PESTICIDES IN ZIMBABWE

Toxicity and Health Implications

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Occupational Exposure to DDT Among the Mosquito-control Sprayers in Zimbabwe

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Summary

Four hundred and eighty DDT seasonal spraymen were screened for DDT exposure over the period September to March in 1988, 1989 and 1990. The average age of the spraymen was 29 ± 8,5 (range 19–61 years). Their average weight was 62,8 ± 4,7 kg with a range of 44–129 kg. Ninety per cent of the men were between the age of 21 and 50 years. Up to 49 per cent of the spraymen showed evidence of DDT exposure with DDE plasma levels greater than 1,00 µg per 100 ml and vitamin A levels greater than 0,92 mg per litre. Smoking seems to predispose the workers to toxic exposure with 76 per cent of the smokers showing vitamin A levels above normal compared to 58 per cent non-smokers. Forty-eight percent of the men were on medication during the spraying period, the significance of which was not evaluated in this study. The study indicated an unacceptably high magnitude of toxic exposure to DDT among spraymen.

Dichlorodiphenyl trichloroethane (DDT) is a white crystalline powder which is tasteless and insoluble in water, but soluble in a number of organic solvents such as chloroform, 96 g per 100 ml or ethanol, 1,5 g per 100 ml (WHO, 1989).

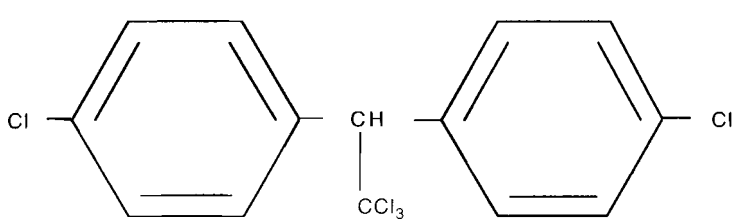

Figure 1: Structure of DDT

Although it is now banned in most industrialised countries, DDT has been used for many years as a broad spectrum insecticide. It is attractive as an insecticide because it is cheap, available and moderately toxic, with an LD_{50} of 0,4 g per kg. It has, in fact, a toxicity rating of 3 on a rating scale of 1 (practically non-toxic) to 6 (super toxic). In humans, DDT plasma levels of greater than 1,00 µg per 100 ml are considered toxic levels.

When used as a drug, DDT is called clofenotane (INN) or dicophane (British Pharmacopoeia), klorfenotan (Swedish Pharmacopoeia) and chlorphethane (United States Pharmacopoeia). For research or reference, it has been designated 0MS0016 and ENT1506 respectively. It has been sold commercially under a variety of trade names, including Anofex, Cezarex, Dinocide, Gesarol, Guesapon, Gyron, Ixodex, Neocid, Neocidol and Zerdane.

DDT is still a popular insecticide in some Third World countries since it is cheaper compared with such substitutes as organophosphates or pyrethroids which increase costs by a factor of up to eight-fold. Generally, most of the exposure to DDT is environmental and occupational in nature and almost all poisoning incidents are accidental, suicidal and/or parasuicidal. Some studies have revealed a positive correlation between blood levels of DDT and/or its metabolites as a measure of body burden due to environmental and/or occupational exposure (Radomski *et al.*, 1971a and Saxen, *et al.*, 1987).

In Zimbabwe, DDT is used as a vector control agent by the Ministry of Health's Malaria Mosquito Control Programme and the Ministry of Agriculture's Tsetse fly Control Programme. Some preliminary screening of exposure among the spraymen have indicated evidence of toxic exposure to DDT (Nhachi and Loewenson, 1989 and Nhachi and Kasilo, 1990).

Assessment of DDT exposure may be done through a number of ways. The direct way is to measure blood levels of DDT and some of its metabolites such as 2,2-bis(p-chlorophenyl)-1-dichloroethylene (DDE), or urinary levels of another metabolite, 2,2-bis(p-chlorophenyl)-1-dichloroethane (DDA). Plasma levels of vitamin A are also used as an index of DDT exposure (Keil and Sandifer, 1972). As such, plasma vitamin A levels have been used as an indicator of toxic DDT exposure (Nhachi and Loewenson, 1989). Furthermore, it has been suggested that the chloride ion which is released during metabolism, degradation or breakdown of DDT in urine may be used as yet another index of DDT exposure.

Some parameters that could be used as indices of toxic DDT exposure include the following: plasma DDT, plasma DDE, plasma vitamin A, urinary DDA, urinary 17-B-hydroxycortisone and urinary chloride ion.

In a major study spread over three years, 1988–90, 480 DDT spraymen (only men do the spraying) who spray DDT in homes of villagers in the malaria-endemic areas were screened for DDT exposure over the spraying period of September to March 1988, 1989 and 1990. Spraying is done using ultra low volume (ULV) dispensers which are strapped on the backs of the men. The sampling places, that is, the places where spraying is done, are located in

seven different provinces throughout the country and the researchers covered a distance of 6 000 km to collect the samples. The spraymen's plasma levels of vitamin A and DDE were utilised as indices of DDT exposure. Total and albumin serum protein levels of the men were also assessed. Table 1 shows the age and weight distribution of the spraymen.

The majority of the spraymen were within the optimum working age group of 20–50 years, with 54 per cent of the men under the age of 40 years. The age range was 19–60 years. In Zimbabwe, the average age of retirement is 60 years.

Table 1: Age and weight distribution of spraymen.

Age range (years)*	Number of men and (%) Total	Mean weight (kg)
15–20	22 (4,6)	64,5
21–30	186 (38,8)	63,9
31–40	150 (31,2)	63,5
41–50	96 (20,0)	65,3
51–60	25 (5,2)	66,8
> 60	1(0,2)	52,5
Total	480 (100)	mean = 62,8 + 4,7

* Age limit was 19 to 61.

Most spraymen (95,2 per cent) are within the working age group of 21–50 years, with a preponderance of 38,8 per cent within the 21–30 years of age group. A significant number of those screened (48,9 per cent) showed evidence of toxic exposure to DDT, that is, plasma DDE levels of greater than 1,00 µg per ml and vitamin A levels greater than 0,92 mg per ml (see Table 2). Preliminary work done by the authors revealed that vitamin A plasma levels and DDE are more sensitive indices of toxic DDT exposure than urinary 17-B-hydroxycortisone. (Nhachi and Loewenson, 1989)

Table 2: The distribution of DDE serum concentrations in relation to serum vitamin A among the spraymen.

DDE concentration range (µg/100 ml)	Mean vitamin A concentration (mg/ml)	Number of men. (Percentage of total)
	0,00–0,92	171 (51,2)
0,00–1,00	1,55–0,92	90 (27,0)
1,01–5,00	1,79 + 1,52	60 (18,0)
5,01–10,00	1,91 + 0,35	13 (3,9)

Measurement of plasma protein levels gives an indirect nutritional status of a subject and together with anthropometric calculations, a definitive estimate of nutritional status can be deduced. The mean albumin content of the assessed spraymen was 4,4 ± 0,42, that is, well within the prescribed normal range of 3,70–5,20 g per 100 ml. It follows therefore that the dynamics and kinetics of the plasma levels of DDT and its metabolites were not significantly altered by the status of the albumin content.

Of the 480 spraymen assessed, 187 (39 per cent) were smokers. Smoking during spray periods is probably one avenue of exposure. An investigation of the relationship between vitamin A levels, DDE levels and smoking habits showed evidence of a correlation between smoking habits and DDT exposure (see Table 3).

Table 3: The relationship between smoking and DDE and vitamin A levels

Smoking habits	Number of spraymen N = 480 (%)	Number with vitamin A levels above controls (%)	Number with detectable DDE levels (%)
Smoker	187 (39)	142 (76)*	23 (12,3)*
Non-smokers	293 (61)	171 (58)	23 (8,0)

*indicates significance.

The significance, as indicated above, points to a positive correlation between smoking and exposure to DDT. Table 4 below is an analysis of the extent of provision of the recommended protective clothing to the spraymen.

Table 4 Evaluation of provision of legislated protective clothing

	Gloves	Respirator	Overalls	Mask	Boots	Goggles
Total number of men	29	17	446	446	446	117
Percentage of Total (N = 480)	6	3,5	93	93	93	24

An assessment of the spraymen's knowledge of the health effects of DDT was carried out. Table 5 depicts the statistical responses obtained. The majority of the spraymen were provided with and used overalls, masks and boots. The significant scanty provision and use of gloves and goggles may have provided easy exposure access. One of the reasons for lack of respirators is that the apparatus is just not widely available nor affordable in the country, instead masks were provided.

Only 36 per cent of the spraymen had a complete knowledge of the possible health hazards or effects of spraying DDT, while 53 per cent had partial knowledge, that is, they might have heard about it and 11 per cent had no knowledge of the health effects of DDT at all (Table 5).

Table 5: Knowledge of the health effects of DDT.

	Complete Knowledge	Partial Knowledge	No Knowledge
Health Effects Code	1	2	3
Number of men	127	184	39
Percentage of total (N = 350)	36	53	11

The interaction of DDT with other chemicals or drugs may exacerbate the toxicity of DDT. Table 6 below outlines the various types of medication that some of the spraymen were on during the spraying period. It is not certain whether the discrepancy in provision and use of certain protective clothing and knowledge of the health effects of DDT have any bearing on risk of toxic exposure, as this was not evaluated in the study. It is important to point out that 48 per cent of the spraymen were on some form of medication during the spraying period (Table 6). The significance of this is not known.

Table 6: Medication taken during spray-time.

Drug	Number of Sprayers	Percentage (N = 228)
analgesics	67	29,4
antimalarials*	62	27,2
antibiotics	27	11,8
traditional medicines	23	10,1
antiacids	11	4,8
Cold/ "flu" medications	7	3,1
metrifonate (bilharzia)	5	2,2
eye ointment	5	2,2
dermatologicals	4	1,1
antidiarrhoeals	3	1,3
vitamins	3	1,3
zimeldine	3	1,3
cimetidine	1	0,4
salbutamol	1	0,4
matrip	1	0,4
gamatox	1	0,4
unknown	1	0,4
Total	228	48,0

Conclusion

Although acute and/or systemic toxicity from occupational exposure to DDT rare (Violante and Coltelli, 1986) periodic screening of DDT handlers recommended to monitor and safeguard against the chronic accumulativ effects of DDT (WHO, 1989). Occupational exposure to DDT among th mosquito-control sprayers in Zimbabwe is evident. There is need to improv the provision and use of protective clothing to minimise the risk of exposur The workers should be educated as to the possible health hazards associate with handling DDT. Smoking while spraying should be discouraged and th spraymen should wash their hands after spraying and before smoking sinc smoking habits seems to be associated to toxic exposure.

Acknowledgements

The authors thank the Provincial Medical Directors of the following province Manicaland, Mashonaland East, Mashonaland West, Masvingo and Midlan and all the spraymen for their cooperation. The *Bulletin of Environment Contamination and Toxicology* gave permission to publish some of th information.

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Thunberg, T., Ahlbany, U.G., Hakansson, H., Kurantz, C., Monier, M. (19 Effects of 2,3,7,8-tetrachloroiodobenzo-p-dioxin on the hepatic storage retinol in rats with different dietary supplies of vitamin A (retinol). *Ar Toxicol.* **45**:273–85.

*The 62 spraymen, all from one area, were on chloroquine antimalaria prophylaxis.

The DDT spraying period, September to March, of each year coincides with the rainy season which, with the advent of new lash green vegetation, creates optimum breeding conditions for the malaria mosquito. The use of serum DDE and vitamin A levels as indices of DDT exposure has been studied before and found reliable (Nhachi and Loewenson, 1989, Keil and Sandifer, 1972 and Brown and Chow, 1975).

Although most of the smokers claimed they did not smoke during spraying, the significant exposure levels among smokers suggests otherwise. It is possible that the smokers indulge in their habits after spray duties without first washing their hands. Incidentally, 1 310 cigarettes were smoked per day with an average of 11,1 ± 3,0 cigarettes per smoker per day. Evaluation of smoking habits is very subjective since some of the smokers tend to underestimate (deliberately or inadvertently) the number of cigarettes they smoke per day. However, the figures quoted in this study indicate a moderately high rate of cigarette smoking.

Evaluation of provision and use of protective clothing was based on the six legislated items of clothing which, by law, sprayers are required to put on when spraying (Table 3). The significant, scanty provision and use of gloves and goggles could provide exposure access. In some cases, these two items were available but the men did not use them because they were uncomfortable and "in the way".

Only 36 per cent of the men who responded to the questionnaire had complete knowledge of the health hazards of spraying DDT; 53 per cent had partial knowledge, that is, they might have heard about it and 11 per cent had no knowledge of it at all (Table 4). It is not certain whether the discrepancy in provision and use of certain items of protective clothing and lack of knowledge of the toxic effects of DDT had any bearing on risk of toxic exposure, as this was not particularly evaluated in this study.

It was evident that 48 per cent (228) of the spraymen were on some form of medication during the spraying period (Table 5). Notably there was a high use of antibiotics and this is related to the prevalence of sexually transmitted diseases (STDs). Some of the patients were on traditional medication (herbal medicine) which was also commonly used for stomach ache and discomfort. Analgesics, mostly aspirin and paracetamol, were utilised for such symptoms as headache, stomach ache and generalised body aches. The antimalarials, mostly chloroquine, were used prophillactily for the prevention of malaria. In fact, all the workers should have been on chloroquine prophillaxis, but only 27 per cent were. The effects of the interactions between DDT and some of the drugs that the spraymen were on may never be known but it is important to realise that DDT, like most organochlorines, induces the metabolism of other chemicals if taken concommitantly and this could have important repercursions.

Conclusion

Although acute and/or systemic toxicity from occupational exposure to DDT is rare (Violante and Coltelli, 1986) periodic screening of DDT handlers is recommended to monitor and safeguard against the chronic accumulative effects of DDT (WHO, 1989). Occupational exposure to DDT among the mosquito-control sprayers in Zimbabwe is evident. There is need to improve the provision and use of protective clothing to minimise the risk of exposure. The workers should be educated as to the possible health hazards associated with handling DDT. Smoking while spraying should be discouraged and the spraymen should wash their hands after spraying and before smoking since smoking habits seems to be associated to toxic exposure.

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