

Experience in controlling lead poisoning in the People's Republic of China

by Gu Xue-qi¹

GU XQ. Experience in controlling lead poisoning in the People's Republic of China. *Scand J Work Environ Health* 11 (1985): suppl 4, 16–19. This paper summarizes the work done to control lead poisoning in the People's Republic of China. The work can be divided into the following four phases: (i) health surveillance of lead workers, (ii) health standard setting, (iii) research for early detection indicators, and (iv) improvement of the work conditions and health surveillance of "undeserved" groups. In 1949 prevention started with the initiation of the health surveillance of lead workers. Since then health surveillance has been used to supplement environmental monitoring in the early detection of lead poisoning, and the prevalence of lead poisoning has decreased. This activity has also helped to identify the needs for improvement in technological control. The next step has been the promulgation of health standards. The current standard for lead gives the maximum allowable concentration in air as 0.03 mg/m³ for lead fume and 0.05 mg/m³ for lead dust. Research on indicators for the early detection of lead has improved the quality of prevention. It has recently led to the addition of zinc protoporphyrin to the list of indicators in use. Finally the work conditions and surveillance of workers that had earlier been considered "underserved," particularly workers in agriculture and small industries in rural areas, are being improved.

Key terms: early detection indicators, health standard, health surveillance, prevention.

Occupational lead poisoning was first described by the well-known Chinese pharmacist Li Shi-zhen (1518–1593) of the Ming dynasty. In his famous book *Essence of Traditional Medicine* (in Chinese) he presented the process of mining lead ore and making oxides of lead. He also described the etiology and course of lead poisoning. However, there was little preventive work done before the Liberation. Although industry was not developed during that time, severe lead poisoning such as wrist drop and toxic encephalopathy were well documented in old literature. Guided by the policy of putting prevention first in health work, there has been considerable progress in preventing occupational diseases, as in other fields of medicine, during the past 35 years. In the first 10 years after the Liberation (1949–1959) a total of 9 721 lead workers was examined in various investigations, and 38 papers were published (1). Since 1959, achievements have been made in the research on methods for determining lead in air and the medical surveillance and biological monitoring of lead workers. The aim has been to obtain early diagnostic indicators for lead poisoning and a hygienic standard. Technical improvement of plant equipment has been implemented; severe plumbism has been eliminated; and the printing and shipbuilding industries have been brought under control (4). However, lead poisoning is still present among workers in lead smelters and storage battery plants. This paper summarizes some experiences in controlling lead poisoning in industry since 1949.

Health surveillance of lead workers

Prevention started with the health surveillance of lead workers. As has been the experience of other countries in their development of industry, the promulgation of legislation, by the state authority, for the organizing and training of professional personnel with emphasis on prevention is the main measure to maintain the health of the workers. Among the comprehensive preventive measures health surveillance is one of the important approaches, in addition to environmental monitoring and the improvement of technology. The early detection of occupational diseases is the key point in health surveillance. There are three reasons for its importance: (i) Since developing enterprises do not usually have enough capital for improved technology, especially in the small plants run by the communes and brigades, the early detection of occupational diseases usually works as an effective measure; (ii) early detection is a supplemental measure to environmental monitoring; (iii) early detection helps identify the need for improvement in technological control.

Since 1956, the Ministry of Public Health has joined with the Ministry of Labor to promulgate documents such as the "Temporary Regulation for Reporting of Occupational Intoxications and Occupational Diseases," the "List of Occupational Diseases and Measures of Reportable Occupational Diseases," etc. By 1980, 15 documents related to the early detection and prevention of occupational diseases had been promulgated. Among these were diagnostic criteria and principles of preventive measures for silicosis, poisoning

¹ School of Public Health, Shanghai First Medical College, 138 Xi Xue Yuan Road, Shanghai 200032, People's Republic of China.

Table 1. Prevalence of lead poisoning after the implementation of health surveillance of workers in two storage battery plants.

Year	Shanghai storage battery plant			Po-shan storage battery plant		
	Persons examined	Persons with lead poisoning	Prevalence (%)	Persons examined	Persons with lead poisoning	Prevalence (%)
1955	..	..	..	81	31	38.2
1956	110	50	45.0	123	42	35.8
1957	150	15	10.0	175	29	16.6
1958	200	6	3.0	185	9	4.9

Table 2. Average air lead levels and the prevalence of lead poisoning in the Po-shan storage battery plant (1955—1983).

Year	Air lead level (mg/m ³)		Persons examined	Lead poisoning	
	Mean	Range		Persons	Prevalence (%)
1955	13.27	5.7 — 25.17	81	31	38.2
1956	6.71	0.18 — 40.4	123	44	35.8
1957	6.71	0.18 — 40.4	175	29	16.6
1958	2.88	0.14 — 13.37	185	9	4.9
1961	5.22	0.79 — 22.7	380	37	9.79
1963	9.62	0.04 — 36.97	252	37	14.6
1965	7.92	0.09 — 75.0	188	14	7.4
1966	0.92	0.02 — 4.32	238	14	6.0
1972	0.92	0.03 — 4.7	613	34	5.7
1975	1.24	0.02 — 10.14	541	7	1.3
1977	1.03	0.02 — 3.9	510	10	1.96
1979	2.54	0.01 — 35.77	529	12	2.3
1981	0.446 1.089	0.051 — 1.759 (fume) } 0.084 — 4.17 (dust) }	403	10	2.48
1983	0.46 0.37	0.02 — 1.91 (fume) } 0.019 — 1.41 (dust) }	414	9	2.17

Table 3. Average air lead concentrations and the prevalence of lead poisoning in representative workshops of the Po-shan storage battery plant (1955—1983).

Year	Smelting plate		Filling oxides powder		Charging room	
	Air lead (mg/m ³)	Prevalence (%)	Air lead (mg/m ³)	Prevalence of lead poisoning (%)	Air lead (mg/m ³)	Prevalence of lead poisoning (%)
1955	11.20	..	25.17	..	..	..
1957	1.51	21.7	15.22	87.5	..	..
1958	0.14	..	13.37	..	..	..
1961	0.86	6.7	9.11	14.2	2.05	20.0
1972	0.12	5.6	2.63	9.5	0.44	7.8
1975	0.12	1.2	1.35	0	6.73	5.0
1977	0.11	0	3.81	5	3.49	11.0
1979	0.11	0	35.77	4.2	1.19	8.5
1983	0.19	0	1.37	5.1	0.45	12.8

caused by lead, etc. These documents were effective in preventing the occupational hazard mentioned. For example two storage battery plants in Shanghai and Shangtung (Po-shan) experienced a dramatic drop in lead poisoning after 1956, as shown in table 1 (1).

Before routine health examinations were carried out in the two storage battery plants, the air lead concentration in the workshop exceeded the old standard (0.01 mg/m³) by several hundredfold. After the implementation of health surveillance, the air lead concentration dropped quickly, and thereby the prevalence of lead poisoning was reduced. In the Po-shan stor-

age battery plant, where record keeping is complete, the decreasing prevalence of lead poisoning correlated with the average lead concentration in the air. The Spearman's rank correlation coefficient (γ_s) equaled 0.7385, a value greater than the critical value at the 0.01 level for 14 pairs [γ_s 0.01 (14) = 0.679], $p < 0.01$ (table 2) (3). This occurrence shows that early detection is an important step to promote technological control.

In the 1960s preventive efforts were further emphasized. We had more experience and more professional personnel. In 1979—1981 a nationwide survey

of workers exposed to lead, mercury, benzene, organophosphorus pesticides, and trinitrotoluene was implemented. A total of 355 000 workers exposed to lead were examined, the prevalence of chronic intoxication was shown to be 1.68 %. This figure nearly coincides with that shown in one factory.

Appropriate health standard setting

Health standard setting began in 1956 when we used the Soviet Union's health standard as our tentative document, and it was revised and promulgated as the official document in 1962, after 17 years of practice. The first standard based on our own experience was promulgated in 1979. The tentative standard for lead was 0.01 mg/m³, which was actually so strict that it was unattainable. As can be seen from table 2, all average values exceeded the old standard by at least an order of 92 times. However, we still managed to decrease the prevalence of lead poisoning to below 2 %. If the air lead concentration in different workshops is examined, there was no case of poisoning in the smelting plate workshop in 1977 and 1979, while the air lead in these two years still exceeded the old standard by an order of ten times (table 3). Using these figures and similar figures from other field work, we set the new standard at 0.03 mg/m³ for lead fume and

0.05 mg/m³ for lead dust. In a recent nationwide survey the new standard proved to be appropriate.

Research for early detection indicators

Research for indicators of early detection is helpful to improve the quality of prevention. In the 1950s we only used urinary coproporphyrin, urinary lead level, and red-cell stippling as indicators in preventive examinations of lead workers. In the middle of the 1960s urinary δ -aminolevulinic acid was added as an indicator. As a result, the prevalence of lead poisoning further decreased. It is proved by the change of prevalence seen in the Po-shan storage battery factory in table 2. Recently we are appraising free erythrocyte protoporphyrin, zinc protoporphyrin, and blood lead by anode-stripping voltimetry as indicators for the early detection of lead effect. The work on zinc protoporphyrin is one example. A total of 155 workers was examined (two groups of 53 and 52 workers with lead exposure and 50 referents). The levels of lead in air were 0.578 mg/m³, 0.0015 mg/m³, and 0.0006 mg/m³, respectively (2). No one in the three groups was diagnosed as suffering from lead poisoning according to the old diagnostic criteria. Blood samples were taken from each person for zinc protoporphyrin assessment, in addition to other routine examinations for lead exposure. The presence of five of the eight subjective complaints of workers (fatigue, nausea, impairment of memory, metallic taste, abdominal pain, sweating, numbness of extremities, joint pain) was considered a positive manifestation of lead effect. In addition, a blood zinc protoporphyrin level of 80 μ g/dl (1.44 μ mol/l) was considered the limit for a positive test. When the figures were arranged in a fourfold table, the sensitivity was 77.4 % and the specificity 93.5 % (table 4).

Table 4. Correlation of symptoms with blood zinc protoporphyrin (ZPP).^a

	With symptoms	Without symptoms	Total
ZPP positive ^b	24	8	32
ZPP negative	7	116	123
Total	31	124	155

^a Sensitivity: $(24/31) \times 100 = 77.4$ %; specificity: $(116/124) \times 100 = 93.5$ %

^b Blood ZPP > 80 μ g/dl (> 1.44 μ mol/l) = positive.

Table 5. Different indicators used in relation to prevalence of lead poisoning in different periods (Po-shan storage battery plant).

Period	Prevalence (range)	Indicators used
1955—1963	4.9—38.2 %	Urinary coproporphyrin (semiquantitative) Urinary lead Red-cell stippling
1965—1979	1.3—7.4 %	Urinary coproporphyrin (quantitative) Urinary lead Urinary δ -aminolevulinic acid
1981—1983	2.17—2.48 %	Indicators of preceding period plus the following: Free erythrocyte protoporphyrin Zinc protoporphyrin Blood lead

On the basis of this research, we were assured that the level of zinc protoporphyrin could be used as an early detection indicator. Further work is going on to convert it to popular use. Nerve conduction velocity is also being tested for its reliability and usefulness. We are sure that our work on the prevention of lead poisoning can be further improved in the 1980s (table 5).

Special attention to the "underserved" working population

Not all the workers enjoy the aforescribed occupational health services. In fact, the majority of the working population, particularly in agriculture and small industries, is considered "underserved."

In recent years, industrialization has proceeded rapidly in rural areas, many small plants being established and managed at the county, commune, and

brigade levels. However, safety regulations, hazard prevention, medical care, and hygienic services have not kept pace. Occupational hazards have not been fully recognized, and many preventive measures have been neglected by managers or workers. As a result, occupational health conditions in many of these plants are unsatisfactory. As occupational health services are a part of primary health care, this situation should be changed. The controlling of lead poisoning in rural areas may serve as an example.

The prevention of lead hazard was one of the priorities. There were 45 plants with lead exposure of some sort, mainly smelting, lead storage battery manufacturing, soldering and coating, in Shanghai County. Although, in the beginning, the air lead concentrations within these latter two categories of plants exceeded the old standard of 0.01 mg/m³, there were only 10 persons [8.7 % of the total number of workers (N = 115)] who showed lead absorption in the health surveillance.

We then placed emphasis on lead smelting and storage battery manufacturing. Qi-yi commune has two storage battery plants. We began our work in 1973 and found the prevalence of plumbism fluctuating between 4.8 and 13.7 % (table 6). These levels were comparable to the condition of a bigger factory in the 1960s (table 2) and was much less than what had occurred in the same plant without prevention in the early 1950s (38.2 %) (5).

Table 6. Prevalence of lead poisoning of workers in storage battery plants in the Qi-yi Commune.

Year	Workers exposed	Workers with lead poisoning	
		N	%
1973	63	3	4.8
1974	74	7	9.5
1975	79	8	10.1
1976	90	11	12.2
1977	92	6	6.5
1978	153	21	13.7
1979	174	10	5.7
1980	172	10	5.8

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