PESTICIDES IN ZIMBABWE

Toxicity and Health Implications

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Epidemiology of the Health Impact of Pesticide use in Zimbabwe

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Summary

About 30–50 per cent of the workers on large-scale commercial farms involved in pesticide use in Zimbabwe are exposed to organophosphates during the spraying season. Pesticide exposure is associated with use of manual techniques, little provision of protective clothing and inadequate safety information. There is evidence that pesticide exposure spills over into non-sprayers and into the communities living on farms. Hospital admissions for acute poisoning appear to be a poor guide to the extent of sub-acute or chronic exposure to pesticides, given the extent of exposure documented in the surveys. The use of simple biological monitoring techniques can be extremely useful in epidemiological assessment of patterns and possible sources of exposure. The findings of the studies reported in this chapter add weight to the growing body of evidence that there is a need for a greater allocation of resources towards identifying and controlling the negative health impact of pesticide use in developing countries.

Introduction

The use of pesticides has become an integral part of agricultural production worldwide. Today, more than one kilogram of pesticides is applied yearly for every person on earth. The value of global sales of pesticides doubled from 1972 to 1985, the most rapid growth being in the Third World. Africa has the fastest growing market, with sales increasing by 182 per cent between 1980 and 1984 (WHO, 1989).

Most pesticides are developed, tested and manufactured in developed countries situated in temperate climates. Attempts made to simulate tropical climatic conditions do not address all the interacting factors producing the environment of pesticide use in developing countries. Of the approximately 3 350 pesticides in existence, information to make even a partial assessment of effects is known for only one-third (Goldenman and Rengam, 1987).

In 1984, the Economic and Social Commissions of Asia and the Pacific estimated two million cases of pesticide poisoning in the world each year and 40 000 fatalities (Staring, 1984). The World Health Organisation (WHO) estimated 50 per cent of fatalities to have occurred in developing countries (Wambugu, 1987). The direct health effects of pesticide use may be acute (due to a single dose or exposure) or sub-acute (due to low level, short-term exposures). Acute poisonings are usually detected through the hospital system, police reports or forensic laboratories. In developing countries, these sources probably underestimate the real extent of acute poisoning, due to poor access to health services and notification of poisonings, particularly in rural areas, where pesticide use is high. These biases may inflate the reported proportions of particular types of poisonings, such as deliberate use of pesticides for suicide in urban communities.

There is evidence of reversible illness effects of low-level exposure to pesticides, although the exact relationship between these effects and acute or chronic poisoning is not fully elucidated. Low-level exposure to organophosphate pesticides is associated with symptoms such as anxiety, nausea, vomiting, abdominal pains, diarrhoea, blurred vision and dizziness. However, there is little evidence (in the literature) of a direct relationship between these symptoms and reduced blood cholinesterase activity.

Chronic organophosphate and organochloride pesticide poisoning has been noted to result in damage to the nervous, digestive and cardiovascular systems, including delayed polyneuropathy (Namba *et al.*, 1971) and neuropsychological impairment (Savage *et al.*, 1984 and Rosenstock 1990). Dipyridals, such as the herbicide paraquat, produce local injury to the skin, eyes, respiratory and gastrointestinal systems, including nasal bleeding and lung damage. The International Agency for Research on Cancer (IARC) has indicated that a number of pesticides, including ethylene dibromide, ethylene oxide, chlorophenols, chlorophenoxy herbicides have been associated with an elevated risk of soft tissue sarcoma's (IARC, 1987; Harder and Sandstorm 1979 and Balarajan and Acheson, 1984)

Zimbabwe has about 500 registered formulations of pesticides, half of which are for insecticides, 21 per cent herbicides and 16 per cent fungicides (Ncube *et al.*, 1987). Although pyrethrins are gradually assuming a central role at the expense of organochlorines, organophosphates are the most widely used pesticides, followed by organochlorines and carbamates (Bwititi, 1983).

Agrochemical consumption is concentrated within the large-scale commercial farming sector, but is also increasingly used by other sectors (peasant, resettlement and small-scale farmers).

There is no consistent monitoring system for reporting agrochemical poisonings in Zimbabwe. Scattered data exist on the extent of acute pesticide poisoning reports to health facilities. At Harare Central Hospital in the 18 months from January 1980 to July 1981, there were 120 cases of organophosphate poisoning alone, 16 per cent of which were fatal; 12 per cent of these were in children under the age of ten years (Bwititi, 1983). In the two years, 1987 and 1988, 167 cases of organophosphate poisoning were admitted to the two central hospitals in Harare, 85 per cent of these reported as deliberate ingestion (Munyikwa and Levy, 1990).

In 1985, a questionnaire was sent to district medical officers (DMOs) staffing rural district hospitals (secondary level curative care), with responses obtained from 27 district hospitals (48 per cent of the total) on admissions for and management of pesticide poisonings (Bwititi and Loewenson, 1987). October to January, the intensive months of agricultural spraying, were reported as the peak incidence period of poisoning, with 46 per cent of annual cases reported in these four months. Of the 274 cases reported, 20 per cent were in children under the age of 15 years. Half the cases were in adult males and 30 per cent in adult females. The greatest proportion of poisoning was reported by the DMOs to be due to organophosphates and came from large-scale commercial farms.

Biological monitoring of workers using organophosphates is carried out in some industries in Zimbabwe, but not on farms and the results in industry are not analysed epidemiologically. Exposure to DDT used only in public health spraying for *Anopheles* mosquito, the vector of malaria, has been investigated (Mpofu, 1990 and Nhachi and Loewenson, 1989). The studies reported here are, however, the first assessment of occupational exposure in rural areas.

Workers' assessment of occupational exposure to pesticides

In a repeated cross-sectional study carried out in 1985/86 on 12 large-scale commercial farms in Mashonaland Central province, a cotton-growing area in Zimbabwe, occupational exposure to organophosphates was assessed by comparing cholinesterase activity levels in sprayers and non-sprayers before, during and after the spraying season. The WHO spectrophotometric kit was used to measure cholinesterase activity levels, the methods and study design being more fully described in Bwititi *et al.* (1987). In 1988/90, two further studies of organophosphate exposure were carried out in large-scale commercial farming areas producing cotton and coffee in Mashonaland West and Manicaland provinces respectively.

In the peak spraying months, February–March, of 1988, a cross-sectional survey was carried out on 65 male workers in 15 randomly selected large-scale commercial cotton-producing farms in Mashonaland West (a northwest province of Zimbabwe). All workers spraying or using pesticides on these farms within the previous four weeks were tested for cholinesterase activity levels using the WHO spectrophotometric kit and interviewed to obtain information on pesticide use during the previous one-month period, work practices, knowledge about pesticide safety and symptoms experienced. The surveyed workers were mainly using dimethoate (a red-triangle organophosphate), thiodan (a red-triangle organochlorine) and cybolt (a pyrethroid). Most workers, 47,6 per cent, were using knapsack or ultra low volume (ULV) sprayers, while 38,5 per cent were involved in tractor spraying and 9,2 per cent in mixing and formulating the pesticides. Two workers (3,1 per cent) were both mixing and spraying, while one reported working with pesticide packaging. Most workers (31 per cent) were 31–40 years old.

In November-December 1988, 67 male workers were tested in a cross-sectional survey (as described above) of randomly selected large-scale commercial coffee farms in Manicaland (an eastern province of Zimbabwe) during months of relatively intense spraying. All workers using pesticides in the selected farms were included in the study. The workers were primarily using parathion (a red-triangle organophosphate) and spraying for at least 10 months of the year. Most workers (74,6 per cent) were involved in tractor spraying, while 11,9 per cent were involved in handgun spraying, 4,5 per cent in ultra low volume (ULV) spraying and 6 per cent in mixing and formulating pesticides. One worker reported working with aerial spraying. The majority of the workers in this study (40 per cent) were 21–30 years old.

While initial tests in the 1985/86 Mashonaland Central study showed no differences between sprayers and non-sprayers, by mid-season, the cholinesterase activity levels of the sprayers were significantly reduced ($p \leq 0{,}05$) and significantly less than those of the non-sprayers ($p \leq 0{,}05$).

Up to 30 per cent of workers using pesticides had cholinesterase activity levels at or below 75 per cent of the reference standard levels (Bwititi *et al.*, 1987).

Non-sprayers in this study also experienced a slight, but not statistically significant decline in cholinesterase activity levels during the spraying season. Some exposure may have arisen out of poor control of distribution of pesticides (with toxic substances easily available to the public), poor storage of pesticides, re-use of pesticide containers, contamination of food and water sources or through too early re-entry onto recently sprayed fields. While workers reported returning used pesticide containers to the farmer, burning or burying them, 12 per cent said they re-used them for domestic purposes and 30 per cent thought the containers could be used for water and food storage.

The mean cholinesterase activity levels of non-sprayers were not significantly different throughout the spraying season to the 100 per cent activity level standard of test. This finding justified using the 100 per cent activity level in test kit (also found in a control group of non pesticide exposed university staff members) as a reference value of non-exposed workers for studies of other exposed populations.

This was a useful finding as repeated cross-sectional studies comparing workers against pre-spraying baselines are not always feasible, given the employment patterns and remote location of many farm workers in Zimbabwe. While this assumption applied to grouped data, it was noted that interpretation at the individual level would still be best made against that individual's pre-spraying baseline.

Over half (54 per cent) of workers in both the Mashonaland West and in the Manicaland studies had cholinesterase activity levels less than or equal to 75 per cent standard (see Table 1). Although exposure was high in both areas, cholinesterase activity levels were lower in areas of cotton production (see Table 1).

Table 1: Cholinesterase activity levels by area, Mashonaland West and Manicaland, 1988.

Cholinesterase activity level % of standard	Mash. West Number	Mash. West % Total	Manicaland Number	Manicaland % Total
< 37,5	5	7,7	0	0,0
38 - 50	8	12,3	4	6,0
51 - 62,5	13	20,0	9	13,3
63 - 75	9	13,8	23	34,3
76 - 87,5	22	33,8	11	16,4
88 - 100	8	12,3	20	29,9
Total	65	100,0	67	100,0
Mean activity level (%)	74,15		81,34	
SE	2,32		1,87	

Cholinesterase activity levels were lower in Mashonaland West (cotton-growing areas) where manual spraying was more common. In this area, exposure was significantly greater (as measured by cholinesterase depression at or below 75 per cent normal) in workers mixing pesticides or using knapsack or ULV sprayers than those using tractor sprayers (see Table 2). This trend was found after controlling for chemical type, that is, for different spraying techniques within the same chemical group (see Table 3). Workers indicated that their knapsacks often leaked onto their backs. There is need to further investigate the manual spraying techniques, both in respect of the equipment and the spraying practices. Pilot studies by the authors of the field use of backpack sprayers indicated that poor maintenance of equipment and incorrect practices may contribute to exposure.

Table 2: Method of application/exposure by cholinesterase activity level, Mashonaland West, 1988.

Method	Cholinesterase activity % with <75 %	>75 %	N
Formulation	50	50	6
Packaging	0	100	1
Tractor spraying	28	72	25
Knapsack/ULV	74	26	22
Mixing and spraying	100	0	2

Table 3: Cholinesterase activity by pesticide type and method of application, Mashonaland West, 1988.

Pesticide type	Application method	Cholinesterase activity % with <75 per cent	>75 %	N
Dimethoate	tractor	17	83	6
	manual	75	25	4
Thiodan	tractor	33	67	3
	manual	00	0	2
Delcin	tractor	25	75	4
	manual	100	0	1

In all survey areas, administrative controls such as reducing work times or job rotation were not evident. In Mashonaland Central, for example, the same workers reported to be carrying out spraying throughout the season, with about 55 days of spraying per year. Workers reported that they did not get adequate information on safe use of spraying technologies, except in relation to spraying upwind. Most were, however, cautioned to wear protective clothing. The selected method of protection against exposure appears to have been through provision of protective clothing.

Despite this emphasis on personal protection as the selected means of control, it is probably neither adequate nor effective. In the 1988/89 survey areas, provision of protective clothing was variable and poorest in Mashonaland West where exposure was higher (see Table 4). There was no statistical relationship between provision of protective clothing and cholinesterase activity levels. There is need to look more closely at how effective the current protective clothing is (the state of repair, fit, extent of use, etc.) and how it is used.

Table 4: Protective clothing used when working with pesticides (as reported by the workers, re-use in past four weeks).

	Mash. West (N=65)		Manicaland (N=67)	
Type of clothing	No. given	% total	No given	% total
Gloves	31	47,7	44	65,7
Overalls	47	72,3	64	95,5
Mask	8	12,3	65	97,0
Boots	38	58,5	58	86,6
Goggles	28	43,1	5	7,5
Respirator	NA	NA	12	17,9

NA = Not available. In Mashonaland West, field workers combined the two categories "respirator" and "mask".

Problems in the work environment interact with behavioural factors to increase the risk of exposure. For example, workers with hand contamination due to manual spraying techniques ingest pesticides when they eat or smoke in the fields. In the cotton and coffee production survey areas, while 52–69 per cent of workers indicated that they smoked cigarettes, only a fifth of these said they smoked in the fields. Food consumption while at work was also low in both areas. In Mashonaland West, neither smoking nor eating in the field were significantly associated with cholinesterase activity levels. In Manicaland, 81 per cent of surveyed workers who smoked had reduced cholinesterase activity compared to 23 per cent of non-smokers. It is not clear whether this result is due to hand contamination or other factors.

According to employers in the Mashonaland Central survey, workers were instructed prior to pesticide use to be "careful", not to eat or drink while spraying, to wash their hands after spraying, to wear protective clothing and to ensure that all sprayers are upwind of the spray. One-third (34 per cent) of the sprayers, however, claimed to have received no instructions before use, while the remainder said they had been instructed on use of protective clothing and not to smoke and/or drink in the fields. Workers did not know the chemicals they were using or their effects. Coloured triangles have been introduced to enable illiterate workers to tell the toxicity of the pesticides they are using. Only 16 per cent of the workers in the Mashonaland Central study knew the correct order of toxicity labelling of these coloured triangles.

Most workers in the Mashonaland West and Manicaland surveys had only partial knowledge of what the coloured triangles meant, of the chemicals they were exposed to, of the protective clothing they were required to wear and of the correct method of disposal of containers (see Table 5). Workers in Manicaland were not well-informed on the health effects of the pesticides, 25 per cent had no knowledge of symptoms of poisoning. In the more highly exposed Mashonaland West, knowledge of health effects was somewhat higher, although other areas of knowledge were poorer. In the same area – Mashonaland West – there was a weak inverse association between knowledge of effects and cholinesterase activity inhibition (see Table 6).

There is need for more effective education on pesticide safety. While education has been targeted at the use of protective clothing or safe disposal of containers, workers need information on safe work practices, including safe methods of mixing and spraying, appropriate re-entry times and detection of equipment faults that may cause exposure. There is also a need to identify the work or organisation factors that limit the translation of this knowledge into practice.

Other factors

Farm labour communities have been shown in previous studies to experience amongst the highest rates of acute and chronic malnutrition in Zimbabwe (Loewenson, 1986). In the Mashonaland West and Manicaland surveys, between

Table 5: Knowledge of practices and hazards amongst workers

	Mash West		Manicaland	
Subject	No.	% total	No.	% total
Knowledge of triangles in correct order of toxicity				
None	15	23,1	3	4,5
Partial	47	72,3	58	86,6
Complete	3	4,6	6	9,0
Knowledge of correct disposal of containers				
None	10	15,4	13	19,4
Partial	45	69,2	26	38,8
Complete	10	15,4	27	40,3
Knowledge of protective clothing required for chemical used				
None	8	12,3	16	23,9
Partial	39	60,0	26	38,8
Complete	18	27,7	24	35,8
Knowledge of health effects of pesticides used				
None	3	4,6	17	25,4
Partial	30	46,2	27	40,3
Complete	32	49,2	23	34,3

Table 6: Cholinesterase activity level by knowledge of effects of pesticide use, Mashonaland West, 1988.

Cholinesterase activity level, % total with	Knowledge of effects % complete	Partial	None	N
≤ 75 % normal	37	57	6	35
> 75% normal	63	33	3	30

28 and 39 per cent of workers were under-nourished using less than 90 per cent standard weight for age, although this was primarily mild (76 – 90 per cent standard) in form. The relationship between weight for age and cholinesterase activity level is shown in Table 7, aggregated for these two survey areas. All those with moderate malnutrition had depressed cholinesterase activity, and there was a weak correlation between depressed cholinesterase activity and under-nutrition (using weight for age).

Table 7: Cholinesterase activity level by nutritional status, Mashonaland West and Manicaland combined data.

% standard weight for age	Cholinesterase activity level % total with ≤ 75% standard	>75 % standard	N
61 – 75 (moderate)	100	0	5
75 – 90 (mild)	53	47	36
> 90 (normal)	52	48	91
Total			132

Chi-squared = 4,95 (p < 0,1)

Communities on large-scale commercial farms have been reported to suffer high levels of morbidity (Loewenson, 1986), but it is not known how this interacts with pesticide exposure in Zimbabwe. In the Mashonaland Central study, symptomatic assessment of poisoning was found to be unreliable, possibly due to the prevalence of other communicable diseases presenting with the same symptoms as those associated with sub-acute poisoning – headaches, nausea, sweating, abdominal pain, (Bwititi *et al.*, 1987). Similarly, in the Mashonaland West and Manicaland studies, reported illness was not associated with cholinesterase activity levels. Workers commonly dose themselves with analgesics and antimalarials, whose interaction with occupational exposure to agrochemicals is not clear. The interaction in effect between the anti-schistosomal drug, metrifonate, itself an organophosphate, and organophosphate pesticides in agriculture is also not known (Nhachi *et al.*, 1991).

Lack of early detection and surveillance of pesticide-related morbidity, inadequate provision of health and first aid services or of regular monitoring of workers on farms undermines both detection and control of pesticide-related morbidity (Bwititi *et al.*, 1987 and Loewenson, 1986 and 1988). The Ministries of Health and Labour have both called for improved health inspection on farms and advocated more systematic data collection of pesticides poisoning cases and their causes (Ncube *et al.*, 1987 and Bwititi, 1983).

In the Mashonaland Central study in 1985/6, none of the farm workers received regular medical checks and over three-quarters said they did not know first aid or if there was a first aid kit on the farm (Bwititi *et al.*, 1987). In both the Mashonaland West and Manicaland surveys, there was no regular medical check on pesticide exposures during the spraying season.

These associated health and health care factors indicate that while industrial workers may be at increased risk of exposure through contact with more toxic, concentrated forms of agrochemicals, the risk for workers on farms is compounded by poor practices of use, poor health status and absence of monitoring or effective health interventions.

Indirect health effects of pesticide use

Increasing capital intensity of large-scale commercial farm production in Zimbabwe over the past decade has resulted in greater productivity per worker and a shift in employment patterns towards smaller work forces, with a loss of over 100 000 jobs between 1975 and 1984 (Loewenson, 1988). Together with this, overall job loss, increasingly capital-intense production has been associated with employment of a diminishing core of permanent labour, with non-permanent workers, often female, employed during periods of peak labour demand. Income, diet and health status in selected farm labour communities indicate that non-permanent employment and underemployment represents a serious threat to household income and food security, and is associated with increased adult and child ill-health and decreased use of health facilities (Loewenson, 1989). During the short employment periods, non-permanent workers hired on contract to do piece jobs have resisted leaving work to go to health services because of the potential loss in earnings this would bring.

Hence, while increasing pesticide use amongst other capital inputs has increased crop yields and labour productivity, it has also been associated with increasing ill health of a growing section of the labour force.

Conclusions

These findings suggest that about one-third to one-half of workers spraying pesticides on large-scale commercial farms involved in cotton, coffee and production of other crops in Zimbabwe are exposed to organophosphates during the spraying season. With about six workers per farm involved in spraying and about 3 500 large-scale commercial farms involved in such crop production, this implies that about 10 000 workers may be exposed to organophosphates in this occupational category alone.

Pesticide exposure appeared to be associated with greater use of manual techniques, little provision of protective clothing and inadequate provision of safety information to workers. Spraying technologies judged "safe" when new from the factory appeared to become a source of exposure when poorly maintained and incorrectly used. The studies also indicated that while great emphasis is placed on personal protection and human behaviour as the selected methods of control of exposure, lack of effectiveness of protective clothing – possibly due to inadequacy, poor fit, incorrect use and poor maintenance and lack of complete knowledge of workers undermine control and probably increase exposure. The findings also indicate that pesticide exposure probably spills over into non-sprayers and into the communities living on farms. The mechanisms of this spill-over are, however, not yet clear.

While the findings indicate that other health problems and poor nutrition may exacerbate pesticide exposure, there is clearly need for more work in this area and in identifying the chronic health effects of pesticide exposure in these and other groups. Lack of medical surveillance of rural workers using pesticides and lack of access to health facilities undermines monitoring and detection of pesticide-related ill-health of exposed workers. Hospital admissions for acute poisoning appear to be a poor guide of the extent of sub-acute or chronic exposure to pesticides, given the extent of exposure documented in the field surveys. It is important to carry out a more detailed assessment of the hospital data in the areas where field exposure studies were done to assess the relationship between symptoms and cholinesterase levels. The levels found in these field studies indicate further problems in attempting to assess low-level exposure symptomatically without using biological monitoring techniques. The use of simple biological monitoring techniques such as the spectrophotometric kit can be extremely useful in epidemiological assessment of patterns and possible sources of exposure. There is need for more such simple field techniques if the logistic, human and financial resource problems in doing epidemiological work in developing countries are to be overcome. The findings of the studies reported here add a further weight to the growing body of evidence that there is a need for a greater allocation of resources towards identifying and controlling the negative health impact of pesticide use in developing countries.

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