Crop Duster Aviation Mechanics: High Risk for Pesticide Poisoning

ROB MCCONNELL, MD, A. FELICIANO PACHECO ANTÓN, MD, AND RALPH MAGNOTTI, PHD

Abstract: A cross-sectional medical survey was conducted among 63 Nicaraguan aviation mechanics exposed to organophosphate and other toxic pesticides. Thirty-one (49 percent) reported having been acutely poisoned on the job. Also, seven of 14 novice mechanics, with less than one year on the job, reported that they had been poisoned. Thirty-eight (61 percent) had cholinesterase levels below the lower limit of normal, including three workers with levels less than 20 percent of the lower limit of normal. Risk factors for low cholinesterase included recent hire and recent poisoning. Workers did not use protective equipment, nor were there facilities for bathing on site. As a result of this survey, the government has prohibited the mixing and loading of pesticides at this airport and requires the washing of planes prior to maintenance work; coveralls and thin, pesticide impermeable gloves are to be issued to mechanics handling pesticide-contaminated parts. Closed system mixing and loading systems have been installed at satellite airstrips. (*Am J Public Health* 1990; 80:1236–1239.)

Introduction

Pesticide poisoning has been a major public health problem in Nicaragua for the last 30 years.[1] The country's principal traditional export is cotton, a crop which is sprayed up to 35 times a season with organophosphate insecticides for control of the boll weevil. Most of this spraying is done from crop dusting airplanes, and poisoning of highly exposed mixers and loaders at the airports and landing strips which service these airplanes has been recognized as a problem, both in Nicaragua and in the developed countries.[2]

The airplane mechanics who service these airplanes are a little studied population who have high exposure to pesticide-contaminated parts. To characterize exposure of these workers to pesticides and to assess any acute health effects, we evaluated mechanics at Nicaragua's largest crop dusting airport in late December 1987.

Methods

The 28 crop dusters owned by the six companies operating out of the airport made approximately 10 flights daily during the peak cotton spraying season (October 15 through early January). It was estimated that as much as 130,000 gallons were sprayed daily on flights originating from this airport, accounting for almost 30 percent of all pesticides sprayed in the department of Chinandega, the principal cotton growing region (Mario Pais, Ministry of Industry, personal communication). The mechanics were under pressure to do minor service and adjustment as quickly as possible, because the companies and pilots were reimbursed for each flight. There was little time to wash planes before minor maintenance. Most exposure was to the hands, since the manipulation of small mechanical parts was necessary for the routine work of changing pesticide filters and adjusting spray nozzles, and difficult to perform while wearing clumsy protective gloves.

The mechanics often did not know what pesticide was loaded in the plane they were servicing. One employee from each company, with responsibility for recording the pesticide used in each flight, characterized frequency of spraying as daily or as less frequently for the various pesticides used at the airport during the month prior to the study.

The 71 mechanics (all men) employed at the airport were invited for a questionnaire interview which asked about history of use of personal protective equipment, history of training regarding poisoning prevention, about previous poisoning, and about symptoms compatible with cholinesterase inhibitors (organophosphate and carbamate insecticides). The questionnaire asked about specific symptoms, such as headache, lightheadedness, blurred vision, lack of appetite, vomiting, stomach ache, and frequent spitting (sialorrhea). Erythrocyte cholinesterase is inhibited by organophosphate insecticides and is an early indicator of overexposure. It was measured using the Ellman assay (adapted for use with a new battery operated field kit), as previously described[3]:

> Briefly, 5 μl of blood was pipetted into a cuvette containing 200 μl of sample buffer containing Tris-HCl, Triton X-100 surfactant, and trace azide. Two ml of reagent solution containing acetylthiocholine iodide substrate, DTNB [5,5′-dithiobis(2-nitrobenzoic acid)] indicator, quinidine sulfate (to inhibit plasma cholinesterase), and phosphate buffer were added to the cuvette. The solution was incubated for three minutes and the change in absorbance noted between one minute and three minutes. The activity was adjusted for temperature and converted to international units. The results were not adjusted for hemoglobin. Forty-six healthy, unexposed male Nicaraguan health workers were sampled in order to establish a lower normal limit of 3.7 international units/minute/ml of blood. (This is the mean minus 1.65 standard deviations).
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> Each worker was given the result of his cholinesterase assay at the time of the test.
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> Confidence intervals for relative risk of low cholinesterase for various risk factors were calculated using the test-based method of Miettinen.[4] Multivariate analysis of mean cholinesterase was done using SPSS-PC.[5]

Results

All pesticides sprayed at the airport during the month prior to the survey are listed in the Appendix. Methamidophos, mephosfolan, methyl and diethyl parathion are all US Environmental Protection Agency (EPA) category I (acutely toxic) organophosphate insecticides. Chlorpyrifos (category II) and acephate (category III) are less toxic organophosphates. Cholinesterase depression reflects overexposure to these insecticides. Unfortunately, there are no good field methods for evaluating exposure to the non-

Address reprint requests to Rob McConnell, MD, Division of Occupational and Environmental Medicine, Mount Sinai Medical Center, Box 1057, 10 East 102nd Street, New York, NY 10029. Dr. Pacheco is with the Ministry of Health, Region II, Leon, Nicaragua; Dr. Magnotti is with the Department of Internal Medicine, University of Cincinnati Medical School, Cincinnati, Ohio. This paper, submitted to the Journal August 10, 1989, was revised and accepted for publication December 14, 1989.

organophosphate pesticides, although there are several pesticides with chronic effects. A metabolite of chlordimeform was recently reported to be associated with a 73-fold excess risk of bladder cancer in exposed workers.[6]

Questionnaire

Sixty-three mechanics (88 percent) of the 71 who worked at the airport came to the health screening. Those who did not participate had been assigned temporarily to smaller satellite airports, were sick, or refused to participate. This is a relatively mature work force with an average of almost 10 years in the current job (Table 1). Nevertheless, there was a sizable proportion of novices (22 percent) with less than one year of experience, including one 11-year-old and one other worker under age 16, the minimum legal age for work with pesticides.[7] Almost half the workers reported having required medical attention for acute symptoms resulting from pesticide exposure at some time during work at the airport. Twelve (19 percent) of 63 reported that they were poisoned in the previous 12 months, and half of the 14 workers with less than one year of experience had been poisoned. Some older workers reported having been poisoned as many as seven times at the airport. The most common protective equipment used were boots (used by 14 percent), followed by coveralls (11 percent). No worker used protective gloves, a respirator, or protective glasses.

Cholinesterase Measurements

Thirty-eight (61 percent) of the 62 workers sampled had low erythrocyte cholinesterase levels (Table 1). The mean cholinesterase (3.1 international units [IU]/minute/ml blood) for all mechanics was less than the lower limit of normal of 3.7 IU. The lowest level recorded was 0.61 IU, one of three samples less than 20 percent of the lower limit of normal. That worker complained of headache and nausea, had pinpoint pupils and sialorrhea, and was diaphoretic, all of which responded to treatment with atropine sulfate.

We evaluated the following risk factors for depressed cholinesterase levels among these workers: recent poisoning, recent hire, no training about safe use of pesticides, less than daily change of clean work clothes, and symptoms compatible with organophosphate insecticide poisoning. In addition, the mean cholinesterase for workers with each risk factor was compared with the mean for all workers without the risk. Almost all workers poisoned in the previous year and almost all mechanics hired within the previous year had low cholinesterase values at the time of the screening (see Table 2). The presence or absence of more than two symptoms compatible with organophosphate insecticide poisoning was not reflected either in higher prevalence of low cholinesterase values (52 percent compared with 67 percent among those with two symptoms or less) or in lower mean cholinesterase levels.

Paradoxically, there was a higher prevalence of low cholinesterase among mechanics who reported a daily change of clean work clothes (87 percent) compared with mechanics who changed work clothes less often (53 percent).

There was a slightly lower prevalence of low cholinesterase levels among workers who had received some previous training about the safe handling of pesticides, and the mean cholinesterase level among workers who had received training (3.6 IU) was higher than among workers without any training (2.9 IU). However, this beneficial effect of training was confounded by the high exposure tasks of recently hired workers, who were also less likely to have received training. After controlling for a dummy variable representing recent hire (within the last year) in a multiple regression procedure, there was still a slight beneficial average effect on cholinesterase of having received training, but the effect was reduced (regression coefficient = 0.41 I.U.; 95% CI = −0.28, 1.13).

TABLE 1—Demographic Characteristics, History of Poisoning, and Cholinesterase Levels among Aviation Mechanics, Chinandega, Nicaragua, December 1987 (N = 63*)

Mean age (SD)	29.1 (10.1)
Mean duration (years) of employment (SD)	9.6 (8.2)
Number employed less than 1 year (%)	14 (22)
Number poisoned during employment at airport (%)	31 (49)
Number poisoned in previous 12 months (%)	12 (19)
Number poisoned in previous 12 months among mechanics with less than 1 year employment (%)	7/14 (50)
Number who have received pesticide safety training on current job (%)	16 (26)
Number with low erythrocyte cholinesterase (%)	38 (61)
Mean cholinesterase in international units/minute/ml blood (SD)	3.1 (1.3)

*Because of missing data the denominator varies slightly within this and subsequent tables.

Discussion

To our knowledge mechanics engaged in routine maintenance of crop dusters have not been studied previously. At this airport, they were at extraordinarily high risk for pesticide overexposure and for poisoning. Many of these workers reported being hospitalized for treatment, almost exclusively with signs and symptoms compatible with the cholinesterase inhibitors used at the airport. The high prevalence of cholinesterase depression is probably underestimated, because pre-exposure baseline levels of cholinesterase were not available. We therefore used a normal range based on inter-individual variability in cholinesterase. A more appropriate criterion for a low cholinesterase level is a drop of 30 percent from baseline, as recommended by the World Health Organization[8] and the US National Institute for Occupational Safety and Health.[9] Because the inter-individual normal range is almost a two-fold increase over the lower limit of normal, a decrease of well over 30 percent for someone with a high baseline cholinesterase level would still leave that person in the normal range in this study.

In workers with daily exposure to organophosphate pesticides, cholinesterase may be depressed without clinical signs and symptoms of poisoning.[10] The absence of association between symptoms and cholinesterase depression probably reflects the importance of the rate of decline in cholinesterase in producing symptoms.[2] A gradual inhibition of cholinesterase from continued low level exposure to organophosphates is less likely to produce symptoms than the same inhibition from a single large exposure. Our experience is not dissimilar to that reported in other studies, where symptoms sometimes have been found to be associated with chronic depression of cholinesterase and sometimes have not.[2,11–13]

It is likely that experienced workers tolerate the hazards of this job, because it is highly skilled and it pays well. In addition, the most hazardous work is done by the newly hired apprentice mechanics, many of whom do not return the following season. The anomalous increase in proportion of workers with low cholinesterase levels among those who changed to clean work clothes daily probably occurred because these young workers are in the dirtiest, most highly

TABLE 2—Mean Cholinesterase and Frequency of Low Cholinesterase among Aviation Mechanics by Selected Risk Factors, Chinandega, Nicaragua, December 1987

Risk Factor	Number with Low Cholinesterase (%)	Relative Risk (95% CI)	Mean Cholinesterase	Difference of Means (95% CI)
Poisoned in the previous year (N = 12)	11 (92)	1.7 (1.1, 2.6)	1.5 IU	−2.0 (−1.3, −2.7)
Not poisoned in the previous year (N = 50)	27 (54)		3.5 IU	
Less than 1 year in job (N = 14)	13 (93)	1.8 (1.2, 2.7)	2.0 IU	−1.4 (−0.7, −2.1)
One or more year in job (N = 48)	25 (52)		3.4 IU	
Has not received pesticide safety training at airport (N = 45)	30 (67)	1.5 (0.91, 2.5)	2.9 IU	−0.7 (−0.07, −1.3)
Has received training (N = 16)	7 (44)		3.6 IU	
Changes work clothes less often than daily (N = 47)	25 (53)	0.61 (0.40, 0.93)	3.2 IU	0.6 (1.3, −0.1)
Changes work clothes daily (N = 15)	13 (87)		2.6 IU	
More than 2 symptoms compatible with cholinesterase inhibitors (N = 23)	12 (52)	0.78 (0.50, 1.2)	3.0 IU	−0.1 (0.6, −0.8)
Two or fewer symptoms compatible with cholinesterase inhibitors (N = 38)	26 (67)		3.1 IU	

exposed jobs and are also more likely to need to change work clothes daily.

Pesticide hazards at this airport are characteristic of Central American and other developing countries where regulations or their enforcement are not adequately developed to protect workers from poisoning. Even for these highly trained workers at a work place of strategic importance for one of the country's principal sources of foreign exchange (cotton), there were no bathing facilities and the companies did not provide protective equipment. To have removed all mechanics with low cholinesterase levels from exposure would have severely compromised production at a time when it was critical to spray to control the boll weevil. Only workers with the lowest cholinesterase levels were automatically removed from production. Where possible, workers with less depressed levels were assigned to less exposed tasks, hardly an ideal solution, as all mechanic jobs involve potential pesticide exposure.

In addition, the pesticide multinationals have introduced products which are prohibited or severely restricted in the developed world, or which are not registered in developed countries and for which there is little health information available to national regulatory authorities. Although lowered cholinesterase levels reflect overexposure to, and poisonings result from, cholinesterase inhibitors, overexposure to cholinesterase inhibitors can be considered a marker for overexposure to other pesticides with chronic toxicity. Ethyl and methyl parathion are almost always mixed with the animal carcinogen toxaphene[15] in Nicaragua and were often applied with chlordimeform. Until recently, methyl parathion was involved in almost half of all poisonings reported in certain regions of the country.[11] The common practice of promoting the use of personal protective equipment (gloves and respirators) in a country where there is little personal protective equipment available, and where temperatures commonly reach 38 degrees centrigrade, is an inadequate solution to the problem of pesticide overexposure.

Nevertheless, Nicaragua appears to be taking the problem of pesticide health hazards seriously. In the past five years the government, with support from various non-governmental organizations, has initiated programs to install closed systems (which mix and load the crop dusters without the workers having to directly handle the pesticide), and has initiated training programs to protect these workers. The Ministry of Health has prohibited the mixing and loading of pesticides at this airport; the airport is to serve as a base for storage, maintenance, and repair of previously washed planes. All mixing and loading is to be done at outlying satellite airstrips, where the closed mixing and loading systems have been installed. Although in practice this may be difficult to enforce, the Ministry's order (based on concern about contamination of ground water as well as worker health) is proving to be a useful tactic in forcing the companies to cooperate with remedial action. Coveralls have been distributed to all mechanics, and free laundry service is available to most of the mechanics working at the airport. Prior to the spray season in 1988, all mechanics were released from work for a two-day training program on safe handling of pesticides. A worker health and safety committee has been established and is being trained further in basic preventive measures and in emergency treatment of poisoning from cholinesterase inhibitors. Children under 16 years old are no longer employed at the airport, and funding has been obtained for a pilot program to evaluate a new, thin (but pesticide impermeable) glove to see if it can be used for the fine manipulation of parts by the mechanics. Perhaps the most important change which may result in decreased pesticide poisoning by these workers is the decreasing amount of land planted in cotton in Nicaragua. The result may be less demand for aerial spraying and less pressure to get the maximum production from each crop duster, making it possible to enforce the washing of each plane before any maintenance is done. Finally, despite strong objections by the cotton producing industry, the importation of chlordimeform was recently halted, and a new regulation gives a commission headed by the Ministry of Health the right to veto the importation of pesticides deemed to be dangerous to public health.

APPENDIX

Pesticides Used at Crop Dusting Airport, Chinandega, Nicaragua, December 1987

Pesticides with Long-term Health Effects

Chlordimeform** (metabolite is human bladder carcinogen)[8]
Methamidophos** (human delayed peripheral neurotoxin[14])
Toxaphene** (animal carcinogen[15])
Maneb/mancozeb** (animal carcinogen[9])

Other Pesticides Restricted or Prohibited in Other Countries[16]

Methomyl** Mephosfolan** Methyl** and diethyl* parathion

Other Pesticides not Registered in the US

Dominex** Bendocet** Jupiter**

Other Pesticides of Lesser Toxicity

Acephate**	Chlorpyrifos**	Deltamethrin**	Bacillus Thuringiensis**
Propargite**	Talstar*	Propiconazole*	Lambda Cyhalothrin**

*Sprayed at one or more companies during the 30 days prior to the study but not sprayed daily by any company.
**Sprayed daily by one or more companies during the 30 days prior to the study.

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