

Prevention of acute parathion and demeton poisoning in farmers around Shanghai

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SHIH JH, WU ZQ, WANG YL, ZHANG YX, XUE SZ, GU XQ. Prevention of acute parathion and demeton poisoning in farmers around Shanghai. *Scand J Work Environ Health* 11 (1985): suppl 4, 49—54. After the occurrence of poisoning episodes among commune members who handled the insecticides parathion and demeton during the first few years of application in the early 1960s, a series of surveys was conducted and comprehensive regulatory actions were adopted. The surveys showed that the cause of most of the poisoning cases was percutaneous absorption of toxicant as a consequence of skin contamination during careless operating. As a result of a comprehensive program carried out by large numbers of administrators, health workers, and commune members, the incidence of intoxication quickly declined, starting in 1965, to a negligible level and has remained so to the present, even though parathion and demeton use has increased greatly. It is suggested that the experience obtained might be helpful to other areas in the People's Republic of China and in some developing countries.

Key terms: pesticide poisoning, prevention.

Around the city of Shanghai there are 10 counties with a population of 4.5 million engaged in agricultural activities. Rice and cotton are the main products in this area. In spite of their hazardous properties, pesticides are unavoidably needed and play a very important role in agricultural protection. With the spraying of pesticides manually, close contact and frequent exposure seem to be unavoidable. It seems very difficult to handle and spray such highly toxic chemicals without adverse effects. This serious situation required a series of efforts to implement preventive measures, including strategies for offering better special training courses on the safe use of insecticides, mass education, demonstrations of certain successful models, meetings to exchange information, etc. In health care and epidemiologic investigations, research on developing devices for the early detection of poisoning and antidotes for use in treatment, field surveys, and trials were all important. A registration system for pesticide poisoning was established in 1961. On the basis of this work, the intoxication of parathion and demeton was controlled (1, 3, 4, 6, 7, 10, 12, 13, 14, 15, 16 and an unpublished report of Xue et al). The purpose of this paper is to review this work.

Initial epidemiologic surveys

A study of pesticide sprayers in two communes, in 1959, revealed that there were 98 incident cases (4.5 %) of pesticide poisoning among 234 sprayer teams. In that year, 150 kg of parathion and demeton had been applied (1). The affected workers were in 41 of the 234 production teams. Two-thirds of those affected complained of illness during or after the first workday. Seventeen percent of those affected were unconscious, and some were comatose. Absorption of the pesticide was facilitated by heavy contamination of the skin and clothes, eating or smoking with unwashed, contaminated hands, and failure to wash the pesticide off the skin quickly. Since poisoning did not affect two-thirds of the teams, it may have been associated with lack of knowledge of preventive measures for such toxic chemicals among the affected teams.

The general conditions reported in another survey following this period, however, were not as bad. It showed that the incidence of parathion and demeton poisoning during 1962—1964 was 1.5 % on the average, although the range of the rates obtained from different communes varied widely from 0.4 to 10.9 % (10). Study data revealed a trend of a higher incidence of poisoning where less pesticide had been used, and vice versa. The reason for this trend may have been that, when smaller amounts of pesticide were used, less attention was given to prevention.

During the early 1960s, in the People's Republic of China and elsewhere, there was debate as to whether the percutaneous or the respiratory route of the entry of pesticide was more important among sprayers. Our 1959 study suggested that the percutaneous route of entry was dominant (table 1). However, further direct

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Table 1. Possible causes of pesticide poisoning, 1959.

Possible causes	Percentage of occurrence
Marked contamination of clothes	42
Eating with unwashed hands	35
Large-scale pesticide contamination of skin	30
Inadequate personal protection	20
Continuous spraying exceeding 5 d	18
Breakage of spraying tool	17
Working in a field where pesticide had just been applied	7

evidence of exposure and absorption was necessary.

Another epidemiologic survey, performed in 1960, detected parathion (at a very low concentration, 0.02 mg/m³) in only 1 of 14 samples collected from the breathing zones of sprayers who sprayed insecticide downwind to avoid inhaling the toxic mist. Personal contamination was greater in commune members, who worked carelessly, than in college students, who handled the insecticide with great care to avoid contamination (table 2).

Significant differences in contamination of the right hand and leg between the two groups were found. Among the commune members, who worked unaware of the risk and ignoring safety precautions and our advice to them, workers were poisoned later in the working season. Our study indicated that transdermal absorption of pesticide was the main route of entry.

In an analysis of reports of intoxication in 1961 and 1962, consistent findings were obtained (14). Table 3 shows the causes of poisoning, by different routes of entry of the pesticide.

Evaluating the effectiveness of protective measures

In order to minimize the danger of percutaneous absorption, regulations required the avoidance of dermal contamination, the wearing of protective gloves and clothes, and the rapid washing of contaminated skin. A 1961 survey led to our use of the blood cholinesterase activity as an indicator for measuring early effects of organophosphorus insecticides. It was found that sprayers who had worked with parathion for 6 d and

strictly followed precautionary guidelines had a slightly reduced cholinesterase level (85 % of normal) but careless sprayers had an average cholinesterase level of 39 % of normal, as well as cholinergic symptoms.

Correlations among pesticide exposure, cholinesterase inhibition, and the effectiveness of protective measures was investigated in a 1963 field survey (15). In addition to the monitoring of air levels and dermal exposure, blood cholinesterase activity and urinary p-nitrophenol excretion were measured to determine the extent of absorption and adverse effect (table 4). In contrast to very limited respiratory exposure, skin contamination, particularly on the hands and dorsum of the feet, was very great (table 4). This was critical information for preventive measures. Trouser covers made of plastic film and dermal application of soap paste proved to be effective and simple preventive measures (table 5). Together with awareness of the need to avoid skin contamination and to clean the contaminated skin thoroughly and promptly, these measures were effective in keeping the blood cholinesterase activity of the workers above the warning limit. We used a 40 % reduction of blood cholinesterase activity as the action level to remove workers from exposure. Workers so removed were usually transferred to a job without pesticide exposure.

The concentration of parathion in air samples from the breathing zone of workers was 139 (SD 70), 91 (SD 34), and 87 (SD 44) mg/l at different periods of time.

The effectiveness of the application of soap paste onto skin for prevention was demonstrated on laboratory animals with the labeled pesticide (13).

Developing biological monitoring devices and therapeutic antidotes

A simple kit for estimating blood cholinesterase activity was developed for the biological monitoring of exposure and the early detection of acute poisoning (unpublished results of Xue et al). Thousands of such kits were sent to primary health care units in the mid-1960s. The test sample is simply matched with six pieces of colored glass in the tintometer; the result can easily be read after 15 min of incubation of the sample and substrate. The limit of discrimination is

Table 2. Amount of parathion contamination on worker.

Location of sample and source	Commune members		College students	
	Number measured	Mean level of parathion contamination (mg)	Number measured	Mean level of parathion contamination (mg)
Face mask	8	10.1	8	10.1
Arm (30 cm ²)	4	5.7	4	4.9
Glove of right hand	4	1 271.0*	4	307.8
Leg (30 cm ²)	4	30.8*	4	6.0

* $p < 0.01$.

10 %. Forty percent reduction of the enzyme activity was set as the warning limit for removal from further exposure. If this limit was reached together with some mild symptoms, such as headache, dizziness, blurred vision, sweating, nausea, excess salivation, etc, the subject was advised to see a physician for treatment.

The antidote 2-PAM (pralidoxime iodide) was already made available in hospitals and drug stores at the beginning of the 1960s, through the collaboration of the Department of Pharmaceutical Chemistry, School of Pharmacy, and the Department of Occupational Health, School of Public Health, Shanghai First Medical College (12, 16). The requirement of intravenous injection of a relatively large amount of solution was difficult, however, for most primary health workers, and the use of 2-PAM was limited to first-aid or emergency treatment. Since 1964, therefore, intramuscular preparations of safer 2-PAM chloride and the more potent reactivator DMO₄ (obidoxime) have been provided to the countryside by the same groups (3, 4, 11, 12, 16). This change greatly facilitated treatment because of simple administration and less frequent adverse side effects.

A successful example

Many sprayer groups successfully did their work safely for a long time. Introducing and demonstrating their experience in a scientific way would, of course, be more convincing, but we are unable to do so. However, Chie-Tong Commune is a useful example. During a 10-year period, it doubled its cotton production yield per acre (1 acre = 0.405 ha) and the total amount of parathion and demeton used reached 5 t for these years. The accumulated work of sprayers approached 11 411 person-years. Only 18 cases occurred among

these workers for an incidence of 0.16 %. A survey revealed that the amount of dermal contamination of 37 sprayers was significantly lower than that of the sprayers in neighboring communes (eg, their erythrocyte cholinesterase activity was less reduced). The effectiveness of prevention in Chie-Tong Commune was further supported (9) (table 6).

Table 3. Analysis of the causes of poisoning according to routes of entry.

Route of entry	Cause of poisoning	Percentage
Percutaneous	Nonuse of protective gloves during work	21
	Clothes soaked by pesticide solution	18
	Spraying against the wind	13
	Arms and legs bare during work	10
	Use of leaky tools	9
Respiratory	Misuse of the concentrated pesticide formula	8
Oral	Eating during work	7
	Taking food with unwashed hands	4
Miscellaneous	Combined	10

Table 4. Amount of parathion on extremities and protective devices.

	Number of determinations	Amount of parathion (mg/30 m ²)	
		Mean	SD
Leg	18	0.31	0.029
Dorsum of feet	21	0.37	0.045
Cloth, glove	14	1.31	0.080

Table 5. Blood cholinesterase (ChE) activity and excretion of parathion metabolites in urine from different types of sprayers and formulators.

Subjects	Blood ChE activity (ΔpH/h)			Urinary p-nitrophenol (mg/l)		
	Number of measurements	Mean	SD	Number of measurements	Mean	SD
Well protected sprayers	59	1.59	0.026	112	70	7
Partly protected sprayers	53	1.44	0.027	94	79	9
"Poorly" protected sprayers	56	1.53	0.022	90	97	12
Formulators	11	1.34	0.069	21	140	36

Table 6. Comparison of the conditions of two groups of sprayers.

Commune ^a	Parathion in air (mg/l)	Average contamination (mg/cm ²) on hand and foot in 3 h	Plasma cholinesterase activity	Erythrocyte cholinesterase activity
Chie-Tong (N = 37)	0.0—0.9	0—20.1	72 %	59 %
Xe-Shia (N = 18)	1.0—2.7	6.0—44.1	72 %	49 %

^a N = number of study subjects.

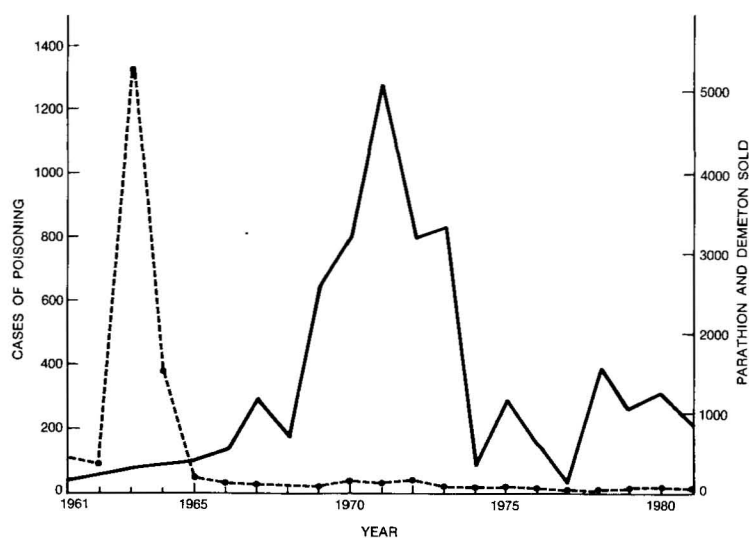


Figure 1. Change in the amount of parathion and demeton sold and the number of cases of poisoning due to them. The solid line represents the tonnage of parathion and demeton and the broken line the number of cases of poisoning, all in relative figures referring to 1961 as 100.

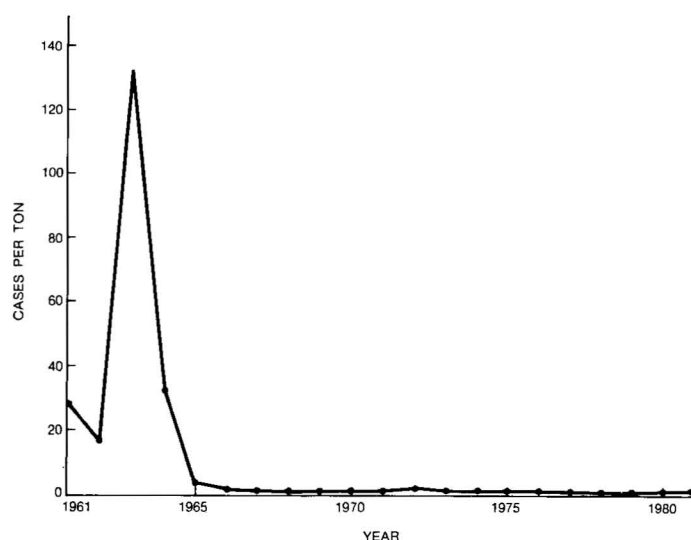


Figure 2. Change in the number of cases of poisoning per ton of parathion and demeton sold.

Table 7. Severity of poisoning (in percentage) in 1961—1975.

Degree of severity	1961—1962	1964	1973	1974	1975
Severe (with coma)	10.2	10.0	1.1	0.0	0.0
Moderate (with tremor)	45.2	71.1	17.4	29.2	1.8
Mild	44.6	18.9	81.5	70.8	98.2

Preventive measures and experiences

According to the statistical analysis of reported poisoning cases, incidence clearly correlated inversely with the preventive programs. Poisonings have declined since 1965 in spite of an increased use of parathion and demeton. Figure 1 shows the relative proportions of the amount of the toxic pesticides sold and the number of cases reported, using 1961 with an index of 100 as the reference year. For comparison, the number of

poisonings per ton of use of these chemicals is shown in figure 2. In addition, the severity of intoxication was also reduced (table 7).

The feasibility of long-term and large-scale control of intoxication in the use of the highly toxic pesticides parathion and demeton was demonstrated. This achievement was accomplished by the efforts of vast numbers of administrative officials, health workers, and commune members living in the area. The major activities of this prevention program, in addition to

those already described, were: (i) establishing a joint committee of related departments to collaborate in planning, facilitating, inspecting, and reviewing all the related activities; (ii) promulgating rules and precautionary guidelines for the handling of highly toxic pesticides; (iii) training and education, for special professional groups, sprayer teams, and the general population; (iv) changing kinds of pesticides, using less hazardous ones instead of highly toxic ones, parathion and demeton being substituted by dimethoate, methylparathion, fenitrothion, orthene, etc; (v) changing the formulation of pesticides, concentrated emulsion preparations being substituted by diluted powder formulations; (vi) improving the method of application by increasing the use of machine tools; (vii) environmental monitoring and health surveillance; and (viii) convening meetings for different levels of workers and for professional groups for summarizing and exchanging information.

From the past 20 years of field work, our experience in preventing organophosphorus insecticide poisoning may be summarized as follows:

1. The prevention of poisoning is a multisectoral task. The health and antiepidemic station works jointly with different sectors, such as the plant protection division, the distributing agency, the commune hospital, and leaders of brigades. Each sector has its own duty, but precautions in preventing poisoning should be observed at every step.
2. The achievement should also be attained through self-reliance of the commune members. Sprayers, as well as managers of the production teams, should be educated about the risks and preventive measures in handling toxic pesticides. Everyone should realize that health cannot be given by others, but can only be attained through one's own effort.

The wide variation in agricultural conditions, the types and amounts of pesticides used, and the preventive measures adopted in different regions and countries make it inappropriate to compare records of pesticide poisoning reported in the literature and ours. But reviewing some of these data would still be interesting.

The reporting system for pesticide intoxication in California in the United States is thought to be the best in the developed countries. In 1979, 472 cases of systemic poisoning were reported and in 1980, 600 (8). An incidence of 23–25 % among individual farmers during 1965 and 1966 was reported in Japan (2). At the International Symposium on Hazards of Pesticides to the Environment and Human Health held in Egypt in 1978, it was reported that 15 105 cases of pesticide poisoning were reported during 1966–1977 in Egypt, with an annual average of 1 259. There were 363 deaths in the same period, an annual average of 30, with a

death rate of 2.4 % (5). (About 0.1 % of our cases died.) All of these data represent problems. We therefore suggest that our experience may be helpful to fellow workers under similar conditions in the People's Republic of China and elsewhere, especially in some developing countries.

Now, with the situation gradually changing as the acute episodes subside, the long-term adverse effects of pesticides may be more important. Since these effects are difficult to recognize, much more research is urgently needed. In some counties and communes in the People's Republic of China, professional or commercial plant protection teams are beginning to take most of the responsibility for handling highly toxic pesticides. With the use of mechanical tools to raise efficiency, much larger amounts of pesticides will be handled. Health care of these high-risk groups of workers is another challenge for us to meet.

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