Blood lead monitoring in a decorative ceramic tiles factory in Singapore

K D K Y Choy, H S Lee, C H Tan

ABSTRACT

Introduction: To illustrate the lead hazard in the ceramics art industry and the importance of blood lead monitoring and suspension of workers with high blood lead levels.

Methods: Interviews were conducted for workers exposed to the lead hazard from a factory manufacturing decorative ceramic tiles. Serial blood lead levels were taken and measurements of lead-in-air and lead in the bulk samples were conducted.

Results: High blood lead levels were observed in four out of 12 workers. Three workers were suspended from further lead exposure and one left the factory. These workers were not aware of the hazards of lead and the importance of good personal hygiene. They were educated on the hazards of lead, the importance of good personal hygiene practices and on the use of the appropriate personal protective equipment. There was an improvement in overall blood lead results in the subsequent months.

Conclusion: Lead hazard is present in the ceramics art industry and ingestion is probably an important route of absorption. The monitoring of blood lead levels was useful to identify and follow-up workers with high blood lead levels. Suspension of workers from further lead exposure was effective in decreasing the blood lead levels of the workers.

Keywords: blood lead monitoring, ceramic tiles, ingestion, serial blood lead levels

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INTRODUCTION

In Singapore, legislation requiring pre-employment and periodic medical examinations for lead exposed workers was introduced in 1985[1]. The examinations include a clinical examination and estimation of blood lead and haemoglobin levels at six-monthly intervals. The legislation also provides for the suspension or removal from further exposure of the lead-exposed workers who have blood lead levels of >50ug/dL (males) and >30ug/dL (females). Males with haemoglobin level of <11g/dL and females with <10g/dL would also be suspended. A rising blood lead and/or falling haemoglobin levels may also be an indication for suspension[2].

As part of the Factories (Medical Examinations) Regulations, medical examinations for lead hazard were conducted in a factory producing decorative ceramics tiles. Part of the assessment included screening for blood lead for workers exposed to lead. The results showed that four out of twelve workers had high blood lead levels. These four workers had direct contact with enamel paints during mixing and silk-screen printing. This paper illustrates that there is a lead hazard in the ceramics art industry in Singapore. It also highlights the importance of blood lead monitoring and suspension of workers with high blood lead levels.

METHODS

Twelve workers from a factory manufacturing decorative ceramic tiles were identified to be exposed to the lead hazard. Interviews were conducted for eleven of them as one had left the factory. This was to determine their duration of exposure, work section, personal hygiene habits, smoking history, usage of personal protective equipment and past work histories. The workers were also asked about their past medical histories and whether they had symptoms of lead poisoning such as weakness or tiredness, headache, abdominal pain and insomnia. Measurements of lead-in-air and lead in the bulk samples together with serial blood lead levels were taken.

The manufacturing process in the production of the ceramic tiles consists of the wet cutting of the tiles, silk-screen printing or brush painting of patterns and designs, the application of frit glass, and the drying of the tiles in an oven. The mixing of the paints was done in a laboratory to obtain the correct colour tone. Blood samples were taken by the Occupational Health Department and by the designated factory doctors appointed by the factory. Blood lead analysis was

Occupational Health Department
Ministry of Manpower
18 Havelock Road
#05-01
Singapore 059764

K D K Y Choy, MBBS, MMed
Specialist Medical Advisor

H S Lee, MBBS, MSc, FAMS
Specialist Medical Advisor

C H Tan, B Eng
Industrial Hygiene Engineer

Correspondence to:
Dr Choy Kwok Yin Kenneth David
Tel: (65) 6317 1129
Fax: (65) 6317 1140
Email: Kenneth_CHOY@mom.gov.sg

Table I. Demographic pattern and exposure duration of workers.

Job category	No. of workers	Age range (yrs)	Exposure duration (mths)
Hand painters	2	39 to 48	61 to 83
Mixers	2	20 to 23	1 to 9
Printers	4	27 to 46	8 to 59
Kiln workers	2	25 to 30	8 to 11
Supervisor	1	30	84
Packer	1	23	9
Total	12		

conducted by graphite furnace atomic absorption spectrophotometer.

Lead-in-air analysis was carried out using a filter cassette holder attached to the worker's collar. Static sampling was also conducted with the filter cassette holder located at a representative location. The filter cassette holder consisted of a mixed cellulose ester filter (37mm diameter, 0.8 micron pore size) placed in three-piece cassette and connected by a plastic tubing to a sampling pump with a flow rate of 2 L/min. The personal and static samples were collected over six hours. Bulk samples were collected in laboratory glass bottles. The air and bulk samples were analysed by the Industrial Health Laboratory of the Health Sciences Authority. The method of analysis used for both types of samples was the flame atomic absorption spectrophotometer. The statistical analysis using the paired t-test was performed using the Statistical Package for Social Sciences (SPSS 9.0) for Windows.

RESULTS

Twelve workers were exposed to lead, comprising 10 male and two female workers. The two female workers were in the hand painting section while the 10 male workers were in the other sections. The exposure duration of the 12 workers to lead ranged from one month to 84 months. The various job categories were hand painters, mixers, printers, kiln workers, supervisor and packer. The workers were not known to have any exposure to lead in their previous occupations. They did not have symptoms of lead poisoning (Table I). Out of the 11 workers interviewed, one was a smoker. Six workers had their meals in the store. Four ate with their hands and four workers used proper gloves when handling the lead compounds.

The initial blood lead levels ranged from 7.6mg/dL to 65.6mg/dL. Those in the printing section had blood lead levels ranging from 24.8mg/dL to 65.6mg/dL. The two workers in the mixing area had blood lead values of 16.5mg/dL and 51.9mg/dL, respectively. The supervisor and the two women working in the hand painting section had blood lead levels which were lower than those in the other job categories (Table II).

Four workers were identified to have high blood lead levels. These were the mixer and the three workers in the silk-screen printing sections. Their blood lead ranged from 47.6mg/dL to 65.6mg/dL (biological threshold limit value = 50mg/dL for males). All had direct handling of the enamel paints without use of proper gloves. Their exposure duration ranged from nine to 48 months. Two of the three silk-screen printers ate with their hands and one was a smoker. The worker with the highest blood lead level (65.6mg/dL) was a smoker, ate with his hands, and had the longest exposure duration among the four workers. All the workers were not aware of the hazards of lead and importance of personal hygiene. The three silk-screen printers with high blood lead levels were suspended from further lead exposure. The mixer with high blood lead level left the factory. Other measures taken include the education of the workers on good hygiene practices and the use of the correct type of gloves. Paints and frit glass were stored away from where the workers had their meals.

Table II. Initial blood lead levels of workers.

Job category	No. of workers	Blood lead (μg/dL)	Mean blood lead level (μg/dL)	No. >80% BTLV**
Hand painters	2	8.07 - 12.42	10.25	0
Mixers	2	16.5 - 51.9	34.24	1
Printers	4	24.8 - 65.6	47.39	3
Kiln workers	2	27.4 - 31.5	29.45	0
Supervisor	1	7.6		0
Packer	1	29.6		0
Total	12*	7.6 - 65.6	31.23	4

* Of the 12 workers, there were only 2 females and both were the hand painters.

** BTLV: biological threshold limit value.

Table III. Summary of the blood lead results.

Job Category	Worker	Blood lead (μg/dL)			No. >80% BTLV**		
		Initial blood test (Jan to Apr 2001)	Blood test (6-9 months later)	Blood test (1-1.5 years later)	Initial blood test (Jan to Apr 2001)	Blood test (6-9 months later)	Blood test (1-1.5 years later)
Printers	A*	65.6	54.4		3	2	0
	B*	47.6	45.1	30.8			
	C*	51.8	35.6	28.7			
	D	24.8	29.9	26.8			
Hand painters	E	8.07	5.4	5.0	0	0	0
	F	12.42	15.5	15.6			
Mixers	G	16.5	32.6	30.6	1	0	0
	H*	51.97					
Kiln workers	I	27.4	30.7	28.3	0	0	0
	J	31.5	29.6				
Supervisor	K	7.6	9.3	8.9			
Packer	L	29.6	25.6	20.7			
Total					4	2	0

* Worker A – Suspended as from April 2001. Lost to follow-up.
Worker B – Suspended as from April 2001.
Worker C – Suspended as from May 2001.
Worker H – Left factory.

** BTLV: biological threshold limit value.

The repeat blood tests for the workers showed an overall improvement in the blood lead levels in the subsequent months (Table III). The blood lead levels of the four workers in the printing section are shown graphically (Fig. 1). Three of the workers in this section were suspended as they had high blood lead levels. Workers A and B were suspended from April 2001, and worker C was suspended from May 2001. The blood lead levels showed a general decline over the subsequent months. The three suspended workers did not go back to work in the printing section. The blood lead results of the three suspended workers before and after suspension are compared (Table IV). The mean blood lead before and after suspension was 55.0mg/dL and 38.0mg/dL, respectively, and the difference was statistically significant.

Two lead-in-air samples, consisting of a personal and static sample, were taken at the mixing area and the results were 12.7% (personal) and 6% (static) of the permissible exposure levels. The permissible exposure level for lead is 0.15 mg lead/m^3 of air. Bulk sample analysis was done on some of the ceramic enamels. The percentage of lead ranged from 0.012 to 2.619 %w/w. Analysis of the frit glass showed that it contained 0.038 %w/w of lead.

DISCUSSION

Inhalation and ingestion are the main routes of absorption of inorganic lead. In this factory, ingestion of lead is the most likely route of entry. It was unlikely that the inhalation route is the main source of entry of lead as the lead-in-air levels were low. Exposure to lead occurred during the mixing of the enamels, hand painting, silk-screen printing and application of the frit glass coat. Four of the workers ate with their hands and consumed their meals in the workplace. The likelihood of lead ingestion would increase if the workers' hands became contaminated with the enamels or frit glass. A review of the medical examination results for 771 workers in 53 factories occupationally exposed to lead in Singapore showed that Malays and Indians had higher blood lead levels than Chinese[3]. In a study of 36 workers in a factory manufacturing lead accumulator batteries, the blood lead levels of the Malays were also found to be higher than the Chinese. The authors suggested that this could have been contributed by the ingestion of lead powder from the practice among Malays of eating with their hands[4].

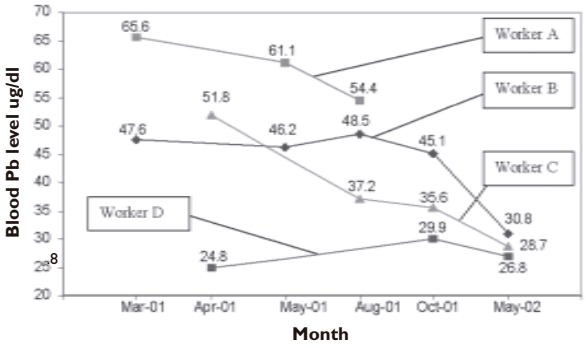
A study of 25 lead-acid battery workers showed that lead contamination of the hands and mouth contributed significantly to the body absorption of

Table IV. Blood lead results of the three suspended workers before and after suspension.

	Mean blood lead level (μg/dL)	Standard deviation (μg/dL)	Range (μg/dL)
Before suspension	55.0	9.4	51.8 – 65.6
After suspension	38.0	14.2	28.7 – 54.4

p value = 0.038

Fig. 1 Serial blood lead levels of workers in the printing section.



lead among the exposed workers[5]. Overtime work or increased production was shown to be a common cause of rising blood lead levels[6]. In our study, the worker with the highest blood lead had the longest exposure in his work section, in addition to being a smoker and eating with his hands. Suspension of the workers from further lead exposure was effective, as shown by the significant decrease in the blood lead levels of the workers over the next few months. In addition, there was also a better understanding of the lead hazard among the workers. The factory provided and ensured that the workers wore the proper gloves, and that they did not consume any food in the work area.

There is a lead hazard in the ceramics art industry in Singapore, and ingestion is probably an important route of absorption. The monitoring of blood lead levels was useful to identify and follow-up workers with high blood lead levels. The effectiveness of the suspension of workers from further lead exposure was shown by the decrease in their blood lead levels over the subsequent months. Preventive measures taken included health education, use of proper personal protective equipment, good personal hygiene and house keeping.

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