



Acute health effects of organophosphorus pesticides on Tanzanian small-scale coffee growers

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Acute health effects of organophosphorus (OP) pesticides on coffee farmworkers in 1991–1992 in Tanzania are reported to provide a basis for concern over farmworkers being overexposed during application. Workers exposed to OP pesticides ($N=133$) were drawn from a population of about 240,000 coffee farmers. They were interviewed on symptoms and personal protection, and their erythrocyte acetylcholinesterase (AChE) activity was determined during both spraying and nonspraying period. AChE activities during spraying and nonspraying period were comparable (mean 32.0, SD 7.8 vs. 33.0, SD 8.7 U/g HgB, $P=0.26$). The prevalence of cough, headache, abdominal pain, excessive sweating, nausea, excessive salivation, diarrhea, and vomiting did not differ significantly between spraying and nonspraying periods. There was no suggestion of decreased AChE in exposed subjects who complained of OP-related symptoms compared to symptomless exposed subjects. Use of gloves, long boots, head cover, face cover, and coverall was not significantly associated with AChE activity. No marked AChE depression was found during spraying season, which may explain the lack of association between symptoms and AChE. The fact that only moderately toxic OP pesticides were used may indicate that toxicity was not sufficiently high to cause depression. Experience, however, suggests that occupational poisoning remains a potential serious danger in coffee cultivation in Tanzania. *Journal of Exposure Analysis and Environmental Epidemiology* (2001) **11**, 335–339.

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Introduction

About 20% of pesticides used in Tanzania are organophosphorus (OP) compounds (Mbakaya et al., 1994, 1996), with the use of pesticides in coffee farming amounting to 6353 tons or approximately 0.5% of the average estimated Third World consumption in 1989 (Ngowi et al., 1992). Exposure to OP compounds inhibits mammalian acetylcholinesterase (AChE), resulting in the development of symptoms that have their origin at different parts of the nervous system (Coye et al., 1986; Magnotti et al., 1988). When cholinesterase is blocked, acetylcholine level increases and builds up in the muscles. Enzyme activity returns only when new AChE molecules are synthesized, a process that takes days or weeks. Excessive amount of acetylcholine causes the muscle to lose its function (Hayes and Laws, 1991) and repeated

exposure to anticholinesterase compounds may depress cholinesterase to a dangerous extent. Moreover, cholinesterase inhibition and health effects of OP pesticides in agricultural workers have been documented (e.g., Ngatia and Mgeni, 1980; Jeyaratnam et al., 1982, 1987) Rama and Jaga, 1992; Cielski et al., 1994; Ohayo-Mitoko et al., 1997). Ohayo-Mitoko et al. (2000) reported on the prevalence of OP-related symptoms among agricultural workers in the Kenyan component of the East Africa Pesticide Network (EAPN), a sister study to the present one (Partanen et al., 1999). Prevalence of respiratory, eye, and central nervous system symptoms were elevated in workers with over 30% AChE inhibition. Workers on Tanzanian coffee farms who spray OP pesticides usually do so with no precaution and no protection (Ambridge et al., 1990). The present study is the Tanzanian component of EAPN, initiated to estimate the occurrence of symptoms of pesticide poisoning among Tanzanian small-scale coffee farmers. This report addresses the extent and intensity of OP exposure and associations between external exposure, exposure biomarker, symptoms, and use of protective equipment.

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Materials and methods

The fieldwork was carried out between June 1991 and May 1992. The spraying period was individually defined in such a manner that the subjects had been exposed to OP pesticides on the day of interview and blood sampling, or at least within the same week. The nonspraying period implied no exposure during a period of 1 month preceding interview and blood sampling. All districts in Tanzania with coffee as a major crop and with pesticides being sprayed were selected. As a matter of protocol, the principal investigator visited the districts to establish contact with the relevant authorities (agricultural, cooperative union, and health officers). During these meetings, the interview and blood sampling dates were set and the study subjects identified and recruited with the help of village leaders, cooperative union, and agricultural officers. The study population was restricted to small-scale coffee farmers who sprayed pesticides, their relatives who did the spraying, and hired spraymen. A total of 350 subjects were recruited into the study, and 182 subjects who were in contact with OP pesticides were considered exposed.

This report is based on the subset of 133 exposed subjects (73%) who were available for blood sampling and interviewing during both spraying and nonspraying periods. The remaining 49 who provided data for the nonspraying period only were omitted from the calculations. Most of the 133 subjects (88%) were farmers by occupation, whereas

those employed as spraymen made up 11% of the subjects and among them were farmers with own farms. With the mean age for subjects at 41 (SD 14.0) years, many (71%) had reached a level of education equivalent to five and above years of schooling and 95% were literate. Farmworkers reported a range of pesticides for various types of crops grown (Table 1) with fenitrothion (23%), chlorpyrifos (19%), and profenofos (16%) being the most commonly used OP pesticides, and coffee (94%) the most sprayed crop.

Small-scale farmers (0.5–12 acres) cultivated Arabica coffee intercropped with bananas, cocoyams, beans, maize, vegetables, potatoes, fruit trees, and animal fodder.

Trained interviewers conducted semistandardized face-to-face interviews in Swahili. The interview covered knowledge, attitudes, and practices with regard to pesticide hazards and use and 42 symptoms (Format: Do you have headache now? Yes/No) known to be associated with pesticide exposure. The presented data is on those 12 symptoms that have been reported to be associated with exposure to OP pesticides (Partanen et al., 1991). In addition, use of protective equipment was asked in the form of structured questions. Finally, time since last handled pesticides and pesticides handled last were asked so as to ensure correct interpretation of AChE.

The interviews were conducted similarly during spraying and nonspraying seasons, when blood AChE activity and blood hemoglobin levels were also determined. Using the

Table 1. Pesticides reported by farmworkers as used on crops by crops grown.

Pesticide (USE ^a)	Chemical (WHO Hazard Class) ^{b,c}	Acute toxicity (mg/kg BW) ^d	Number of users		
			Food crops ^e	Coffee	Total % ^f
Triadimefon (FU)	OT (III)	602	–	8	4
Propiconazole (FU)	OT (II)	1520	–	5	3
Profenofos (IN)	OP (II)	358	2	29	18
Fenitrothion (IN)	OP (II)	503	–	40	25
Endosulfan (IN)	OC (II)	80	2	3	3
Dieldrin (IN)	OC (O)	–	–	2	1
DDT (IN)	OC (II)	113	3	–	1
Copper oxychloride (FU)	OT (III)	1440	–	17	8
Copper oxide (FU)	OT (II)	470	–	9	5
Copper hydroxide (FU)	OT (III)	1000	2	11	6
Chlorpyrifos (IN)	OP (II)	135	2	30	21
Chlorothalonil (FU)	OT (U)	>10000	–	13	6
Atrazine (HE)	OT (U)	2000	2	–	1
Anilazine (FU)	OT (O)	–	–	5	3

^aIN: insecticide; HE: herbicide; FU: fungicide.

^bChemical class OP: organophosphate; OC: organochlorine; OT: benzonitrile, triazole, triazine or inorganic.

^cWHO Class Ia: extremely hazardous; Ib: highly hazardous; II: moderately hazardous; III: slightly hazardous; O: obsolete as pesticide by WHO (1998), therefore not classified; U: unlikely to present acute hazard in normal use.

^dBW: body weight.

^eFood crops: maize, tomato and cabbage.

^fNumber of users per total exposed (n=133).

Table 2. Prevalences of OP pesticide-related symptoms among exposed during spraying and nonspraying.

Symptom	Prevalence (%)		<i>P</i> ^a
	Nonspraying period (N=133)	Spraying period (N=133)	
Cough	30.8	33.8	0.69
Headache	27.1	30.1	0.64
Feeling weak	25.6	22.6	0.64
Difficulty in seeing	27.1	22.6	0.38
Dizziness	19.5	15.0	0.38
Abdominal pain	6.0	12.8	0.06
Excessive sweating	7.5	12.8	0.23
Nausea	10.5	11.3	1.00
Excessive salivation	8.3	10.5	0.66
Diarrhea	5.3	8.3	0.45
Vomiting	4.5	6.8	0.58

^aMcNemar test.

Testmate™ OP field kit, pretested and approved for field use by the WHO, approximately 18 ml of blood was drawn by venipuncture, of which 10 µl were assayed (Anon., 1991). The AChE levels measured in international units (IU) were temperature adjusted and automatically corrected for hemoglobin. A technician blinded from the exposure status of subjects did all field kit measurements. The ethical committee of the Ministry of Health of Tanzania approved the study, and its aim was explained to all study subjects before starting the interviews and sampling. All subjects were also informed of their right to withdraw anytime, whereafter each participated voluntarily. Subjects with health problems, such as low hemoglobin or depressed

cholinesterase, were informed and referred to the nearest health facility. The mean AChE levels during spraying period, for users and nonusers of personal protective equipment, were compared and tested for significance with *t*-distribution. Paired *t* tests were used to test for difference between spraying and nonspraying periods of the mean AChE and of the number of symptoms. The differences in symptom prevalence between spraying and nonspraying periods were tested with McNemar test and the SPSS 9 statistical package was used.

Results

Within the week preceding the tests, the subjects had sprayed as follows: 49% on the day of assay, 38% in the past two days, and 13% in the past 3–7 days. AChE activity during spraying (mean 32.0, SD 7.8 U/g HgB) was not significantly lower than during the nonspraying period (mean 33.0, SD 8.7; *P* 0.26). The mean number of symptoms among the exposed was the same during spraying (mean 1.9; SD 2.3) and nonspraying periods. The only symptom that bordered on significance for the prevalence difference between spraying and nonspraying was abdominal pain (Table 2). Table 3 shows the mean change of AChE (spraying minus nonspraying) among subjects without a symptom during nonspraying but who expressed the symptom during spraying (“symptom developers”) and the rest of the subjects (“nondevelopers”). There was no suggestion for lower AChE in subjects who complained of OP-related symptoms.

Table 3. Mean change in erythrocyte AChE level from nonspraying to spraying periods (level during spraying minus level during nonspraying season) in farmworkers who developed symptoms during spraying and in those who did not.

Symptom	Change (U/g HgB) in symptom developers ^a			Change (U/g HgB) in symptom nondevelopers ^b			Mean difference of change (U/g HgB) between developers and nondevelopers	<i>P</i> ^c
	Mean	SD	<i>N</i>	Mean	SD	<i>N</i>		
Cough	1.20	7.48	29	-1.05	9.54	103	-2.26	0.18
Headache	1.23	7.17	21	-0.93	9.46	111	-2.31	0.21
Feeling weak	0.05	11.8	19	-0.65	8.69	113	-0.66	0.82
Difficulty in seeing	0.05	5.15	13	-0.62	9.49	119	-0.67	0.67
Dizziness	2.68	8.47	13	-0.91	9.18	119	-3.60	0.17
Abdominal pain	2.18	5.94	14	-0.88	9.42	118	-3.06	0.11
Excessive sweating	1.44	7.22	16	-0.83	9.37	116	-2.28	0.26
Nausea	3.69	8.58	10	-0.91	9.14	122	-4.60	0.14
Excessive salivation	7.54	8.20	12	-1.36	8.86	120	-8.91	0.001
Diarrhea	6.19	6.34	10	-1.11	9.14	122	-7.30	0.005
Vomiting	4.30	6.24	8	-0.87	9.23	124	-5.17	0.056

^aSymptom during spraying period.^bAll others except.^c*t* test.

Table 4. Mean AChE (U/g HgB) by use of protective clothing.

		No	Yes	<i>P</i> ^a
Gloves	Mean	32.1	34.8	0.51
	SD	7.9	8.2	
	<i>N</i>	174	4	
Long boots	Mean	31.9	33.4	0.35
	SD	8.1	6.7	
	<i>N</i>	148	30	
Face cover	Mean	32.1	32.6	0.77
	SD	8.2	5.4	
	<i>N</i>	154	24	
Head cover	Mean	32.2	32.1	0.94
	SD	8.1	7.6	
	<i>N</i>	116	61	
Coverall	Mean	32.0	33.0	0.55
	SD	8.3	5.3	
	<i>N</i>	149	29	

^at test.

Use of gloves, long boots, face cover, head cover, and coverall was not associated with increase in AChE activity (Table 4).

Discussion

Experience suggests that occupational pesticide poisoning remains a serious danger in coffee cultivation in Tanzania. Unlike in the early 1980s, when a number of suicidal poisoning cases were documented (Ngowi et al., 1992), in 1995, a coffee farmer audit was conducted for the then International Group of National Associations of Agrochemical Manufacturers (GIFAP) Safe Use Project (unpublished), in which a number of occupational poisonings were reported, including skin and eye contact with spray due to a change in wind direction during spraying or a leaking sprayer, accidental ingestion of pesticides mistaken for drink or flour, and reentry into sprayed field immediately after spraying to collect firewood or animal feed.

This study found no strong indication for adverse effects of pesticides, either on AChE or symptoms at the time of the study. Therefore, measuring AChE or asking about symptoms is not sufficient to indicate systemic poisoning or imminent death/suicide (Ngowi et al., 1992). Apparently, among long-term pesticide spraymen, even when clinical symptoms of excessive cholinergic activity are not present, reduced cognitive function has been reported (Feldman et al., 1997). Although measures were taken in the present study to ensure that questions asked were clear and understandable, the possibility of questions not being fully understood cannot be ruled out. There is also a possibility of bias in the reporting of symptoms with subjects

feeling uneasy about job stability, if they would be referred to a hospital for medical checks or treatment on account of reported symptoms. Moreover, farmworkers having symptoms might have involved themselves less in spraying or been more likely to use personal protective equipment. This would explain the increased AChE in those with symptoms, but the data did not allow for the scrutiny of this possibility.

In the present study, erythrocyte AChE was determined because chronic liver problems or malnutrition do not affect it (Hayes and Laws, 1991), and an adjustment for hemoglobin level was made to control for anemia. In a previous study from Tanzania (Ngatia and Mgeni, 1980), reduced cholinesterase levels were reported in the plasma of subjects exposed to OP pesticides.

The small-scale coffee farming in Northern and Southern Tanzania, which constituted the major part of this evaluation, is characterized by small individual farms that usually take two people the maximum of 6 days to spray the coffee trees. Thus, the amount of insecticide sprayed might have been insufficient for an exposure to be detected. Therefore, although the present data was limited to spraying as the source of exposure, there might have been other sources, such as storage, food, water, and environmental contamination affecting the general population to explain the symptom prevalence. The study was designed to be conducted during spraying and nonspraying periods, but both studies were conducted concurrently due to unforeseen weather and logistics limitations. Consequently, a dilution of AChE difference and differences in symptom prevalence between spraying and nonspraying may have occurred. However, the AChE in both seasons did not show any association with exposure to OP pesticides either. However, the intermingling between the seasons had an advantage of balancing any possible seasonal influences, while also controlling for factors that change seasonally for farmers, such as diet and activity levels. Extension workers and village leaders who selected the study subjects might have selected those more likely to participate, thus rendering a possible selection bias. These findings will therefore be useful in formulating intervention studies but may not be generalizable to other locations and crops where OPs are used.

Experiments have shown that the blood AChE level must be depressed to less than 20% of its normal value before symptoms of systemic poisoning appear (Coye et al., 1986; Kishi et al., 1995). In the present study, there was no indication of such depression, which may explain the lack of relationship between symptoms and AChE. The fact that only moderately toxic OP pesticides were found in use could indicate that toxicity was not sufficient to cause depression. The results of the present study appear to suggest that for a short-term spraying of the type of pesticides used in the study area there may not have been serious problems arising from the use of OP pesticides.

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