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Lead in Blood and Hair of Shipyard Workers, Sabah, Malaysia

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Lead toxicity is known to cause health problems in human. Blood was reported to be a good indicator of the current level of lead in human body but not a good indicator of the total lead body burden (Ahmed and Elmubarak 1990). Lead concentration in blood depicts the dynamic equilibrium between exposure level, rates of uptake, distribution and excretion (Ratcliffe 1981). The half life of lead in blood was about 27 days but this figure could decrease when concentration increases (Harrison and Laxen 1981). Hair has been used as indicator filaments for lead accumulation in human because lead concentration in hair is probably correlated to lead storage in bones (Eltayeb and Grieken 1990).

In Malaysia such studies are still few. Scientific data on assessment of possible effects of metal pollution on human beings especially in industrial sectors which used hazardous chemicals are still scarce. Ismail (1983) reported work in using blood samples to estimate level of lead exposure in Government Printery workers in Kuala Lumpur. Mokhtar and Hazan (1990) have reported their preliminary research work on levels of lead in hair of population in the vicinity of a copper mine in Sabah. Mokhtar *et al.* (1994) have also presented their findings on lead in blood and hair samples of population living near the operational copper mine in Sabah and the background levels for populations near a proposed second copper mine in Sabah. Occupational exposure of lead to workers is becoming an important issue in Malaysia. Thus this research was carried out and it is hoped that the data to be presented here will be used in future comparisons.

MATERIALS AND METHODS

One hundred and seven men (n = 107) participated in the study by donating their hair samples, but only eighty five (n = 85) of them could donate their blood samples. Each participant was asked to complete a questionnaire in order to obtain information on smoking, alcohol consumption, length of service, section of work, *etc.*

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Blood samples were taken by venipuncture using disposable syringes and needles, and transferred into a 10-ml heparinised tubes (Becton Dickinson). These blood samples were kept cooled during transportation to the laboratory where they were kept frozen before being analysed. Hair samples were cut from all sections of the head using stainless steel scissors, and kept inside clean plastic bags.

Blood samples (10 ml) were digested in concentrated nitric acid (6 ml) on a hot plate. A mixture of 1 ml concentrated nitric acid and 5 ml distilled water were added to the solution and low heating was continued until a clear solution was obtained. The solution was cooled down to room temperature, and transferred into a flask and two drops of phenolphthalein indicator and 5 ml of 2% ammonium citrate solution were added. Ammonium hydroxide solution was added dropwise until a red colour was observed. A 2% KCN solution (1 ml) was then added and this was followed by an addition of 1 ml of a 2% APDC solution. Four ml of a water-saturated MIBK solution was then added and the solution was shaken for about 30 seconds. The MIBK layer was separated from the aqueous layer and transferred into a 5 ml container.

Hair samples were washed with distilled water, Triton X-100 (1%, 10 ml), with a mechanical shaker for 30 minutes. The mixture was filtered and residue was further washed with 0.1 M EDTA solution and rinsed with distilled water, and dried in an oven at 100^0C until constant weight. Cleaned hair sample (about 0.5 g) was digested in concentrated nitric acid (20 ml) and 70% perchloric acid (1 ml) on a hot plate until the solution was about 5 ml. It was cooled and diluted to the mark of a 10 ml volumetric flask with distilled water. Concentration of lead from hair in aqueous solutions were measured by using flame Atomic Absorption Spectrophotometer (FAAS), whereas the concentration of Pb-APDC complex in MIBK was analysed using a Graphite Furnace AAS (Perkin-Elmer) at wavelength 283.3 nm with the aid of calibration graphs.

RESULTS AND DISCUSSION

All blood samples, n = 85, were obtained from male workers only. Mean concentration values for the different work sections are shown in Table 1. For the painting section, statistical tests showed that there was no significant difference ($p > 0.05$) between mean PbB values for the 18-24, 25-31, 32-38, 39-45 and > 45 yrs age groups. The mean PbB values for painters who had worked < 1 yr, 2-9 yrs and 10-17 yrs were not significantly different ($p > 0.05$) from each other. For fabrication and welding sections, t-tests showed that the difference of mean PbB values of the various age groups and of workers with different length of service, between each other, were also not significant ($p > 0.05$). When the whole sample population was combined without discriminating work sections, the effect of age group on PbB concentration

values was investigated. Comparisons of mean PbB values for any two age groups did not show any significant difference ($p > 0.05$).

According to Selander and Cramer (1970), the normal maximum level (NML) of PbB in adults is 0.40 ug/ml. Nevertheless PbB values in the range of 0.40-0.80 ug/ml have been recommended as acceptable levels. PbB levels which are greater than 1.20 ug/ml was stated as being dangerous (Selander and Cramer 1970). Pb poisoning in adults who have less than 0.80 ug/ml of PbB were very rare. This study revealed that PbB values for all workers sampled were still below the NML (0.40 ug/ml).

Means and standard deviation PbB values according to smoking and alcohol drinking habits for the workers in different sections are shown in Table 2. There was no significant difference ($p > 0.05$) in mean PbB values between (non-smoker, non-drinker) and (smoker, non-drinker) in the painting, fabrication and welding sections. For a particular work section, no significant difference ($p > 0.05$) of mean PbB values between (smoker, non-drinker) vs (non-smoker, non-drinker); (smoker, non-drinker) vs (smoker drinker); (non-smoker, drinker) vs. (smoker, drinker); and (smoker, drinker) vs. (non-smoker, non-drinker), was found.

On the whole if the samples for the three sections were combined it was found that the mean PbB value of (non-smoker, non-drinker) did not differ significantly ($p > 0.05$) from that of (smoker, non-drinker). No significant difference ($p > 0.05$) was observed between (smoker, drinker) vs (non-smoker, drinker); and between (non-smoker, drinker) vs (non-smoker, non-drinker). There was also no significant difference between the mean PbB for (non-smoker, non-drinker) and that for (smoker, drinker).

This study revealed no significant differences between concentrations of PbB of smokers and non-smokers, which coincides with the results of studies reported by Hones *et al.*, 1972), and Tola and Nordman (1977). However, some other investigators have reported that smokers do have higher PbB levels than non-smokers (Hofreuter *et al.* 1961; Tepper and Levin, 1972).

The elevated PbB levels of smokers without occupational lead exposure have been attributed to the small amounts of lead in tobacco leaves which was used in leaded pesticides. The estimated average daily amount of lead absorbed from cigarette smoke for an average smoker (17 cigarettes/day) was 3.1 ug (Szadkowski *et al.* 1996). This amount is small when compared to that absorbed daily from food, even though that absorbed from food displays a large individual and day to day variance, and when compared to the amount absorbed from air (Nordman 1975). Thus, the contribution of lead from smoking to the daily lead absorption can scarcely be regarded as hazardous to man's health (Tola and Nordman 1977).

Table 1. Mean blood lead (PbB) concentration values for the different work sections of the shipyard.

Work Section	Mean ± standard deviation (ug/ml)	Range (ug/ml)	Coefficient of variation (%)
Painting	0.16 ± 0.08 (n = 15)	0.08 - 0.38	52.8
Fabrication	0.12 ± 0.09 (n = 19)	0.03 - 0.28	69.7
Welding	0.11 ± 0.06 (n = 51)	0.04 – 0.31	59.8

According to Tola and Nordman (1977), smoking in lead-exposed work environments seems to cause elevated PbB levels in smokers as compared to nonsmokers. The lead exposure provided by smoking among lead-exposed workers was reported to be different from that of the general population. The contamination of cigarettes and fingers with lead particles probably affect exposure more than the lead content of the cigarette itself. The overall mean PbB for all samples was 0.12 ug/ml with a range of 0.03 – 0.38 ug/ml. This mean value is lower than the mean PbB value of 0.50 ug/ml for workers at a non-ferrous plant exposed to lead (Triger *et al.* 1989); lower than a mean of 0.34 ug/ml for laboratory workers in Pakistan (Talib *et al.* 1990); and lower than a mean of 0.81 ug/ml for acid battery workers in Sudan (Mohamad *et al.* 1986).

The mean concentration values of lead in the men's hair samples (n = 107) working in the different work sections are shown in Table 3. For the fabrication section the mean PbB value for the 18-24 yrs age group was significantly higher ($p < 0.05$) than that for the 25-31 yrs age group, whereas the other age group pair combinations did not show any significant difference ($p > 0.05$). No significant difference in PbH values due to different age groups were observed for the painting section. For the welding section the only significant difference observed was the mean PbH value for the 18-24 yrs group which was about 2.6 times higher than the mean PbH value for > 45 yrs age group.

In terms of length of service, in each of the three work sections, there was no significance difference in PbH mean values between the <1, 2-9 yrs and 10-17 yrs of service groups. Thus for this study age and length of service did not affect the PbH values. Smoking and alcohol drinking habits also did not contribute to any significant difference in PbH values. Smoking and alcohol drinking habits also did not contribute to any significant difference in PbH values (Table 4).

Table 2. Mean blood lead (PbB) concentration values for workers in different work sections of the shipyard.

Work Section	Mean PbB concentration (ug/ml) (smoker, non-drinker)	(non-smoker, drinker)	(smoker, drinker)	(non-smoker, non drinker)
Painting	0.14 ± 0.07 (n = 6)	NS	NS	0.16 ± 0.10 (n = 8)
Fabrication	0.15 ± 0.10 (n = 9)	0.12 ± 0.11 (n = 2)	0.11 ± 0.06 (n = 2)	0.10 ± 0.08 (n = 6)
Welding	0.09 ± 0.05 (n = 16)	0.15 ± 0.07 (n = 5)	0.11 ± 0.05 (n = 8)	0.12 ± 0.08 (n = 22)

NS: No subjects

Table 3. Mean hair lead (PbH) concentration values for the different work sections of the shipyard.

Work Section	Mean ± standard deviation (ug/g)	Range (ug/g)	Coefficient of variation (%)
Painting	284 ± 336 (n = 15)	68.6 – 1000	118
Fabrication	133 ± 123 (n = 23)	35.5 - 558	92.7
Welding	176 ± 130 (n = 69)	35.1 - 670	73.8

Overall the mean PbH value for all samples is 181.6 ug/g with a range of 35.07 – 1 121 ug/g. This mean value is higher than a mean of 90.30 ug/g reported by Carvalho *et al.* (1984) for male fishermen who lived nearby a lead smelting plant in Santo Amaro, Brazil. It is also higher than mean PbH values of 24.40 ug/g for a study in Canada (Petering *et al.* 1973) and 2.52 ug/g by a study conducted in Germany (Wilhelm and Ohncsorge 1989). The normal maximum level reported by Fergusson *et al.* (1981) is 30 ug/g. For the painting workers, they were exposed to the leaded paints. Lead are used to produce colours and to act as a drying agent. According to Lansdown and Yule (1986) red lead (Pb_3O_4) is used as an important ingredient in paints especially that were used for coating in shiping industry. Red lead acts as an

anti-fouling agent. Application of paints by spraying could cause leaded paint particles to be airborned and these could easily stick to the hair of the workers.

Table 4. Mean hair lead (PbH) concentration values for workers in different work sections of the shipyard .

Work Section	Mean PbH concentration (ug/g)			
	(smoker, non-drinker)	(non-smoker, drinker)	(smoker, drinker)	(non-smoker, non drinker)
Painting	249 ± 368 (n = 6)	NS	462 (n = 1)	287 ± 350 (n = 8)
Fabrication	123 ± 100 (n = 10)	61.6 ± 7.1 (n = 3)	195 ± 10 (n = 2)	156 ± 176 (n = 8)
Welding	168 ± 149 (n = 22)	0.15 ± 0.07 (n = 7)	141 ± 105 (n = 12)	191 ± 130 (n = 28)

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