# PESTICIDES IN ZIMBABWE

## Toxicity and Health Implications

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# 7
# Organophosphate Poisoning in Urban Zimbabwe

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## Summary

Between 1969 and 1989, 973 organophosphate (OP) poisoning cases were recorded and analysed. Of these, 776 cases (79,8 per cent) were admissions recorded and analysed retrospectively at the six referral hospitals of Zimbabwe. The remaining poisoning cases were from a rural hospital and formulating and packaging factories and large-scale commercial farming areas.

Of the total, 459 cases (47,2 per cent) were suicides and/or parasuicides, whereas 241 (24,8 per cent) were accidental cases. Of the latter, 7 and 14,4 per cent were due to industrial and agricultural exposure respectively. Among the 776 admission cases, 12 (1,2 per cent) were homicidal, and 66 (6,8 per cent) were of undetermined nature and mortality rate was recorded as 81 (8,5 per cent). All studies associated with OP poisoning carried out over this period reveal that the age group 21–30 years is significantly more prone to poisoning than all other age groups.

The most common first line of treatment was a combination of ipecacuanha syrup plus atropine, with atropine alone a poor second.

Pesticides are used in agriculture and in public health programmes to control pests and vector-borne diseases that are found on food and commercial crops and as infestations in domestic and commercial buildings and on man and domestic animals. In Zimbabwe, some of the pests that cause problems are termites, white grubs (maize), red bollworms, mites, citrus pyslla, black beetles and others (Kasilo *et al.*, 1991).

Organophosphates are among the most commonly used insecticides in Zimbabwe. The other two main groups are carbamates and organochlorines. Newer insecticides such as the synthetic derivatives of pyrethrin – the pyrethroids – have been added to this list. Organophosphates are compounds that contain carbon and are derivatives of phosphorous acid. The earlier products were highly toxic but readily decomposable alkyl derivatives of phosphates and pyrophosphates. Latter, the less toxic thiono and dithio derivatives were developed. Introduced recently are the dialkyl aryl and alkyl diarylthioxo phosphates. These have lower mammalian toxicity but greater persistence.

The obvious advantage of using of insecticides is outweighed by the risks they can pose to humans and the environment. Sound evaluations of the health hazards of insecticides and easy access to these evaluations will help nations choose those insecticides that will create the fewest risks (Ekstrom and Ekerblom, 1990).

Application of insecticides on farms is done by aircraft, tractor spraying and ultra low volume backpack sprayers. Exposure to workers is related to the methods of application, that is, skin and inhalation of aerial sprays, contact with the spraying machines, mixing of the chemicals and orally from drinking contaminated water or eating contaminated crops (Bwititi *et al.*, 1987).

Organophosphates are of varying toxicity. For example, the estimated oral fatal dose of parathion for an adult is approximately 0,1–0,3 g as compared to 25 g of diazinon and 60 g of malathion. One drop of undiluted parathion in the eye may be fatal. Most serious toxicity of malathion results from the impurity, isomalathion, which possesses an $LD_{50}$ in rats of approximately 100 times greater than that of malathion (Ellenhorn and Barceloux, 1988).

The toxicity of OPs in both man and target insect population is caused by the inhibition of cholinesterase enzymes by phosphorylation and subsequent accumulation of acetylcholine at the susceptible receptors. These compounds react with cholinesterase to produce a relatively stable phosphorylated enzyme. This reaction is progressive in time and temperature dependent. In most cases, the phosphorylated acetylcholinesterase enzyme is fairly stable resulting in slow recovery from intoxication. Spontaneous reactivation may occur but the rate of reactivation depends on the animal species as well as the chemical group attached to the enzyme. This is of importance in determining the duration of clinical features of poisoning (Kasilo *et al.*, 1991). Where spontaneous reactivation is rapid there may be a speedy resolution of toxic signs and symptoms.

Information and data from published studies on organophosphate poisoning in urban Zimbabwe (Bwititi *et al.*, 1987; Nhachi 1988 and 1989) were compiled (Tables 1–6 and Figures 1–3). These included retrospective analysis of 35 cases in a five-year period, 1969–1973 (Mackingtosh *et al.*, 1978), 105 cases from Harare hospital in a four-year period, 1974–1977 (Hayes *et al.*, 1978), and a 10-year period, 1980–1989 (Kasilo *et al.*, 1991), analysis of poisoning cases at six major referral hospitals in Zimbabwe's four main urban areas – Harare, Bulawayo, Mutare and Gweru. The six hospitals studied are the penultimate referral health institutions from way down the ladder at the rural health centre or clinic if need be. The six hospitals were Parirenyatwa, Harare, Gweru, Mutare, Mpilo and United Bulawayo. Health hazards in organophosphate use among agricultural and industrial workers were also studied (Bwititi *et al.*, 1987; Mackingtosh *et al.*, 1978. and Hayes *et al.*, 1978). In Mackintosh's study (1978), plasma cholinesterase activity was measured in persons selected as being at risk because of known contact with pesticides. Note was made of the particular pesticide to which the worker was exposed, the type and duration of

exposure and what precautions, if any, were taken. Those selected for testing were employees of eight farms whose chief produce and methods of spraying are indicated in Table 2 (Hayes *et al.*, 1978).

Data for the study performed during 1980–1989 (see Tables 4–6) were collected from the Medical Records Departments (hospital recorded cases) of six urban hospitals.

The information extracted from the records on poisoning due to organophosphates included patient's age, sex, marital status, occupation and area of residence, times of poisoning, admission, and discharge, symptoms on arrival, treatment given and outcome, circumstances and reason of poisoning.

The national statistics on poisoning for the 1980–1990 study were obtained from the Government Analyst Laboratory annual reports. The Laboratory provides diverse services which include forensic toxicological analysis to the cases involving chemical poisoning and services to clinics and hospitals through routine analysis of patient specimens for pesticide, drug and other chemical poisoning. During 1980–1989, 606 cases of organophosphate poisoning from an urban population of about 3 million were studied.

The annual incidence of organophosphate poisoning during the years 1974, 1975, 1976 and 1977 were 14, 10, 19 and 62 cases respectively (Table 1). The source of the poison for each year is shown in Table 1. Forty-four patients admitted that they had ingested poison in an attempt to commit suicide. Patients who had accidentally ingested poison did so in contaminated food or accidentally drank the poison while intoxicated with alcohol. A few cases of accidental ingestion of poison by young children were included in this group. Agricultural contamination usually occurred from contact with insecticide sprays or cattle dips, while contamination in industry occurred from contact with certain furniture lacquers. Although 38 patients did not give a positive history of the source of contact, most related the onset of symptoms after ingestion of vegetables or concoctions of "home-brew" consumed in the rural areas. The increasing availability of organophosphate compounds to the public and their growing popularity as suicidal agents is a point of worry. However, a large number of patients gave no history of contact with organophosphate compounds and were not exposed to these chemicals or their place of work (Table 1). The source of poison in these cases is open to debate. Most of these patients dated their symptoms back to ingestion of vegetables during festivities in the rural areas, but there was no direct evidence that these vegetables had been sprayed with organophosphate insecticides. Perhaps some herbal remedy contains substances allied to organophosphate compounds, but there was seldom any history of ingestion of such a remedy and this postulate would not account for the increasing prevalence in 1978.

It is of interest that so few of the patients reported in Table 2 were poisoned as a result of contamination in industry and agriculture, the farm workers particularly so, in view of the fact that cholinesterase levels of workers involved in manufacture of organophosphate chemicals have been found to be reduced,

often markedly. It takes approximately five days before whole blood cholinesterase levels revert to their normal values (Matchaba, 1994). The measurement of pre-exposure cholinesterase values is essential for comparison of values after pesticide use (Matchaba, 1994, Loewenson and Nhachi, 1994 and Jeyarathnam, *et al.*, 1986).

**Table 1:** Causes of poisoning in cases involving organophosphates in patients admitted at Harare Hospital during 1974–77, in factory and farm workers in Mashonaland West and Manicaland

| | Number of patients, factory and agricultural workers | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1974 | 1975 | 1976 | 1977 | 1988 | Total | % |
| Suicide | 9 | 8 | 11 | 16 | — | 44 | 14,5 |
| Accidental ingestion | 4 | 2 | 2 | 4 | — | 12 | 4,0 |
| Industrial contact | 0 | 0 | 0 | 3 | 65 | 68 | 22,5 |
| Agricultural contact | 1 | 0 | 4 | 3 | 132 | 140 | 46,4 |
| Unknown | 0 | 0 | 2 | 36 | — | 38 | 12,6 |
| Total | 14 | 10 | 19 | 62 | 197 | 302 | 100,0 |

*Sources*: Hayes *et al.* (1978) and Loewenson and Nhachi (1994).

The distribution of poisoning cases from organophosphates and other insectides reported at the six referral hospitals in Zimbabwe during 1980–89 are reported in Table 3. Of the 819 cases of insecticide poisoning, 606 (69,2 per cent) involved organophosphates. Only 17 cases of poisoning were recorded at Gweru General Hospital as compared to other hospitals because there was no systematic recording system until 1988. Similarly, the 1980–84 records from Bulawayo hospitals were scanty, probably for the same reason as for Gweru.

Table 4 shows that males (412) outnumbered females (194) (significant at $P < 0,05$). While some figures from other studies (Goulding, 1991) revealed that women tend to predominate among suicidal and/or parasuicidal cases. Findings from Zimbabwe (Kasilo *et al.*, 1991) and India (Adityanjea, 1991) reported men to predominate and organophosphates poisons are among the commonest agents used. Perhaps, in Zimbabwe and India, men are more often exposed to these substances than women. It is of interest to note that poisoning in urban Zimbabwe is predominantly intentional as the majority of patients, 44 (7 per cent) and 450 (74 per cent) were suicidal and parasuicidal cases respectively

**Table 2:** Farm produce and spraying methods

| Farm | Produce | Method of Spraying |
|---|---|---|
| 1 | Flowers | Knapsack |
| 2 | Vegetables | Knapsack |
| 3 | Vegetables | Knapsack |
| 4 | Strawberries | Tractor |
| 5 | Wheat | Tractor and aerial |
| 6 | Citrus, wheat and maize | Tractor, aerial and manual |
| 7 | Wheat | Aerial |
| 8 | Cattle | Spray-race and plunge dip |

**Table 3:** Distribution of OPs and other insecticides reported at the six referral hospitals in Zimbabwe during 1980–89

| Hospital | OP and other insecticides | Percentage |
|---|---|---|
| Gweru* | 17 | 2,1 |
| Harare** | 266 | 32,5 |
| Mutare | 124 | 15,1 |
| Parirenyatwa | 324 | 39,6 |
| Bulawayo Central Hospitals | 88 | 10,7 |
| Total | 819 | 100,0 |

* Only for 1988–89

**In 1969–73 and in 1974–77 OP cases seen at Harare Hospital were 35 (Mackintosh *et al*, 1978) and 105 (Hayes *et al.*, 1978) respectively.

*Source:* Nhachi and Kasilo, 1992

reason for suicide or parasuicides is domestic dispute and is prevalent among married couples. In a similar study conducted at a rural hospital, the number of suicides or parasuicides accounted for only 30 per cent of the cases (Nhachi, 1988). It could be that urbanisation nurtures more social pressures than rural life. The outcome was death in 25 per cent (60) of all the recorded cases, 5 per cent of which were homicides. Making stricter legislation regarding the availability, sale, distribution, safer storage and disposal of pesticides may reduce the incidence of self-poisoning.

Thirty cases (5 per cent) only were recorded as unclassified (Kasilo *et al.*, 1991). This is a positive sign, since this may relate to the vigilance of the health personnel, relatives or friends of the victims.

Table 4: An analysis of OP insecticides admission cases recorded at one rural hospital in 1988 and at the six urban hospitals from 1980–89

| | Rural | Urban | Total | % |
|---|---|---|---|---|
| Number of OP cases | 30 | 606 | 636 | 100 |
| Number of males | 13 | 412 | 425 | 67 |
| Number of females | 17 | 194 | 211 | 33 |
| Number of accidental cases | 21 | 126 | 147 | 23 |
| Number of suicides and parasuicidal cases | 9 | 450 | 459 | 72 |
| Number of deaths | 0 | 48 | 48 | 7,5 |
| Number of homicides | 0 | 12 | 12 | 18,9* |
| Unclassified cases | 36 | 30 | 66 | 10,4 |

* denotes 18,9 per cent of all the recorded deaths.

*Source:* Nhachi, 1988 and Kasilo *et al.*, 1991.

It is of particular interest to note that a fatality rate of 0,6 per cent has been recorded in a developed country as compared to 25 per cent in a developing country (Goulding, 1991). This figure denotes a difference of about 42 times. Most likely, the difference is due to differences in pesticide legislation laws, pesticide handling practices and pesticide availability. The route of exposure in poisoning cases was mostly ingestion as shown by the ten most common treatment regimens (Table 5). The organophosphate that was associated with suicide or parasuicide in the majority of the cases was dimethoate (Rogor).

**Table 5:** Common treatment regimens instituted

| Treatment | Number |
|---|---|
| Atropine and ipecacuanha syrup | 42 |
| Atropine alone | 19 |
| Atropine and gastric lavage | 16 |
| Ipecacuanha syrup alone | 14 |
| Atropine, ipecacuanha syrup and ampicillin | 11 |
| Atropine, ipecacuanha syrup and mist magnesium trisilicate (MMT) | 5 |
| Tryptanol and ipecacuanha syrup | 4 |
| MMT and ipecacuanha syrup | 3 |
| Atropine and i.v. fluids | 3 |

A significant increase in the number of organophosphate poisoning cases is very evident in the study 1980–89 as shown in Figure 1. Figure 2 shows that poisoning incidences distribute evenly throughout the year, with no particular monthly preponderance. This is because parasuicidal and suicidal cases are not time or period-dependent. A study by Bwititi *et al.* (1987) on health hazards in organophosphate use among farm workers in the large-scale commercial farming sector in Zimbabwe revealed that poisoning incidences occur during the four-month spraying season, December to March.

Figure 3 shows that the age group 21–30 years is the single most vulnerable group (42 per cent of the total cases). Previous studies have shown similar results (Kasilo *et al.*, 1991 and Jeyarathnam *et al.*, 1986).

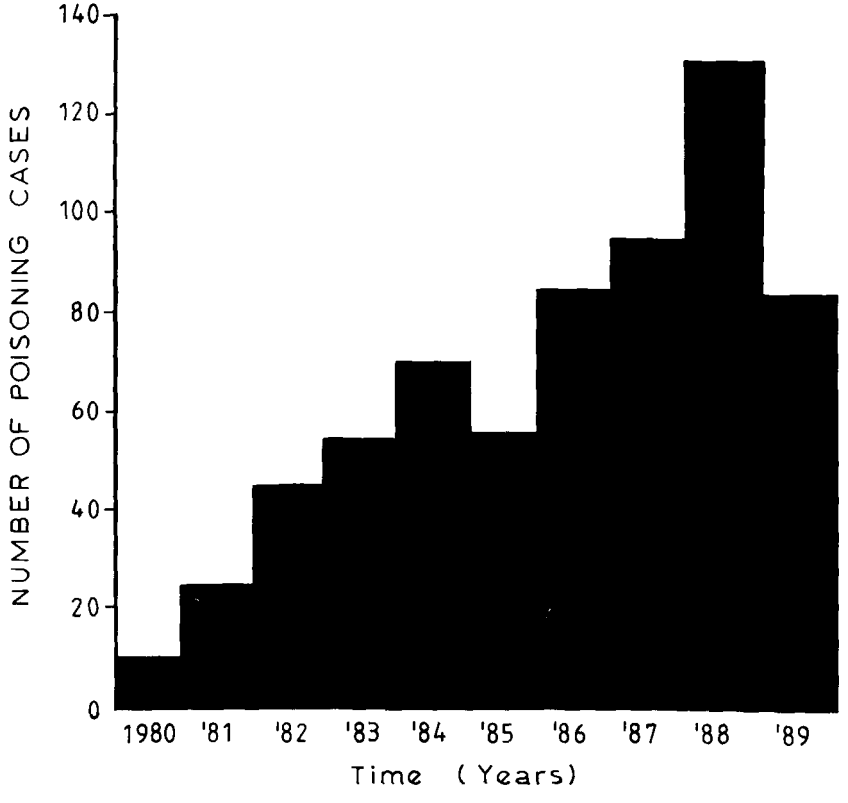


**Figure 1:** Distribution of poisoning cases according to year. The asterisk denotes data for the period 1st January to 31st August 1989.

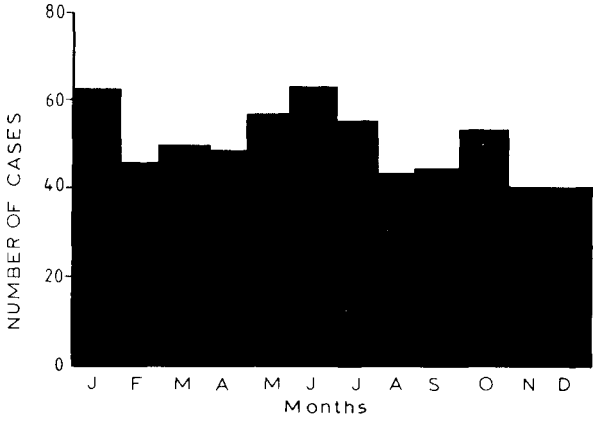


**Figure 2:** Distribution of poisoning cases (accumulated) according to mon
from 1st January 1981 to 31st August 1989.

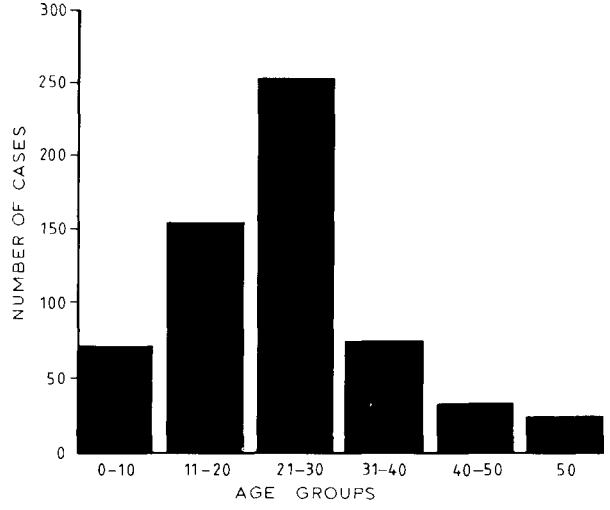


**Figure 3:** Distribution of poisoning cases according to age group.

The data presented here may not give a complete picture of organophosphate poisoning in urban Zimbabwe and the farming sector since it is based only on recorded admissions and health hazards in organophosphate use among limited farm workers. Nevertheless, these results are of significant importance. A sizeable amount of the health budget could be saved annually if incidences of intentional poisoning could be curbed by stricter legislation in order to prevent access to organophosphates by unauthorised personnel. Research should also concentrate on behaviour that leads to pesticide intoxication. This should be done concurrently with proper prospective and retrospective surveys of cases of poisoning in the communities of high pesticide use for accurate assessment of pesticide-related morbidity and mortality. More information should be sought relative to the decision process of import, legislation and licensing. Research and development efforts in appropriate technology and safety devices are also critically needed (Forget, 1991).

It should be pointed out that the use of antibiotics in the treatment regimens of organophosphate poisoning where risk of infection is not evident is irrational, not cost-effective and may exacerbate incidences of antibiotic resistance and should, therefore, be discouraged.

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