PESTICIDE ILLNESS SURVEILLANCE: THE NICARAGUAN EXPERIENCE[1]

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INTRODUCTION

Pesticide poisonings are a serious problem in many developing countries, but lack of epidemiologic data has seriously hampered documentation of their magnitude (1). First reports have usually been of outbreaks, such as the epidemic of worker poisonings in Nicaragua caused by the first use of methyl parathion powder in the early 1950s (2). Also, outbreak reports probably influenced early estimates of incidence, such as the 3,000 poisonings per year estimated to have occurred between 1962 and 1972 in Nicaragua (3).

Subsequently, public health workers have examined death certificates and health service records in circumscribed areas such as Mexicali, Mexico, in the late 1960s (4). A similar retrospective review of medical records in public and private hospitals and clinics was later carried out for the Nicaraguan cotton-growing region of León and Chinandega (5). This latter study documented between 312 and 1,187 poisonings annually for the years 1976–1980.

In addition, national studies have examined medical records in Social Security hospitals and clinics in Costa Rica (6) and Guatemala (7), and in public hospitals in Sri Lanka (8); and regional studies, using a range of information sources, have been undertaken for agricultural workers and their families in Central America (9, 10), and for farmers, workers, and the general population in southern Asia (11).

Seeking to respond to the problems described in studies such as these, some developing countries instituted mandatory reporting systems for pesticide poisonings. With the development of a National Unified Health System after 1979, Nicaragua included pesticide poisoning among its notifiable

diseases, but the results were disappointing. While hundreds of poisoning cases arrived at the hospitals of León and Chinandega each year, the Statistics and Information Division of the Ministry of Health (MINSA) recorded 121 cases nationally from 1980 through 1983, including only two cases from the León-Chinandega region *(12)*. Sri Lanka's experience with such reporting was similar *(11)*.

Another response was to institute cholinesterase screening of pesticide workers, so as to detect excessive exposure to organophosphates before symptoms or clinical poisoning occurred. Through such testing, health workers in China *(13)*, several other Asian countries *(11)*, Brazil *(14)*, and Nicaragua *(15)* gained important information on the extent of organophosphate exposure.

The challenge remained to improve case-reporting and to expand cholinesterase screening activities so that they would constitute an effective system of active pesticide illness surveillance. With this in mind, during July of 1984 a cooperative pilot project was begun in the León-Chinandega region of Nicaragua under the auspices of CARE Nicaragua. This pilot project sought to test methods for documenting populations at risk of pesticide poisoning based on subclinical and clinical outcomes of pesticide exposure. This article describes the project's 1984 findings, comments on the adequacy of the approach adopted and changes made to it, and indicates how the findings are being used for preventive purposes.

MATERIALS AND METHODS

Cholinesterase Screening

A tintometric method, endorsed by WHO as a field screening method *(16)*, was used to measure cholinesterase activity. The procedure is as follows:

"Fingerstick whole blood samples from exposed subjects and from a control (nonexposed) person are allowed to incubate with acetylcholine and the indicator bromothymol blue. Changes in color, reflecting acid produced by hydrolysis of the acetylcholine, are measured by comparison to colored glass standards [rated in percentages]. The time required to reach 100% is established with the control sample, and then compared to that for the exposed subject" *(17)*.

Despite some problems with skin contamination, the method allows for sampling large groups under difficult field conditions *(18)*. It has previously shown good correlation with red blood cell and plasma cholinesterase measured by the laboratory-based Michel method *(19)*. Samples with 50% or less cholinesterase activity were categorized as low.

Worksites chosen for screening included state farms and airfields where sprayplanes were loaded with pesticides. These accounted for about 2,000 of the estimated 15,000 exposed workers or farmers in the region. A physician-technician team programmed visits in coordination with individual enterprises that corresponded with periods of more intense pesticide application. Workers with direct exposure to organophosphate or carbamate pesticides were invited to participate in the screening.

After an initial orientation on the purpose of the screening, a question-

naire was administered to each worker that asked about the worker's job, pesticide exposure, use of personal protective equipment, hygiene measures, and symptoms of pesticide poisoning. Blood samples were then taken and results obtained while the team was still at the worksite. Workers whose tests showed low levels of cholinesterase activity were informed immediately. The local union representative and the administrator of the enterprise were each given a list of workers with low levels and instructed to remove these individuals from work involving pesticide exposure.

A total of 2,006 individuals had one or more blood samples taken. Forty-six samples were deleted due to errors or ambiguities in the collection of questionnaire data or recording of cholinesterase levels. This left 1,960 records for further analysis.

Chi-square analysis of differences was conducted with respect to the major known risk factors for low cholinesterase.

Case Reports of Poisonings

Cases of pesticide poisoning included all those involving patients who were reported by a physician of the public health system to be suffering from poisoning attributable to pesticides. The diagnosis usually depended on a history of exposure to pesticides, signs and symptoms of poisoning, and (in the case of organophosphates and carbamates) response to treatment with atropine and (if appropriate and available) pralidoxime.

The Statistics Department of MINSA Region II compiled 1984 data on pesticide poisonings from three sources: (1) cases reported on a ministry form for notifiable diseases; (2) deaths (as recorded on death certificates); and (3) admissions to the two public hospitals, one private hospital, and the three public health centers with beds (as recorded on combined admission and discharge forms).

In addition, separate questionnaires were developed for hospitalized patients at the two public hospitals and for those seen either at emergency rooms of these hospitals or health centers. The questionnaires elicited demographic data, the patient's workplace and job title, the pesticides used, protective measures taken, signs and symptoms of poisoning, and (for hospitals) case management information. These questionnaires were distributed during the peak pesticide use season (August through December) with instructions to use them in all cases of pesticide poisoning.

Monitoring by project personnel was carried out when possible. Retrievable charts from hospitalized cases seen earlier in the year were reviewed. Cases reported by questionnaire were cross-checked with those reported on admission/discharge forms, death certificates, and notifiable disease forms to remove duplications.

Results

Cholinesterase Screening

Low levels of cholinesterase were discovered among 151 (8%) of the 1,960 workers screened. As Figure 1 shows, during the first nine months of 1984 between 1% and 4% of the samples were found to have low levels of cholinesterase activity. However, during the last quarter the percentage of samples
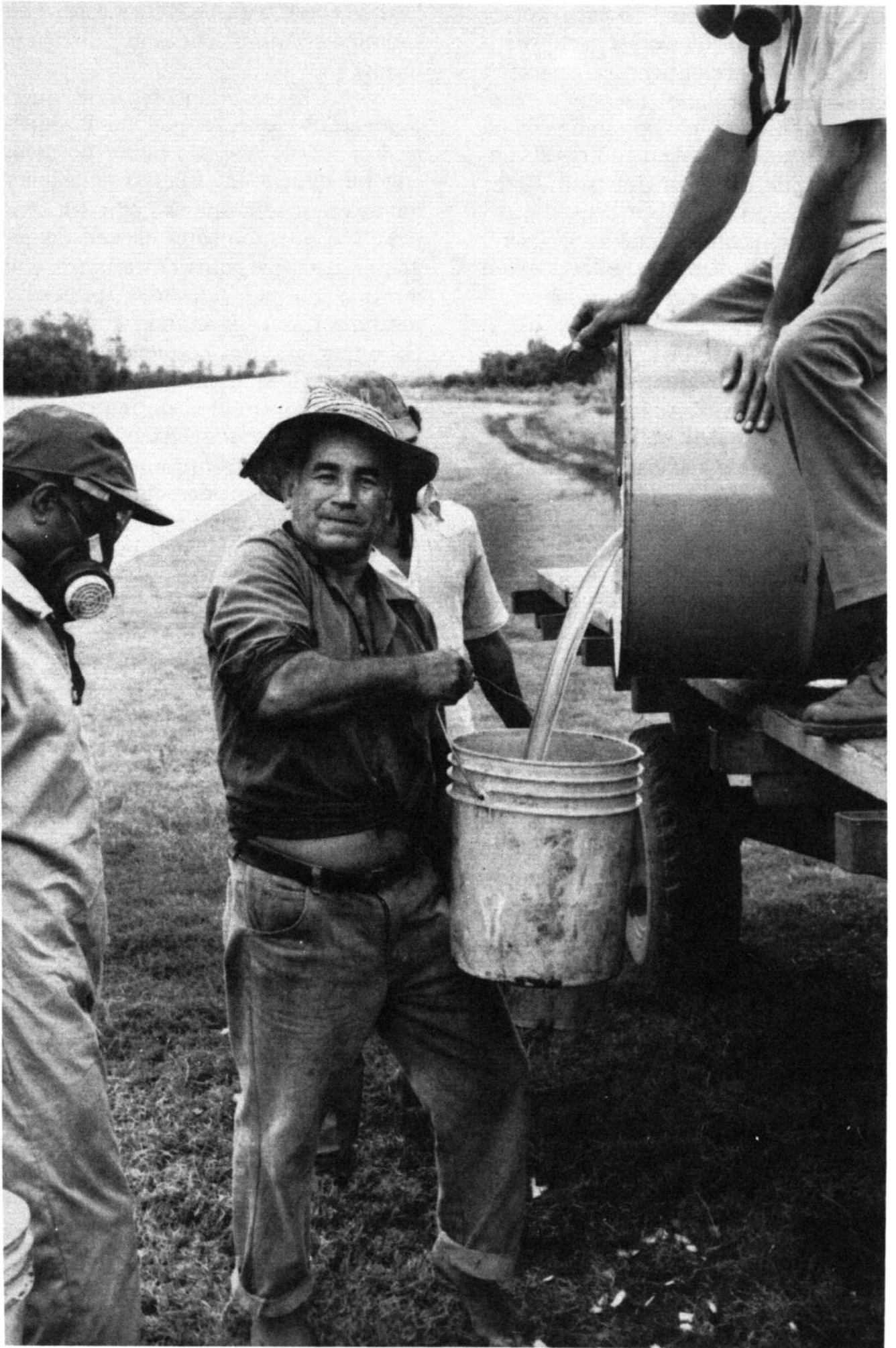
FIGURE 1. Percentage of blood samples showing low levels of cholinesterase activity, by month obtained.
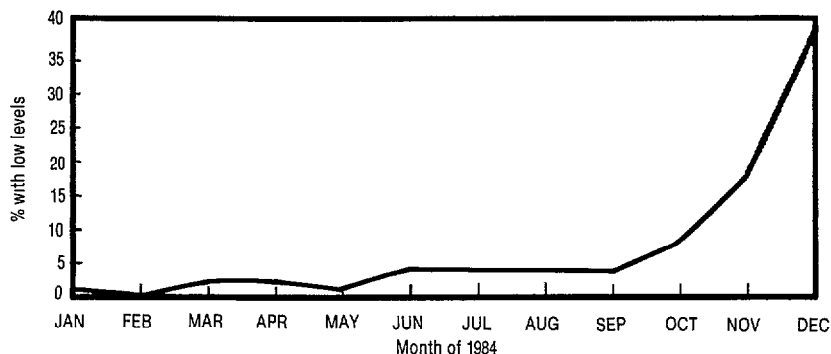
with low levels climbed sharply, reaching a peak of 40% (44 of 111 samples) in December. Since the majority of samples with low levels and with better-quality questionnaire data were obtained during the last quarter of the year, further analysis was conducted solely on the samples drawn from October through December (N = 656).

The highest rate of low levels was found at airfields involved in crop spraying (38%, 49 of 130 samples). Regarding workers farming specific crops, only 4% (3 of 72) banana plantation workers but 17% (58 of 340) workers on cotton farms showed low levels. It should also be mentioned that workers on cotton farms constituted a progressively increasing proportion of those screened— accounting for 42% of the screened samples in October, 71% in November, and 96% in December.

Workers decanting a concentrated insecticide at an airfield without adequate personal protection.

As Table 1 indicates, workers in different job categories showed marked differences in the rates of low cholinesterase detected. Among the airfield workers, those who were plane washers, mixer/loaders, and mechanics were the most affected. Among the farm workers, tractor sprayers and general field workers accounted for most of the blood samples with low cholinesterase activity.

The data in Figure 2 show that workers who reported using specific types of personal protective equipment (PPE) were significantly less likely to have low levels of cholinesterase.

No correlation was observed between low cholinesterase levels and the total number of symptoms reported.

Case Reports

Only seven notifications of pesticide poisoning were made using the ministry form for notifiable diseases. Six deaths diagnosed as pesticide poisoning were reported on death certificates. The three hospitals reported 170 cases through the traditional admission/discharge form. The new questionnaires provided more detailed data on an additional 158 cases from the two public hos-

TABLE 1. Low cholinesterase levels found in the 656 October–December 1984 blood samples, by workplaces and job titles of the workers tested.

| Workplaces | Job titles | Blood samples (fourth quarter) | | |
		No. tested	No. with low levels	% with low levels
Airfields	plane washer	10	6	60
	mixer/loader	27	13	48
	mechanic	44	18	41
	other	49	12	24
Farms	tractor sprayer	10	3	30
	field worker	206	50	24
	scout	51	4	8
	flagger	68	4	6
	other	58	5	9
Other or not stated		133	7	5
Total		656	122	19

FIGURE 2. Percentages of tested workers with low levels of cholinesterase activity, by specific types of personal protective equipment (PPE) used. The data shown are for blood samples obtained in the fourth quarter (October–December) of the 1984 study period.
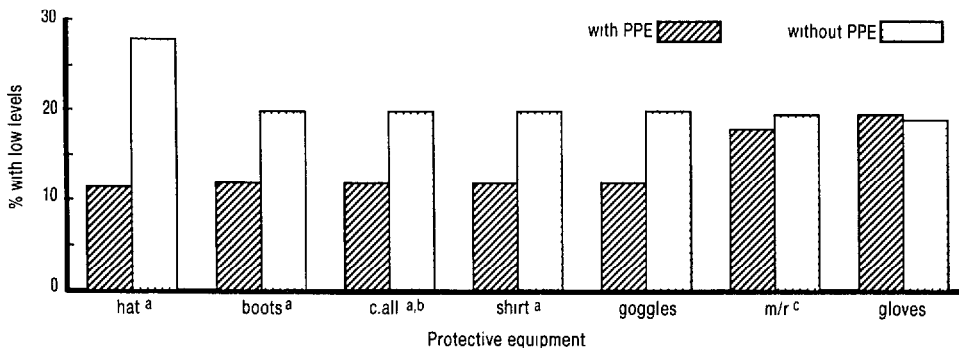
a Chi-square significant at p < 0 05.

b c.all = coveralls, long-sleeved shirt

c m/r = mask/respirator

pitals and 68 cases from 15 of the 18 public health centers. With a total of 396 poisonings (duplications removed) in an estimated general study region population of 531,000, the apparent rate of poisonings was 74.6 cases per 100,000 inhabitants per year. Among the rural population, estimated at 240,000, the rate was 165 cases per 100,000 inhabitants per year.

Twenty-eight (13%) of the 221 study subjects whose ages were reported were in the 10–15 year age group. Most (189 of 224, or 84%) of the poisonings for which a date was reported occurred in the last quarter of 1984, as did five of the six deaths (Table 2). Four of the six deaths and the vast majority of poisoning cases reported via questionnaires (203 of 216, or 94%) were occupationally related. The specific job categories accounting for the highest percentages of poisoning incidents reported on the questionnaires were field worker, applicator, and mixer/loader (Table 3).

Information on the specific crops involved was available in only 53 of the reported cases, two-thirds of which occurred on cotton farms. Of the 128 cases where the patient's workplace was identifiable, 48 (37.5%) occurred on

small private farms, 32 (25%) occurred on state farms, 19 (15%) occurred on large private farms, and 16 (12.5%) occurred at airfields.

The route of exposure was indicated in 195 cases. In most instances (68%) dermal exposure was involved— either alone (in 90 cases, 46% of the total) or together with inhalation (in 38 cases, 19% of the total).

Such dermal exposure could not be prevented by the most commonly

TABLE 3. Pesticide poisoning cases reported on questionnaires in 1984, by job titles of patients.

Job title	Reported poisonings	
	No.	(%)
Field worker	46	(21)
Applicator	36	(17)
Mixer/loader	27	(12)
Scout	24	(11)
Flagger	8	(4)
Mechanic	6	(3)
All other job titles	56	(26)
Not work-related	13	(6)
Total	216[a]	(100)

[a] Ten of the 226 questionnaires completed did not indicate the patient's job title.

TABLE 2. Reported cases of pesticide poisonings and deaths in Nicaragua occurring in 1984, by month.

Month(s)	Poisonings reported		
	No. of survivors	No. of fatalities	Total
January–July	9	0	9
August	8	0	8
September	17	1	18
October	99	2	101
November	70	0	70
December	15	3	18
Month unknown	172	0	172
Total	390	6	396

used piece of personal preventive equipment, a mask/respirator (used in 56 of 146 cases, or 38%). Use of clothing to protect against skin exposure was reported less often. Long-sleeved shirts had been worn in 41 cases (28%), rubber boots in 29 cases (20%), a hat in 27 cases (18%), overalls in 25 cases (17%), and gloves in 22 cases.

Regarding education, only 74 of the 189 subjects providing responses (39%) reported receiving previous education about the safe use of pesticides.

Most (187, or 90%) of the 207 patients providing satisfactory questionnaire answers identified one or more pesticides as the source of their illness. Organophosphates were so named by 129 of these patients, followed distantly by carbamates and pyrethroids, both of which were named by 19 patients. One organophosphate, methyl parathion, either alone or in combination with other pesticides, was named in 96 cases. The poisoning signs and symptoms most commonly reported were consistent with organophosphate poisoning—these being nausea and vomiting, headache, tremor, dizziness, and blurred vision, each of which occurred in over 50% of the 207 cases.

DISCUSSION

Our methods of expanded surveillance succeeded in detecting 151 workers at risk of organophosphate poisoning and in raising the reported number of poisoning cases from seven to 396. Interpretation of these and other results involves difficulties inherent in the analysis of surveillance data. We shall examine these difficulties, changes deemed likely to reduce them, and corroborating evidence that supports the validity of the reported data.

Regarding cholinesterase screening, the major drawback is the absence of information about worker exposure to pesticides and about the populations from which the screened workers were drawn. Employers and cooperatives have been asked to maintain a list of those who work directly with pesticides (e.g., mixer/loaders) or who would have substantial contact with pesticides (e.g., field workers). Measurement of exposure on a mass scale is not feasible, but more detailed descriptions of exposure conditions by health and safety inspectors are being encouraged. (For example, plane washers are a group we have observed who have a high degree of contact with pesticides and make limited use of personal protective equipment.)

Second, it should be noted that the screening conducted was inconsistent during the first part of 1984 and was not oriented toward those at highest risk. Thus, the January 1984 rates of low cholinesterase levels appear unexpectedly low, given the anticipated persistence of organophosphate effects. Subsequent focusing of screening upon other groups identified through this study (such as small farmers) and following the subjects found to have low cholinesterase activity levels until those levels returned to normal required greater resources and more effective cooperation with the workplace involved.

Regarding case reports, major concerns include the reliability of diagnosis and the completeness of reporting.

Above: One of the authors (Dr. Feliciano Pacheco Antón) providing advice and inspecting pesticide in transit. Below: A fieldworker in typical dress pointing to the label on a barrel of chlorpyrifos, an organophosphate insecticide.
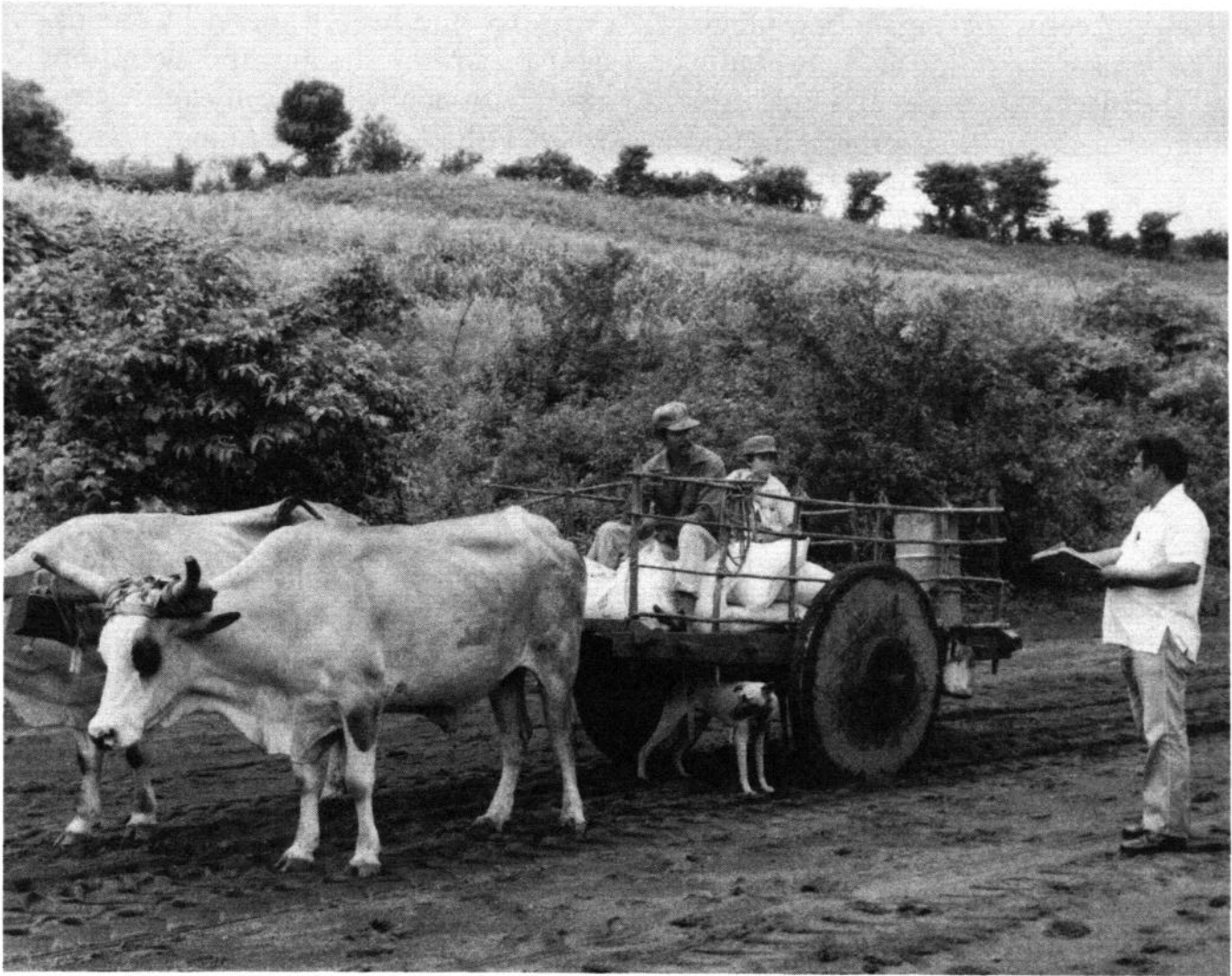
Initial symptoms of organophosphate and carbamate poisoning are nonspecific (e.g., headache, nausea, and malaise) and occur against a high background of similar symptoms among agricultural workers. Laboratory confirmation by cholinesterase testing was only available at the two public hospitals. Only 18 patients had blood samples drawn, and these were commonly obtained after treatment with the cholinesterase reactivator pralidoxime, invalidating the results. A recent mortality study from the Philippines suggests that many cases of organophosphate poisoning are misdiagnosed (20). In our experience, only a

clear exposure history voiced by the patient or advanced signs and symptoms have traditionally been consciously associated with pesticide poisoning.

Interviews with clinical staff members at public health centers indicate that underreporting remains a substantial problem. In 1985, three to seven times more cases were treated than were officially reported to the regional statistics office (21). Shortages of forms or questionnaires and of staff members

Procurement of a blood sample in the field to determine whole blood cholinesterase levels.

tend to reduce the number of reports submitted, particularly at year's end. These difficulties may explain the apparent December drop-off in poisonings, a drop-off not matched by reduced mortality or rates of lowered cholinesterase levels. Shorter, more available questionnaires and increased personnel should counteract this problem.

Corroboration of some of our important findings is available. The most frequently mentioned pesticide, methyl parathion, is recognized as being highly toxic and previously caused substantial numbers of occupational poisonings in California (22), Japan (23), and China (5) before its use was controlled. Methyl parathion was also the most heavily used pesticide in Nicaragua in 1984 (3,056,950 kg of 80% technical grade methyl parathion were imported—24).

Regarding job titles, mixer/loaders at airfields, as well as applicators and tractor sprayers on farms, have traditionally been recognized as high-risk groups (25).

With respect to the route of exposure, a Costa Rican study reported that dermal or ocular exposure was the principal cause of poisoning in 44.5% of the reported cases in 1982 and 53.6% in 1983 (6). Direct exposure measurements have demonstrated that, in general, far greater pesticide exposure occurs through the skin than by the respiratory route (26). Clothing providing skin protection (especially coveralls) has been shown to reduce absorption of pesticides as measured by the presence of urinary metabolites (27). In our study, some use of skin-protective clothing (boots, coveralls, long-sleeved shirts, and hats) was significantly associated with a lower frequency of low cholinesterase levels. The lack of association with glove use was likely due to poor durability of the gloves, faulty maintenance, or less frequent use by those reporting.

A comparison of pesticide poisoning rates and mortality from pesticides in several developing countries (Table 4) indicates that the poisoning rates found in the León-Chinandega region (74.6 cases per 100,000 inhabitants, 165 per 100,000 rural inhabitants) are relatively high. The cause could be a more significant pesticide problem, lack of dilution by low-incidence regions in national statistics, or more effective reporting as a result of our efforts. We find the

TABLE 4. Annual rates of pesticide-related poisonings and deaths recorded in Nicaragua and four other developing countries at various times since 1977.

Country	Period	Rates per 100,000		Reference population
		Poisonings	Deaths	
Sri Lanka (8)	1979	79	7.3	general
Nicaragua, León-Chinandega region	1984	74.6	1.1	general
	1984	165	2.5	rural
Colombia (28)				
Medellín	1979–1982	34.9	1.4	general
Antioquia	1977–1982	11.6	0.75	general
Guatemala (7)	1983	20.3	—	rural
Venezuela (29)	1980–1984	6.0	0.4	general

final explanation most compelling, given the difficulties involved in conducting pesticide epidemiology in developing countries. Our methods are currently being adopted in other regions of Nicaragua.

RECOMMENDATIONS AND CONCLUSIONS

Several policy issues are raised by our findings. We have shared these with the Regional Subcommission on Pesticides.[6]

Specifically, it appears that methyl parathion use should be reduced by further substitution with synthetic pyrethroid insecticides and replacement of chemical control methods with cultural and biological control methods *(30)*.

Also, the risks of pesticide exposure for pesticide mixers and loaders at airfields is a priority problem area. Closed systems (employing safety technology designed to reduce exposure of airfield workers during the loading of sprayplanes) have been mandated by new pesticide regulations. An estimated 40 such systems had been imported and were operational at local airfields during the 1986 spray season.

The provision of personal protective equipment (PPE) to workers ex-

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[6] The Regional Subcommission on Pesticides of the Regional Commission of Comprehensive Worker Care (Subcomisión Regional de Plaguicidas de la Comisión Regional de Atención Integral al Trabajador, CRAIT).

posed to pesticides has been given a higher priority. We believe that the emphasis should be shifted to dermal protection, which would be cheaper than the mask/respirators providing protection. This move has obvious cost implications for Third World governments faced with critical shortages of foreign exchange.

Poisonings among minors (< 16 years) continue to pose a significant problem. Greater emphasis must be placed on child labor standards relating to pesticide exposure.

Implementation of these measures, supported by expanded cholinesterase screening and educational interventions, should reduce pesticide poisonings in Nicaragua's Region II. A balance between increased diagnosis and reporting on the one hand and decreased cases on the other is expected to show itself in the reported poisoning rates of future years.

SUMMARY

In 1984, work designed to expand cholinesterase screening activities and improve the reporting of pesticide poisonings was initiated in Nicaragua's León-Chinandega region as a pilot project.

Using a field tintometric method, 1,960 workers were screened for whole blood cholinesterase. The percentage with low cholinesterase activity levels (50% or less) increased sharply during the peak spraying season. Airfield workers were most affected, though a noteworthy share of certain agricultural workers were also found to have low levels. Workers who used certain kinds of personal protective equipment were significantly less affected ($p < .05$).

In addition to these survey findings, six deaths and 396 pesticide-related poisonings were reported in the León-Chinandega region in 1984. This indicated a relatively high rate of 74.6 poisoning cases per 100,000 inhabitants, 84% of them occurring in October–December. Ninety-four percent of the cases reported via questionnaires were occupationally related, small farms being the most affected. Methyl parathion was implicated in roughly half of these cases, two-thirds of which were due to dermal exposure.

Policy recommendations derived from the initial results reported here include reduction of methyl parathion use, installation of closed systems for safer aircraft loading, provision and use of clothing that protects the skin against exposure, and restriction of pesticide work by minors.

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