Blood lead levels in workers of a lead smelting factory in Gombak, Malaysia

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Abstract

Sixty-two workers (73.8%) in a lead smelting factory were investigated for blood lead levels in a cross-sectional study. Comparisons made to a reference group of 31 office workers not exposed to lead showed significant differences in mean blood lead levels. Personal air-sampling for airborne lead concentration taken over 8-hour work period among 25 randomly selected factory workers at 5 work stations showed that workers at the furnace area recorded the highest mean airborne lead concentration (184.3 ± 28.4 µg/100g blood). The highest individual blood lead level recorded was 78 µg/100g blood, from a worker who worked as an operator at the furnace worksite. Contrary to expectation the mean blood lead level was highest among younger workers (mean age 29.9 ± 6.9 years) who had shorter mean length of service (4.3 ± 3.1 years). Health promotion intervention strategy at the workplace should thus be focused on this group of young and relatively inexperience workers exposed to lead.

Key Words: inorganic lead; regulation; workplace, health promotion, occupational hazard

Introduction

Lead was regulated in Malaysia in 1984 after an extensive survey (Wan *et al.*, 1976) conducted by the Factories and Machinery Department (now renamed Department of Occupational Safety and Health). Other local studies (Premaraj, 1980; Lim & Abu Bakar, 1983) corroborated the need for such a regulation. The Factories and Machinery (Lead) Regulation Malaysia (1984), requires surveillance of lead exposed workers and makes provision for health education at the workplace. Surveillance involves biological monitoring of lead through regular estimation of blood lead level among exposed workers. Blood lead estimation is the only biological indicator adopted for use by the regulation to indicate lead absorption.

The purpose of this paper is to show evidence that lead exposed workers carries higher risk of lead absorption compared to non-exposed workers and to characterise lead absorption among exposed workers with regards to age, length of service and type of work station. This study attempts to identify characteristics of lead exposed workers who will gain maximun benefit from health ptomotive activities at the workplace.

Materials and Methods

Sampling and data collection

In this cross-sectional study the blood lead levels of lead exposed workers were compared to that of a control group. Exposed workers were from a lead smelting factory in the District of Gombak, Selangor. The factoty was selected by simple random sampling from a register of lead-based factories in Gombak District. This register was supplied by the Factories and Machineries Department, Ministry of Human Resource Malaysia. The selected factory, located within a government gazetted industrial site, is about 18 km to the north of the federal capital, Kuala Lumpur. In this factory, lead is reclaimed from discarded lead storage batteries by secondary smelting. The final products are lead ingots (99.9% lead) and lead alloyed ingots (98% lead) produced mainly for export. Permission to enter the factory and conduct the study was granted from the Managing Director of the factory. All workers in this factory were included in the study. Written consent was sought from each worker who responded. Data collection included face-to-face interview using a pre-tested questionnaire. Occupational data collected included work duration at the factory, job placement, job specification for the past 6 months and previous job held prior to current employment. Both demographic and employment data were validated using the employer's record.

Blood pressure recordings were taken by the cuff method using a standard mercury sphygmomanometer used by the Ministry of Health Malaysia. The same instrument was used throughout the study. All readings were taken using the right arm with the subject in the sitting position and the arm resting on a table. Two blood pressure readings were taken consecutively and the average recorded.

The venipuncture site (antecubital veins) was washed with soap and water to ensure lead free field. Blood sample was obtained using lead free disposable syringes and needles. Ten ml of blood was collected in lead free heparinized bottle for blood lead analysis by the Chemistry Department, Ministry of Science, Technology and Environment, Malaysia using atomic absorption spectrophotometer. Blood samples were obtained at a site 200 meters away from the factory in a new vacant block owned by the factory management.

Controls consisted of administrative workers who were from the Gombak District Council Office and not exposed to lead at work. The Gombak District Council Office is situated about 4 kilometers away from the factory. Controls were subjected to the same procedure as the exposed workers.

The survey was conducted at the begining of shiftweek and lasted 4 consecutive days in the fourth week of June 1989. Assessment of exposed factory workers commenced at 6 am at the begining of shiftweek. The timing suited the morning shift workers (7am-3pm) as well as the night shift workers (11pm-7am) who came just before or right after work respectively. For the afternoon shift (3pm-11pm), workers were requested to come in the morning. Air-lead concentration was obtained from factory records for the month of January 1989. This was the most recent record available for the factory. The air-lead concentration was assessed by an established private company (Mediviron Pte. Ltd.), using a personal sampler over the breathing zone for an 8-hour working period, on 25 randomly selected workers at 5 work stations.

Method of analysis

The mean blood lead levels within 2 standard deviations were used to compare the lead absorption among exposed and non-exposed workers. The differences in means of continuous variables in the 2 groups were compared using t-test and for qualitative variables using chi-square test. The 95% confidence interval (CI) was also used to measure the precision of the estimated measures for mean blood lead levels of the exposed and non-exposed group. The distribution of blood lead levels among exposed groups by work duration categories was analysed using ANOVA. All statistical analysis was based on SPSS.

Results

The factory employed a total workforce of 84 workers. Twenty-two workers (26.2%) did not respond to this study. Thus, sixty-two factory workers (73.8%) were studied and these represented the exposed group. The group of responders and non-responders among the lead exposed factory workersdid not differ with regards their mean age, sex, ethnicity and mean work duration (Table 1).

The exposed and non-exposed workers were similar with regards to mean age, mean work duration, smoking status and mean diastolic and systolic blood pressures. However there were more ethnic Malays and females in the non-exposed group and these differences were statistically significant. The mean blood lead concentration in exposed group was 45.2 ± 14.9 μg/100g blood and this was seven times higher then in the non-exposed group (Table 2).

Thirty (48.4%) and 13 (21%) of the factory workers had worked less than 5 years, and greater than 10 years respectively, in this factory. Those who worked less than 5 years at this factory recorded the highest group mean blood lead level (46.6 ± 17.2 μg/100g blood) compared to other workers from the exposed group (Table 3). However, these differences were not statistically significant. This survey identified 43 factory workers (69.4%) with blood lead levels at or above 40 μg/100g blood and as required by existing local lead regulations, prompt notification, within 5 working days, must be made by the employer to the Factories and Machinery Department, Ministry of Human Resources Malaysia for workplace hygiene inspection purposes. None of the workers required medical removal protection and medical examination as none had blood lead level at or more than 80 μg/100g blood. Nine (14.5%) factory workers had blood lead levels between 60-79 μg/100g blood and this group of workers had lower, mean age and mean length of work at the factory compared to other categories of factory workers (Table 4).

The highest airborne lead concentration was recorded from personal samplers worn by workers working at the furnace area followed by lesser levels of lead con-

Table 1. Characteristics of non-responders compared to responders among factory workers (lead exposed workers)

Characteristics	Non-responders (n = 22)	Responders (n = 62)	p-values
Ethnic distribution :			
Malays	10 (45.5%)	35 (56.5%)	>0.05
Others	12 (54.5%)	27 (43.5%)	
Sex distribution :			
Male	19 (86.4%)	58 (93.6%)	>0.05
Female	3 (13.6%)	4 (6.4%)	
Mean age (years) ± 2sd	29.6 ± 7.7	31.9 ± 7.5	>0.05
Mean duration of work (years) ± 2sd	4.4 ± 5.8	6.7 ± 4.8	>0.05

Table 2. Comparison of lead exposed and non-exposed workers by selected characteristics

Characteristics	Exposed (n= 62)	Non-exposed (n =31)	p-value
Ethnic distribution :			
Malays	35 (56%)	26 (84%)	<0.05
Others	27 (44%)	5 (16%)	
Sex distribution :			
Male	58 (94%)	23 (74%)	<0.05
Female	4 (6%)	8 (26%)	
Smoking status :			>0.05
Non-smoking	26 (42%)	13 (42%)	
Smoking	36 (58%)	18 (58%)	
Mean age (years) ± 2sd	31.9 ± 7.5	32.1 ± 7.6	>0.05
Blood pressure(mmHg):			
Mean diastolic ± 2sd	76.4 ± 11.1	77.7 ± 7.7	>0.05
Mean systolic ± 2sd	119.7± 15.9	121.4 ± 12.9	
Mean length of work (years) ± 2sd	6.7 ± 4.8	9.3 ± 7.7	>0.05
Mean blood lead level (μg / 100g blood) ± 2sd	45.2 ± 14.9	6.6 ± 3.4	<0.005
95% CI for mean blood lead level (μg /100 g blood)	43.3 - 47.1	5.9 - 7.2	

Table 3. Comparison between work duration categories among lead exposed workers in relation to mean ± 2 standard deviations for blood lead levels and age

	Work Duration				
Characteristics	<5 years	5-10 years	>10 years	F test	p value
No. of exposed workers (n=62)	30 (48.4%)	19(30.6%)	13 (21%)		
Mean age (years)	28.4 ± 6.1	32.4 ± 7.6	39.5 ± 3.5	14.330	<0.005
Mean blood lead level (μg / 100g blood)	46.6 ± 17.1	44.7 ± 2.1	42.6 ± 3.9	0.316	>0.05

Table 4. Blood lead level categories as stipulated by Factories and Machinery (Lead) Regulations, Malaysia 1984, in relation to the distribution of lead exposed workers by age and work duration

	Blood lead level categories ((g / 100g blood)		
Characteristics	< 40	40 - 59	60 - 79
No. of workers (n=62)	19 (30.6%)	34 (54.9%)	9 (14.5%)
Mean age (years) ± 2sd	31.9 ± 6.6	32.5 ± 7.3	29.9 ± 6.8
Mean work duration (years) and 2sd	7.2 ± 3.5	7.1 ± 4.3	4.3 ± 3.1

Table 5. Mean personal air lead sampling concentrations in relation to lead exposed workers at 3 highest exposure worksites

Workstation	No. of workers (n = 22)	Mean ±2sd air lead conc. over 8 hours work period (µg/m³)
Furnace area	9	184.3 ± 28.4
Break-battery section	5	128.9 ± 31.5
Casting / Kettle section	8	128.0 ± 26.3

centration recordings at the break-battery, and casting and kettle sections (Table 5). The mean air lead concentration of workers working over an 8-hour period at the furnace area exceeded the permissible exposure limit (150 µg/m³ of lead in air averaged over an 8-hour period) as stipulated by the regulation.

Discussion

In this study there were twice as many females in the non-exposed compared to the exposed group. This difference may not be of a major concern as lead absorption is independent of sex (Lim & Abu Bakar, 1983). Distinct ethnic cultural habits like eating with the bare hands has been shown to influence lead absorption (Halim, 1988). In this study, Malays predominate significantly in the non-exposed group and earing with bare hands is consistent with Malay cultural habits. However in this study ethnic difference is not an important determinant as the predominance of Malays among controls (the opposite is true for exposed group) did not influence significantly the mean difference of blood lead level between rhe exposed and the controls. It is customary for Malays to wash their hands before eating and there were ample washing facilities at the factory. Observation corroborate to this practice. It may be concluded that the major route of lead absorption in this study is through the lungs from airborne sources. This srudy showed high airborne lead concentration (Table 5) at all worksites where environmental lead levels were measured. These measurements exceeded the permissible exposure limit stipulated by the Factories and Machinery (Lead) Regulation Malaysia (1984). In terms of selected demographic and work characterisrics the exposed and rhe non-exposed groups were rhus deemed comparable for purpose of analysis.

Air lead concentrarion only indicates at best rhe intensity of lead exposure at various sites in the factory but it does not correlate well with lead absorption (Lim & Abu Bakar, 1983). However, it indicates the presence of lead as a hazard and reflects the need for engineering control in ensuring worksite hygiene and the use of protective respirators to reduce risk. In relation to rhe Factories And Machinery (Lead) Regulation, Malaysia 1984, of the 25 workers sampled in this study, 52% were exposed to air lead levels beyond the permissible exposure limit.

The mean blood lead level among exposed was seven times higher compared to non-exposed group and this is highly significant statistically. This finding is consistent with known sources of lead in the facrory environment and is consistent with other research findings (Premaraj, 1980; Lim & Abu Bakar, 1983).

The factory has been operational for the past 16 years. From the walk-through factory inspection, the factory is cramp for space and bustling with activities. Housekeeping is particularly poor at certain workstations and contribute to the generally poor factory environment. Rapid increased in the demand for lead and hence increased production of lead ingots probably led to haphazard worksite extensions to cater for needed space and also resulted in the recruitment of more workers. Newly recruited workers were young. This is supported by the fact thar 48.4% of the lead exposed workers had been employed for less than 5 years and thar their mean age (28.4 ± 6.1 years) was lower when compared to other groups employed for longer periods. This srudy also showed that this group had the highest mean blood lead level (46.6 ± 17.2 µg / 100g blood). Other plausible reason for the presence of more young workers being employed at this factory may be the high turn-over rare though ill-health as a cause cannot be ruled out from this study.

There appears to be an inverse relationship between mean blood lead level and length of work in the exposed group. The longer the length of service rhe lower the blood lead level. It is common practice for new workers to start at the bottom and work himself up the job heirachy. Bottom rung jobs are often less attracrive and more hazardous with poor pay. Ir may be infered from the data that the relatively junior workers with shorter length of service, were subjected to a more hazardous work environment with higher environmental lead levels. This situation may further be compounded by bad work practice due to lack of work experience. Relatively new and inexperience workers may nor be aware of the hazard nor significance posed by lead or other hazards at the workplace. Thus the importance of safe work practice and the use of protective respirators are most likely to be taken lightly and workers may not follow strict practice guidelines.

As length of service increased and with a high turnover rate as suggested by the data collected from this factory, the chances of promotion is good. Promotion to a supervisors' job involves a change in work environment with less exposure to lead. This is consistent with the lower mean blood lead level (42.8 ± 13.9 µg/100g blood) among factory workers with a longer length of service.

With reference to the legislation, of the 62 factory workers studied, 14.5% (9 workers) registered lead blood level between 60-79 µg/100g blood requiring monthly monitoring until two consecutive blood lead level falls below 60 µg/100g blood. Thirty-four factory workers (54.8%) had blood lead level between 40-59 µg/100g blood and they require three monthly reviews until two consecutive blood lead levels indicate levels below 40 ug/100g blood.

In summary, from the study, factory workers with the highest blood lead level (60 - 79 µg/100g blood) was associated with a younger mean age (29.8 (6.8 years) and shorter mean length of employment (4.3 (3.2 years). These indicate that young workers who are new or inexperience belong to the high risk group. Hence health promotion activities should be targetted at this group on a continuous and regular basis especially if the turnover and attrition rate of workers are high.

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