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Occupational health programme for lead workers in battery plants

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Abstract

The realization of problems resulting from the exposure to undue high lead levels of workers in lead-using industries, particularly in storage battery plants, has given rise to a new occupational health service, the so-called type specific (harmful agent specific) group occupational health. In 1988, the Korean Ministry of Labor designated the Institute of Industrial Medicine, Soonchunhyang University, as an authorized organization to take care of lead workers in lead industries. The following occupational health services are provided by the Institute: (i) physical health examination; (ii) biological monitoring with zinc protoporphyrin, urine δ-aminolevulinic acid and blood lead; (iii) respiratory protection with maintenance-free respirators; (iv) measurement of the environmental condition of workplaces; (v) health education. A three-year occupational health programme for lead workers has contributed to improvements in the working conditions of lead industries, particularly in large-scale battery plants, and has decreased the unnecessary high lead burden of workers through on-going medical surveillance with biological monitoring and health education schemes. The strong commitment of both employers and the government to improve the working conditions of lead industries, together with the full cooperation of lead workers, has served to reduce the high lead burdens of lead workers. This decreases the number of lead-poisoning cases and provides more comfortable workplaces, particularly in battery plants.

Introduction

Lead poisoning in lead-using industries is still prevalent and is an important occupational disease in Korea [1–3]. Bad working conditions, absence of proper health education, and lack of on-going medical surveillance are often blamed for the high incidence of lead poisoning in Korea [4]. The problem of lead poisoning arose following a major outbreak of cases in storage battery plants in 1972. This resulted both in the application of specific laboratory tests relevant to lead exposure and in a growing concern of the government for early detection of such occupational diseases. During the past 10 years, there were several more large outbreaks of lead poisoning and these caused great consternation amongst the public at large. Despite the efforts of government and related organizations there have still been some freak cases of lead poisoning as well as a large number of high-lead absorption cases [5].

Following the above events, the government developed a special occupational health programme: the so-called industry type specific (harmful agent specific) group occupational heath service. This provides a special occupational health service, by a specialist Institute, to lead workers throughout the country. In 1988, the Institute of Industrial Medicine, Soonchunhyang University, was authorized to take care of lead

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workers. All lead workers in battery plants, which covers more than 80% of those lead workers who are classified as a high-risk group, have so far been supervised by the Institute. As a consequence, the health status of lead workers in Korea has been improved during the past few years. In addition, working conditions have been ameliorated, especially in large companies [6]. Nevertheless, there is scope for further improvement.

Brief history of lead poisoning in Korean battery industries

1972

In 1972, 58 lead workers in a storage battery factory were examined for lead poisoning. Quantitative measurements of coproporphyrin and δ-aminolevulinic acid in urine were introduced for the first time in this survey. Blood and urine lead, together with basophilic stippling cells in red blood cells and hemoglobin, were also measured. Only 10 lead workers were found to have a blood lead level below 60 μg/dl. The distribution of blood leads (by zinc protoporphyrin, ZPP) is shown in Fig. 1. The prevalence of anemia was 52.9% in female lead workers (<10.0 g/dl) and 70.9% in male workers (<12.0 g/dl).

1986: nationwide survey of storage battery industries

In September 1986, from a sample of 258 lead workers in a storage battery plant, 66 lead workers were screened for possible lead poisoning. The coproporphyrin test in urine was used and confirmed by laboratory tests (PbB, ZPP, ALAU, CPU, Hb). Of these workers, 29 were diagnosed as having lead poisoning. Six severe cases were admitted to St Mary Hospital and a further six workers received medical treatment at the University Hospital that was close to the battery plant. The initial data from the survey are presented in Figs. 2 and 3.

As a result of this work, the Ministry of Labor organized a field survey team to evaluate the environmental conditions of the workplace and to measure blood ZPP

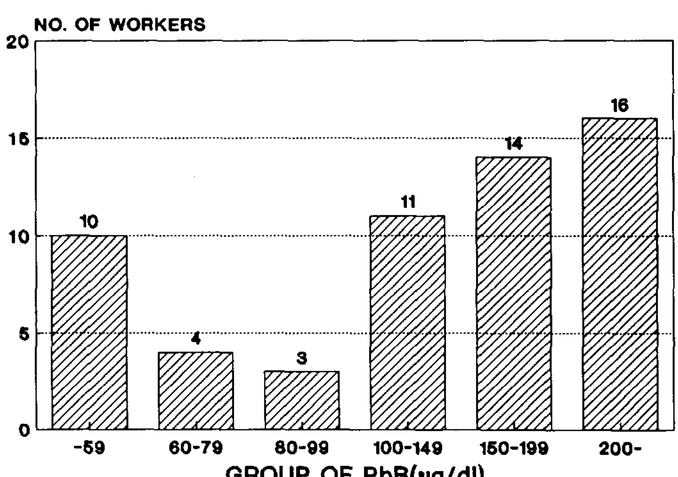

Fig. 1. Blood-lead distribution in lead-battery workers (by group of ZPP), 1972.

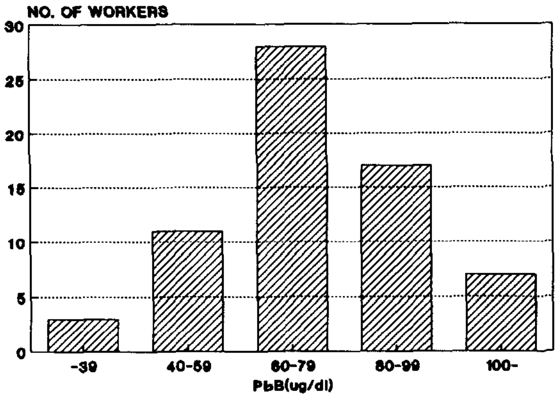

Fig. 2. Blood-lead distribution of lead-battery workers (by group of PbB), 1986.

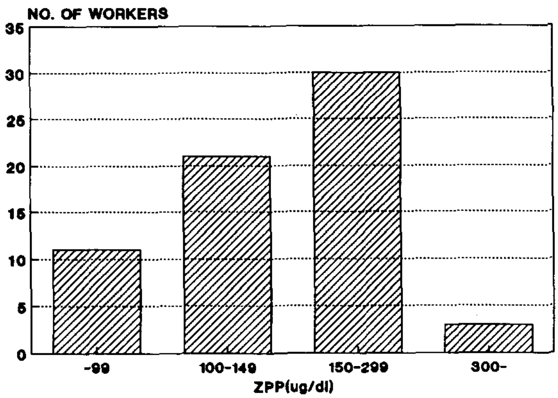

Fig. 3. Blood-lead distribution in lead-battery workers (by group of ZPP), 1986.

level as a screening test for lead poisoning. The target industries were 10 storage battery industries and one primary smelting industry.

The mean air concentration of lead during the different stages of battery making in the 10 plants is given in Fig. 4. The blood-lead distribution of workers classified by group of ZPP is shown in Fig. 5.

The survey team recommended that the Ministry of Labor should tackle the problem of lead poisoning in Korea. The major recommendations were as follows.

(i) The setting up of an agent specific (intensity-type specific) occupational health service by a specialized institute to take care of lead workers.

(ii) Relaxation of the environmental standard for workplaces for a certain period as an interim measure to encourage the employer to comply with the standard for the air concentration of lead.

(iii) The establishment of a central laboratory to provide a service to local occupational health centres that are unable to carry out certain specific laboratory tests, e.g., heavy metal measurement in blood and urine.

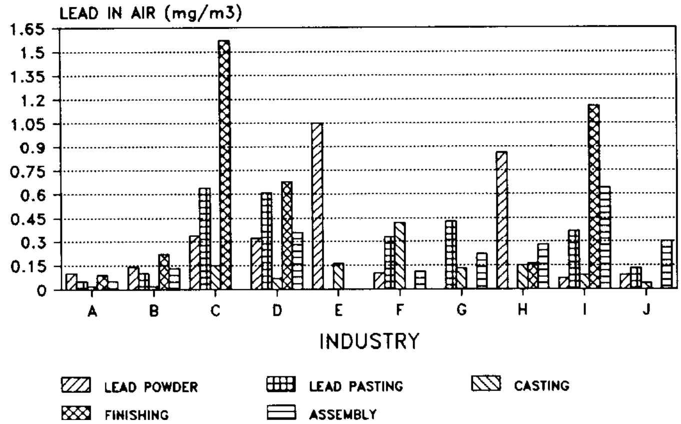

Fig. 4. Mean air concentration of lead for different battery process stages, 1986.

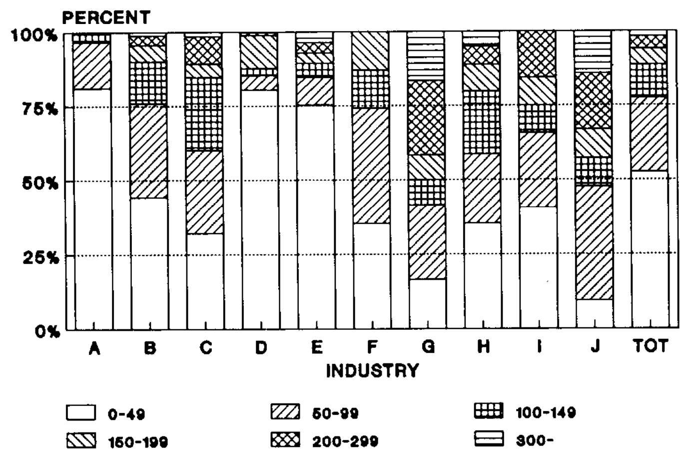

Fig. 5. Blood-lead distribution (μg/dl) of lead-battery workers (by group of ZPP), 1986.

As a result of the survey, the following actions were implemented.

(i) 1987. New regulations were introduced for group occupational health services [7]: (1) area group occupational health service; (2) industry-type specific group occupational health service.

(ii) 1988.6. The Institute of Industrial Medicine, Soonchunhyang University was designated as the authorized institute for an industry-type specific occupational health service for the lead-using industry.

(iii) 1988.6-12. Twenty-seven lead-using industries that belonged to the high risk of lead exposure group such as storage battery industries, litharge-making industries, primary-lead smelting industries, made a special contract to receive an occupational health service provided by the Institute of Industrial Medicine, Soonchunhyang University.

(iv) 1988.10-12. A nationwide survey of thirty-three lead-using industries was ordered by the Ministry of Labor. The selected industries were 11 storage battery makers, 2 primary lead smelters, 13 secondary lead smelters, 4 litharge manufacturers,

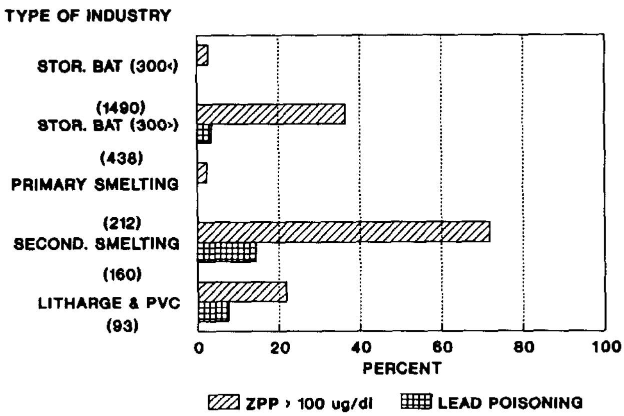

Fig. 6. Prevalence of lead poisoning by type of industry, 1986.

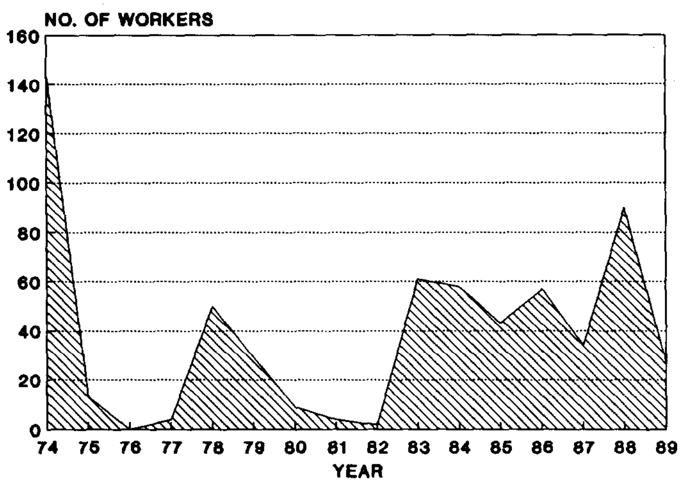

Fig. 7. Workers with lead poisoning (reported cases).

and 2 PVC stabilizer manufacturers. The Korea Industrial Safety Corporation (KISCO) carried out environmental measurements in all these industries and the Institute of Industrial Medicine, Soonchunhyang University, checked the blood ZPP of lead workers in 27 small- and medium-sized lead industries. The ZPP data of the large industries were collected by Soonchunhyang University. The results are given in Fig. 6.

(v) 1974–1990. The trend in lead poisoning during 1974–1990 was determined [8]. The number of reported lead-poisoning cases discovered through the special health examination is shown in Fig. 7.

Current health status of lead workers in storage battery plants

The distribution of lead-poisoning cases reported in 1990 by the Institute of Industrial Medicine, Soonchunhyang University, for the different types of industry is

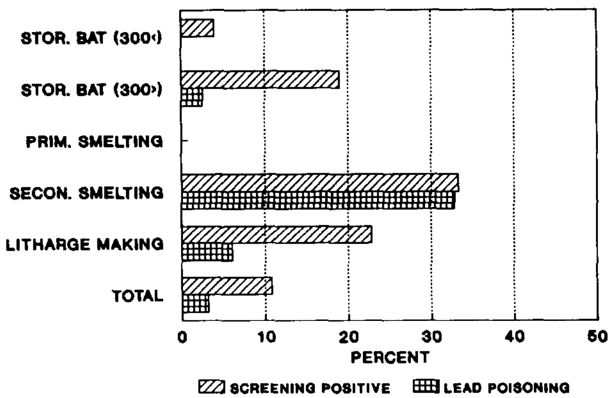

Fig. 8. Rate of lead poisoning by type of industry, 1990.

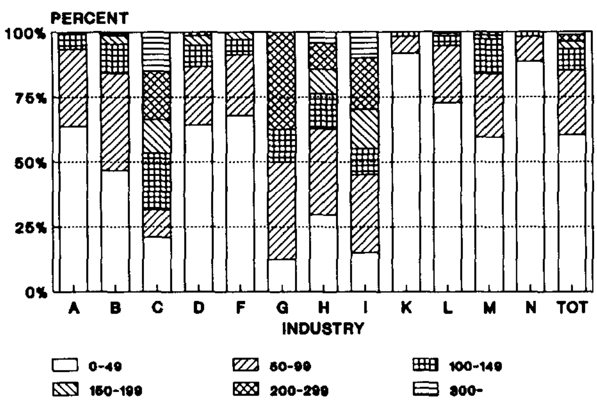

Fig. 9. Distribution of workers by group of ZPP (μg/dl) in various battery plants, 1990.

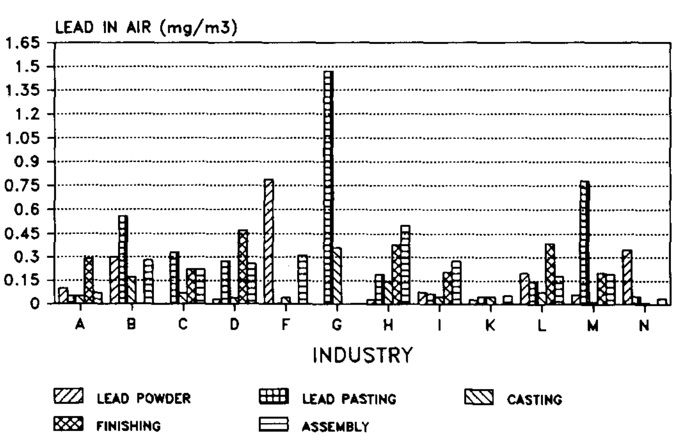

Fig. 10. Mean air concentration of lead by industry, 1990.

presented in Fig. 8. The resulting distribution of lead workers (percent) by blood ZPP in the different battery industries is given in Fig. 9. The mean air concentration of lead in 12 lead-using industries is shown in Fig. 10.

Occupational health programme for lead workers

The occupational health programme for lead workers, that is provided by the Institute of Industrial Medicine, Soonchunhyang University, can be categorized into five main activities as follows:
(i) physical health examination;
(ii) biological monitoring;
(iii) respiratory protection;
(iv) measurement of environmental condition of workplaces;
(v) health education.

Physical health examination

Compulsory physical health examinations are provided twice a year to lead workers under the Industrial Safety and Health Law. The service consists of a primary health examination for screening high-lead absorption and non-occupational diseases and a confirmative health examination for diagnostic purposes to detect lead poisoning and non-occupational diseases.

The laboratory tests used for high lead absorption are ZPP and hemoglobin in blood, and those for diagnostic purposes are lead in blood and urine (δ-aminolevulinic acid in urine, ZPP and hemoglobin in blood).

The diagnostic criteria for lead poisoning recommended by the Ministry of Labor are [9]: for two or more lead related symptoms:
lead, blood (PbB): >60 μg/dl
lead, urine (PbU): >150 μg/dl
δ-aminolevulinic acid, urine (ALAU): >20 μg/l
coproporphyrin, urine (CPU): >500 μg/l
zinc protoporphyrin, blood (ZPP): >150 μg/dl
hemoglobin (Hb): <12.0 g/dl (male)
<10.0 g/dl (female)

Biological monitoring

Zinc protoporphyrin measurement in whole blood with a portable hematoflurometer is employed as a basic screening tool for the detection of undue high lead absorption at the site [10, 11]. Since working conditions of lead-using industries vary from very good (i.e., very low TLVs) to poor (i.e., very high lead concentrations in the air), different criteria have to be applied for the biological monitoring of lead workers in different locations. According to the working conditions, the lead industries can be divided into the three groups listed in Table 1.

The biological monitoring schedule and criteria are given in Table 2.

From the results of confirmative tests and the symptoms and signs of lead workers, several measures have been taken to reduce their lead burden, i.e.,

(i) respiratory protection with proper respirator;

(ii) shift to non-lead using workplaces or other workplaces with relatively low lead concentration in air;

(iii) complete removal from workplace without any medical treatment;

(iv) complete removal from workplace with proper medical treatment.

TABLE 1

Classification of lead-using industries

Group	Lead concentration in air (mg m^{-3})	No. of industries
I	<0.1	3
II	0.1 to 0.3	9
III	>0.3	15

TABLE 2

Biological monitoring of lead-using industries

	Criteria	Frequency
Group I and II industries		
ZPP (μg/dl)	<49	every 3 months
	50 to 99	every 2 months
	>100	every month with confirmative tests (PbB, ALAU, Hb)
Group II industries		
ZPP (μg/dl)	<99	every 3 months
	100 to 149	every 2 months
	>150	every month with confirmative tests (PbB, ALAU, Hb)

Respiratory protection

To reduce the number of cases of lead poisoning and to alleviate the lead burden of lead workers experiencing conditions where the air concentration is well above the TLV (i.e., 0.15 mg m^{-3}), respiratory protection is essential in most lead-using industries in Korea. Since field trials in one battery factory in 1987 demonstrated that the maintenance-free respirator (MFR) was more effective than the regular half-face respirator, most lead-using industries under the supervision of the Institute are now using MFRs. Regular instruction for the correct wearing of the respirator has been provided by both the distributer and the Institute. It has been found that the MFR has several advantages over the conventional unit, for example, it is lighter in weight and disposable, and does not inhibit communication. The use of MFRs has proved to be very high [5].

Measurement of environmental conditions of workplaces

To improve working conditions, measurements of the environment are performed at least twice a year. The results usually call for better, engineering control of the workplace, including the installation of effective exhaust ventilation systems. In addition, improvements to the manufacturing process(es) are often recommended. As a consequence of these activities, the establishment of new modernized secondary smelting factories is now in progress with the full support of the Ministry of Labor and Commerce.

Health education

Formal lectures and informal person-to-person health education are provided regularly to lead workers. The importance of personal hygiene to prevent undue high lead absorption is always emphasized. Smoking and eating in the workplace are prohibited in most battery industries.

Conclusions

Lead poisoning is prevalent in Korean factories and the working conditions of lead-using industries require improvement. Nevertheless, on-going medical surveillance with proper biological monitoring, as well as the strong commitment of both employers and the government to improve the workplace, is expected to reduce significantly the number of overt lead-poisoning cases within a few years. Such activities will therefore provide more comfortable working conditions, particularly in battery plants.

References

1 B. K. Lee, *Ind. Health, 10* (1989) 6–12.
2 B. K. Lee, *Korean J. Occup. Health, 30* (Suppl.) (1991) 1–9.
3 B. K. Lee, *Br. J. Ind. Med., 39* (1982) 283–289.
4 B. K. Lee, K. D. Ahan and T. S. Nam, *Korean J. Occup. Health, 26* (1987) 63–72.
5 B. K. Lee, K. D. Ahn and T. S. Nam, *Korean J. Occup. Med., 2* (1989) 180–185.
6 S. M. Oh, A study on the estimate of permissible limit for airborne lead by zinc protoporphyrin, *Ph.D. Dissertation, Choongang University, 1987.*
7 Korea Ministry of Labor, *Industrial Safety and Health Act,* Ministry of Labor, 1990.
8 Korea Ministry of Labor, *Yearbook of Labor Statistics,* Ministry of Labor, 1990.
9 Korea Ministry of Labor, *The Guideline for Special Health Examination and Criteria for Diagnosis of Occupational Disease,* Ministry of Labor, 1990.
10 J. M. Kim and K. M. Lee, *Catholic Medical College, 37* (1984) 939–951.
11 B. K. Lee, K. D. Ahan and T. S. Nam, *Korean J. Occup. Health, 28* (1989)110–115.