin-Elmer. WMISC ability was measured by extraction of McCarthy Intelligent Quotient (IQ) Index Test and known as WM Index Cumulative Score (WMICS). Demographic background obtained from the distributed questionnaires. Results showed the BLL range between 0.90 – 9.50µg/dL and significantly lower compare to BLL action level at 10µg/dL. The mean of BLL showed significantly higher in boys compared to girls (t=4.233; p<0.01). There was no significant difference of BLL between the expose and control groups (t=1.395; p>0.05). Ultimately result showed there was an inverse association for BLL and WMICS (r= -0.621; p<0.01) even though at the low BLL. In conclusion, the BLL as low as 4.96µg/dL still have negative association with WMICS for the primary school children surrounding ex-copper mining area in Ranau, Sabah. Lead elimination programme are essentially need to be implemented in study area. Further research is needed such as to carry out a comprehensive and complete lead study and monitoring programme which involves all parameters, such as environmental samples, biomarkers, nutritional factors and complete IQ test together with continuous health promotion and education programmes with inter-agency collaborations.

1. INTRODUCTION

Lead is a highly toxic metal which is naturally occurring bluish-gray metal found in small amounts of the earth's crust at about 15 – 20 mg/kg. The characteristics of lead are very soft, highly malleable, ductile and relatively poor conductor of electricity. Besides that, it is also very resistant to corrosion but tarnish upon exposure to air. Pure lead is rare in nature. Usually found in ore with zinc, silver and copper and it was extracted together with these metals. The main lead mineral in galena (PbS) and there are also deposits of cerussite (PbSO4) and anglesite (PbCO3) which are mined. Lead has been mined, processed, and used in commercial and household products for thousands of years (ATSDR, 2007). Sources of lead in dust and soil include lead that falls to the ground from the air, and weathering and chipping of lead-based paint from houses, buildings, bridges, and other structures. Past uses of lead that used in gasoline was a major contributor to lead in soil and air. The higher levels of lead in soil are usually found near roadways, older houses, old orchards, mining areas, and industrial sites, near power plants, incinerators, landfills and hazardous waste sites. A child's mental and physical growth can be affected even at low levels of exposure.

Most findings reported that blood lead has an inverse relationship with mental development and there is a reduction in intellectual quotient (IQ) when blood lead concentration exceeds 10µg/dL (ATSDR, 2007). High levels of lead exposure can severely damage the brain in adults and children ultimately can cause death. Children exposed are more vulnerable to have a lead poisoning rather than adults. The exposure of lead in the womb is from the mother itself. Lead enters to the infant and toddler body through breast feeding, eating and drinking. In addition, babies and children can swallow and breathe lead in dirt, dust, or sand while they play on the floor or ground. Children are more sensitive to the health effects of lead than adults especially on the nervous system. No safe blood lead level in children has been determined (Schwartz, 1994; Téllez-Rojo et al., 2006).

The main objective of this study is to investigate the association between blood lead concentrations that caused by environmental lead exposure at
ex-copper mining area and working memory ability of primary school children in Ranau, Sabah.

Methodology and Material

Sampling Procedure: This is an analytical and experimental cross-sectional study. Sixty respondents were chosen fulfilling minimum requirement of 37 minimum samples for lead related research sample size calculation (Shamsul et al., 2002). Sampling design was systematic random sample and comprised of the students age between 11 and 12 years old in selected primary school in Ranau district. This area was chosen as study area because based on local information that the district has a history of high lead exposure as a result of mining activities. The expose groups collected from S.K Poring (20 respondents), S.K Lohan (20 respondents) and S.K Bongkud (20 respondents).

Interview questionnaire: Sets of questionnaire were used to gather the information on socioeconomic and health status background of respondent. This questionnaire provides the information on age, ethnic, level of parent educations, parent occupations, residential areas, numbers of sibling and any special medication taken. Since the sample/respondents were 11-12 years old student, they were qualified and wise enough to get involved and respond to the questionnaire given. Pre-test of questionnaire was performed to find out the reliability of questionnaire. The questionnaire used has the reliability of higher than 70% based on CronbacAlpha test (Shamsul et al., 2002).

Blood sampling and analysis: Blood specimens of school children was taken by a staff nurses and the medical assistant from the District

Health Office using Intra vascular blood extraction technique. Syringe was used and blood collected into the capillary tube which contains Ethylene Diamine Tetra Acetic acid (EDTA) to avoid the blood sample from clotting. The method used is according to the Australian Standard Protocol[4]. All blood samples were stored at cold room temperature (2-8°C) and transported to the laboratory in School of Food Science and Technology for analysis within 24–48 hours. Lead concentration in the blood sample then analyzed using Inductively Coupled Plasma – Mass Spectrophotometry (ICP-MS) model PerkinElmer ELAN ® 9000 with high accuracy and detection limit up to 0.0007 ppb. Prior to analysis, the calibration of machine was carried out to ensure optimal results produced. This enable the system of ICP-MS to detect the quantity of lead atoms in blood samples optimally. Standard solution was prepared from a primary standard. The sample then tested simultaneously with standardization blank sample, drift control sample and quality control sample. The results reading then downloaded to a spreadsheet for further interpretation (Andrejs et al., 1996; Yonghua et al., 2011).

Working Memory Index (WMI): The measurement of WMI was done by using McCarthy memory index which is extracted from McCarthy Intelligent Quotient Test (1972). The test consists of testing and measuring of Short term Memory (STM) and Long Term Memory (LTM). A special form was provided to guide the memory test for numerical, pictorial, audio visual, sentence, comprehensions and chunk test. Respond by respondent will be given score and calculated by formula provided by the McCarthy memory Index.

Results and Discussions

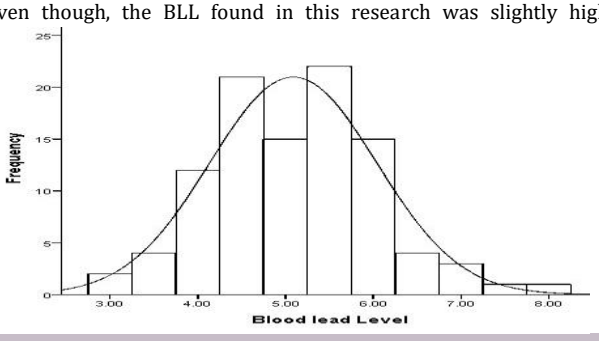
Ranau District situated in the interior part of Sabah, 100 km from Kota Kinabalu, easily access by road. Ranau is situated in the mountainous region known as Crocker Range altitude of 1000– 2000 meters. History has shown that this area is the main proceedings of a copper mine (Mamut Copper Mining Sdn. Bhd.) in Malaysia, started in early of 70' and then was closed in 2001 due to environmental concern. Method of mining was open mine and the area covered almost 20000 acres. During the production period for almost 20 years, Mamut copper mine has contributed significantly to the quality of environment in Ranau District. The valley condition and surrounded with Crocker Ranch the movement of air produced heavy concentration of mineral dust accumulation in streams, rivers and water source (Table 1). The pollutants will be ingested by local population through water supply, ingestion and air. One of the pollutants was lead due to its natural condition can easily available in the environment (Marcus Jopony and Felix Tongkul, 2009).

Table 1: Location of selected schools in study area

Locations		Geographical Location	Discriptions
Exposed	S.K 1	Lat 5°0'45.27"N Long 115°27'43.57"E	Lohan Valley 1 (<1km radius from ex-mining area)
	S.K 2	Lat 5°04'09.63"N Long 115°32'40.52"E	Lohan Valley 2 (<5 km radius from ex-mining area)
	S.K 3	Lat 5°7'4.54"N Long 115°33'18.31"E	Poring Valley (<10km radius from ex-mining area)
Nonexposed	S.K 4	Lat 6°58'29.44"N Long 117°06'49.58"E Lat 5°04'59.77"N	Pitas (agriculture community village) Ulu Sipitang
	S.K 5	Long 115°35'31.50"E	(fisherman community village)

One hundred blood samples were collected consist of expose (n=60) and non-expose (n-40). The range of respondent age is between 11 to 12 years old. The mean and median BLL for all respondents is 4.90±0.12 µg/dL and 5.28µg/dL respectively. The individual blood lead range was 0.1 to 9.5µg/dL (Figure 1). Meanwhile, 55% of the blood lead concentration was less than 5.0µg/dL. The highest level was 9.2µg/dL. The distribution of the data for blood lead level (BLL) was normal.

According to ATSDR, 2007 stated the action level of BLL for children is 5µg/dL and should not exceed 10µg/dL. As comparison, BLL was less than the other developing countries BLL such as China at mean 15.3µg/dL (Wang *et al.,* 2009), 15.57±13.35 µg/dL for Iran (Mahram *et al.,* 2007), and 5.3±2.1µg/dL for South Africa (Battermann *et al.,* 2011). Even though, the BLL found in this research was slightly higher compared to developed countries such as Australia at



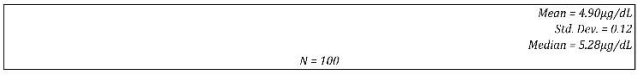


Figure 1: The distribution of respondents BBL

Study found there was no significant difference of BLL between the expose group with nonexpose group (t=1.395; p>0.05); and also the mean of BLL showed significantly higher in boys compared to girls (t=4.233; p<0.01) (Table 2). These findings proved that the risk of getting lead poisoning among boys is higher than girls. The findings were parallel with Al Meida et al (2010) where the BLL ratio of boys and girls are 2.3:2.0µg/dL. Vahter et al (2007) stated, the differences were due to the role of sex, genitals and hormone which influenced the toxic half-life and its existence within the body system including toxicity response of the individuals.

Table 2 : Test of difference for blood lead level – BLL by study groups and gender

	Blood lead level –BLL (µg/dL) Mean ± SD	t value	p value
Study groups (N=100)			
Expose (n=60)	5.22 ± 1.08	1.395	0.166
Non-expose (n=40)	4.96 ± 0.79		
Gender (N=60)			
Boys (n=23)	5.46 ± 0.97		
Girls (n=37)	4.72 ± 0.77		
4.233	* significant at p≤0.01		<0.001*

Working memory Index (WMICS) shows the presentation of severe memory incapability were none among respondents. Only 15.7% represent score less than 80. The mean and median for WMICS test was 100 and 112 score respectively. The highest score is 147 for single student only. Figure 2 showed there was an inverse association for BLL and WMICS (r= -0.621; p<0.01) even though at the low BLL. It conclude that the higher the BLL the lower the WMICS. However, the correlation value of r=-0.621 considered as at medium level due the position between -0.51 to -0.70 (Chua, 2006) and >0.3 (Chinna *et al.,* 2013). According to CDC (2005), the clear reduction of children's IQ can be seen if the BLL was at the action level or less. Shamsul et al. (2005) stated that the reduction of IQ test score for children aged 5-7 years old can occur even if the BLL was less than 10µg/dL and the relationship between BLL and IQ is a inverse linear regression.

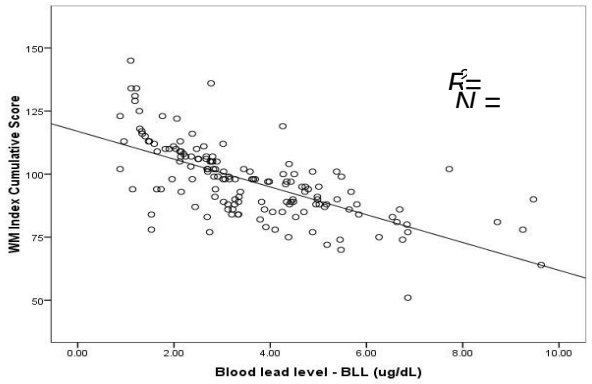


Figure 2 : The association between BLL and WMICS for all respondents

Zhang et al (2013) stated that the students still can score high mark of Mathematics and Science subjects even though the BLL is between 5 - 6µg/dL. There are many previous researchers had proven that lead can affect the IQ at very low level. This statement was supported by most of the scientist especially from developed countries (Shamsul et al., 2005).

Conclusion

The recent result of this research indicates that there has been an improvement of blood lead level among student in Ranau Sabah comparing with the previous study conducted at the same areas. This indication could be from a direct result of improvement on economic back ground, education level, infrastructure especially road and waters supply. It's also due to the government decision to ban lead in fuel and to shut down the Mamut copper mine operation. The level of WMISC also indicates a better performance among students as well as perception on health and wellness among student. Finally, this study has shown that WMISC has the inverse relationship with children blood lead even at very low levels at value of 10µg/dL, and any moves to

protect the environment will directly improve the livelihood of the population as well as their health status.

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