

Estimating Underreported Pesticide Poisonings in Nicaragua

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We undertook to estimate the degree of underreporting to a regional pesticide poisoning registry, and to estimate the true incidence of poisoning in an agricultural region of Nicaragua. We surveyed 633 workers at 25 of 33 agricultural cooperatives and any nearby private farms in a area geographically convenient to the regional health headquarters with a short structured interview about pesticide poisonings. Eighty-three percent of workers described current use of pesticides. Twenty-five percent described a pesticide poisoning in the preceding 12 months, and almost one-half (48%) described having been made ill by pesticides at some point in time. Sixty-nine (11%) described a poisoning in the preceding month, 23 of whom had received medical attention. The names of the medically treated were sought in the Regional Pesticide Poisoning Registry for the survey year of 1988. Only 8 of the 23 subjects were found reported to the registry when a total of 1,143 human pesticide poisonings were reported in the entire region. Using 65% as an estimate of underreporting to the registry, we calculate that 3,300 (95% CI 2100-7500) poisonings had received treatment in the region in 1988, of whom more than 2,100 remained unreported. Based on the ratio of total poisonings (treated and untreated) to registry-reported poisonings among our survey respondents, we estimate that 6,700 (95% CI 4100-18000) systemic poisonings, occurred in 1988 in the region.

Underreporting of pesticide poisonings disguises the enormity of the problem in developing countries. Even in a region with a strong emphasis on illness reporting for targeted conditions, underreporting is substantial. This method for estimating underreporting is easily applied and provides a rough estimate of registry underreporting and actual incidence for conditions identifiable by a community-applied questionnaire. © 1996 Wiley-Liss, Inc.

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INTRODUCTION

Pesticide poisoning is a significant health hazard for much of the world's population. The World Health Orga-

nization (WHO), based on hospital admission data, estimates that 3 million severe pesticide poisonings occur worldwide annually [World Health Organization, 1990]. Based on a survey of self-reported pesticide poisonings from four Asian countries and an estimate of the worldwide agricultural workforce, Jeyaratnam has estimated that occupational pesticide poisonings, both hospitalized and nonhospitalized, affect as many as 25 million agricultural workers per year worldwide [Jeyaratnam, 1990].

Attempts to determine the true impact of pesticide poisoning are limited by the imprecision or absence of data from reporting sources. Many factors, including excessive work load and ignorance of requirements, are prominent deterrents to reporting by clinicians. In California, where medical professionals are legally obligated to report pesti-

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cide related illness, Kahn [1976] estimated that only 1–2% of pesticide illness cases were officially reported. In developing countries, poor communication infrastructure is another barrier to a practitioner's compliance with reportable disease requirements.

In order to estimate the true significance of pesticide poisoning reports to the Regional Pesticide Poisoning Registry in Region II Nicaragua, we undertook a cross-sectional survey designed to develop an estimate of registry under-reporting.

PESTICIDE POISONING IN NICARAGUA

With the establishment of the National Unified Health System in Nicaragua in 1979, pesticide poisonings were included among the list of mandatory reportable diseases. Clinicians in regional health centers and hospitals, report pesticide poisonings by mail or telephone to the Office of Epidemiology at the Regional Ministry of Health. The case definition of pesticide poisoning is not defined by regulation and is left to the clinician's discretion. Although a standard form is provided, reports vary widely in completeness. Reports consistently include name, age, gender, and clinic and often include the pesticide and crop involved and whether the poisoning was accidental, occupational, or suicidal. The activity during which the poisoning occurred and whether safety equipment was used are variably included. During the first 10 years of reporting, the pesticide registry covering the Northern Pacific plain (the country's major agricultural region) received increasing numbers of pesticide poisoning reports. In 1989, pesticide poisoning reports began to decrease. From 1987 to 1991, reports to the registry varied from a high of 1,233 in 1987, during an epidemic of poisonings from the introduction of a new formulation of carbofuran, to a low of 430 in 1991, during changes in governmental agricultural policy [Keifer et al., 1990; McConnell and Hruska, 1993].

METHODS

Study Population

We intentionally focused our cross-sectional survey on a population sector from which we expected to obtain a sufficient number of pesticide poisonings to be able to develop a reasonably stable estimate of underreporting. The area, one of 18 areas in Region II, was chosen because of its proximity to the region's capital and the basic grain cooperative-based farming practices were representative of most of the region. The region's agricultural production focuses on basic grains (corn, sorghum, sesame, and rice), cotton, and cattle. We targeted small farming cooperatives and small private land owners in the area. These cooperatives and owners use pesticides heavily and have relatively high

rates of pesticide poisonings. We also took advantage of the proximity of several large private farms and interviewed all available employees.

The questionnaire was administered during the last 3 weeks of August 1988, a period of traditional heavy pesticide use, toward the end of the planting season. Generally, contact was made first with one of the elected officials of the farming cooperative; arrangements were then made to interview the other cooperative members. Interviewing was performed on all days of the week except Sunday and was usually timed to take advantage of the specific cooperative's weekly meeting.

Data Collection

The structured interview, designed to be brief, required less than 5 min to complete. Respondents were individually asked whether they worked with pesticides and whether they had ever been made ill or had suffered a poisoning due to exposure to pesticides. If a participant responded that he or she had been poisoned or made ill, when and where the incident had occurred was obtained. The interviewer, in an open ended question, then asked what symptoms had been experienced for each incident. The participant was also asked whether and where medical treatment was sought. Neither being "poisoned" nor "made ill" was defined, symptomatically or otherwise, for the participant. All respondents were specifically asked whether, in the previous month, they had been made ill or suffered a poisoning. Details of any recent poisonings were also obtained. Five Ministry workers and one of the authors (M.K.), all fluent in Spanish, administered the questionnaire. Each interviewer was trained by role playing until all administered the questionnaire in a consistent manner.

The symptoms elicited from participants reporting a poisoning were immediately compared to a printed list containing 12 symptoms commonly seen in cholinesterase inhibitor pesticide poisonings. These included: lightheadedness, blurred vision, nausea, vomiting, weakness, excessive sweating, tremor, excessive salivation, headache, difficulty breathing, convulsions, and loss of consciousness. If three or more of the listed symptoms were reported, this was noted on the questionnaire as "verified" and considered a "probable" poisoning for subsequent analysis. Reported incidents which resulted in only dermatological, ocular or respiratory complaints, without at least three symptoms, were not classified as "verified."

We allowed 4 months from the completion of the questionnaire survey for clinical reports from the surveyed area to arrive. Clinical sites routinely reported cases to the registry at month's end, and rarely did reports arrive later than two months after clinical care was given. We then searched the Regional Poisoning Registry for the names of survey respondents who had reported to us a pesticide poisoning

for which they had seen a medical professional in the month prior to the interview. Based on the percentage of those found, we developed an estimate of underreporting.

The results were analyzed with SPSS/PC+ [Norusis, 1990]. Dichotomous outcomes were evaluated by chi-square tests, continuous outcomes by unpaired Student's *t*-test, and confidence intervals calculated by methods described by Armitage and Berry [1987].

RESULTS

Study Population

Six hundred thirty-three agricultural workers were approached for interview; no one approached refused to participate. Most subjects were male (70%); the average age of all those interviewed was 35.6 years (range 7–79). Most respondents were from the cooperative sector (74%). Records from the Ministry of Agriculture indicated 33 cooperatives in operation in the study area; interviews were conducted at 25 (76%). We failed to contact and interview the remaining 24% because the exact cooperative locations could not be found during the time allotted to data collection. We interviewed 458 registered cooperative members, representing 57% of the 803 registered cooperative members in the area. Those absent at the cooperative meetings when interviewing occurred were not interviewed, and no attempt was made to return to cooperatives to ensure more complete sampling. No demographic information was obtained on nonparticipants. The remainder of our respondents were either working relatives of cooperative members or private employees of several large and small private farms in the area. No estimate is available for the number of employee farm workers or family members, or for the number of small land holders in the study area.

Pesticide Use and Poisonings

Among all respondents, 82.5% said they worked directly with pesticides. Male respondents were significantly more likely than women to report work with pesticides (95% of men versus 51% of women, $p < 0.01$). Although Nicaraguan law prohibits individuals under age 16 from working with pesticides, 43% of respondents in this age group reported working with pesticides.

Nearly one-half of all queried workers (48%) reported having been "poisoned or made ill" by pesticides at some time in their lives; 25% reported a poisoning in the previous 12 months; 11% reported a poisoning in the preceding month. Poisonings were described more frequently by current pesticide users (those who worked with pesticides) than by nonusers (57% versus 6%, $p < 0.01$) and in men compared to women (60% versus 29%, $p < 0.01$). Among workers re-

porting pesticide use, poisoning or illness was reported by 62% of men and 48% of women ($p < 0.05$).

Table I shows the age distribution for the survey sample and the cumulative incidence density for self-reported pesticide poisonings by age group among pesticide users. Cumulative incidence density of poisonings is highest for the youngest age group interviewed, and progressively decreases across increasingly older age strata. The proportion of younger pesticide users (less than 17 years of age) reporting a pesticide poisoning in the previous 12 months was 47%, whereas only 38% of all other users reported a poisoning ($p < 0.01$) in the past 12 months. Twelve poisonings were reported by children under 16 years of age (the legal age limit for handling pesticides in Nicaragua).

Respondents reported a total of 438 distinct lifetime poisoning episodes among both pesticide users and nonusers. Several respondents reported more than one poisoning and one respondent detailed 9 separate episodes. Many incidents (38%) involved a mixture of pesticides. Whenever possible, pesticides indicated in a poisoning by a respondent, were classified by the investigators into broad chemical groups. Organophosphates were the class of pesticides most commonly reported as being responsible for poisonings. Most poisonings occurred while backpack spraying (65.6%). This is a common method for applying pesticides in Nicaragua, particularly on small farms.

Respondents reported at least three symptoms characteristic of cholinesterase inhibiting pesticide overexposure in 74.2% of all reports of "poisoning or illness." About one-half of all reported episodes (48%) were seen by medical practitioners. Eighty-five percent of the subjects who saw a clinician for a "poisoning or illness" episode reported three or more symptoms. There was a significant association between seeing a practitioner and the worker reporting three symptoms ($p < 0.001$).

In order to examine the effect of survey-participant memory on self-reporting of poisoning, we examined if time since the incident influenced the described severity of a poisoning (i.e., as having been evaluated by a medical practitioner or reported with three symptoms). A respondent was more likely to report three or more symptoms ($p < 0.05$) and was more likely to report attention by a medical practitioner ($p < 0.05$) if the poisoning had occurred 12 or more months before the survey, possibly indicating that only more severe poisonings were remembered from the more distant past.

Underreporting Estimate

In order to limit the effect of memory bias, our region-wide extrapolations are based only on individuals who reported medically treated, symptomatically verified episodes within 1 month of the survey date. Sixty-nine respondents reported being "poisoned or made ill" from pesticides in

TABLE I. Poisonings per Years of Pesticide Use by Age Group for 520 Survey Respondents Reporting Pesticide Use: Nicaragua 1988

Age group (Y)	No. of respondents in age group reporting pesticide use	Cumulative years of pesticide use by age group	No. of lifetime poisonings reported by age group	Poisonings per 100 person-years of pesticide use by age group
10-19	53	106	35	33.0/100
20-29	118	721	88	12.2/100
30-39	139	1,547	122	7.9/100
40-49	107	1,679	109	6.5/100
50-59	63	1,129	49	4.3/100
60-69	26	354	18	5.1/100
70-79	14	193	8	4.1/100
All users	520 ^a	5,729	429	7.5/100

^aAlthough 522 subjects reported use of pesticides, 2 questionnaires were returned without listing the participants' ages.

the month preceding the survey; 47 (68%) met our three symptom criteria for a probable poisoning. Twenty-seven described having received medical attention for the episode, 23 of whom met criteria as a "probable" poisoning and were sought in the Ministry of Health Regional Pesticide Poisoning Registry. Eight of the 23 legible names were found in the registry database. Therefore, we estimate only 35% of treated poisonings were reported to the registry by the treating clinician. This underreporting of 65% refers only to those poisonings for which medical attention was sought, as non-treated poisonings can obviously not be reported by a clinician.

Figure 1 schematically demonstrates the relationships among various categories of exposed and poisoned population groups. Each larger circle subsumes the smaller circles within. The delineated wedge transecting the circles represents the distribution of our respondents. Using responses on the questionnaire, respondents were assigned into categories ("poisoned"-not treated, "poisoned"-treated). Using the name search in the database, a "poisoned"-treated incident was placed into treated-reported or treated-unreported. Assuming the ratios between these poisoning categories in our sample reflect the reporting percentage of the regional population, by identifying the number in our sample who had been reported to the registry and knowing the total number reported to the registry in 1988, we can estimate the size of each of the categories for the whole population of the region.

If one assumes that the 1,143 clinician-based reports received by the Regional Registry in 1988 represent only 35% of the medically treated poisonings for the year, then we can estimate 3,300 (95% CI 2100-7500) pesticide poisonings actually received medical therapy in Region II in

1988. We further estimate that an additional 3,400 individuals experiencing "probable" pesticide poisonings did not seek treatment, and the total number of "probable" poisonings annually in Region II was 6,700 (95% CI 4100-18,000). If we include those individuals reporting less than three symptoms (which would include most with only dermatological or ocular toxicity), this number rises to 9,400 (95% CI 5700-27,000). We focused our survey on cooperative members who, based on our experience with the Regional Pesticide Poisoning Registry, are generally heavy users of organophosphates, carbamates, and herbicides on basic grains and cotton. As a result, we cannot confidently extrapolate the use experience of this group to other workers who may have less intense contact with pesticides and who are also represented in the "exposed" category (outer circle, Fig. 1). For this reason, we have no estimate for the number of "exposed" in the population.

DISCUSSION

This pilot application of a structured questionnaire-based approach to estimating the degree of underreporting to the Nicaraguan Region II Pesticide Poisoning Registry proved quite promising. Our findings must be interpreted with caution as they are relatively crude. Nevertheless, the results provide evidence that substantially higher rates of pesticide poisoning are occurring in this agricultural region of Nicaragua than portrayed by the already high official counts. By our methods of estimation, the 1,143 pesticide poisonings reported by clinicians to the Region II Registry in 1988 represented only 35% of the treated pesticide poisonings in the region, and only 17% of all reported and unreported "probable" poisonings. To our knowledge, this

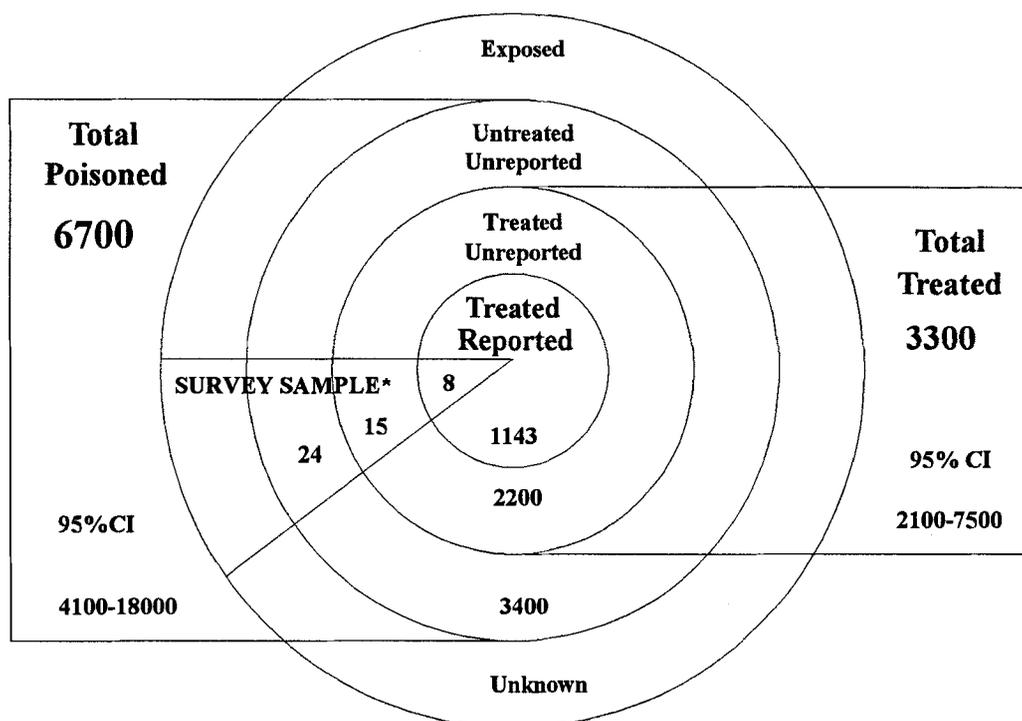


FIGURE 1. Underreporting survey estimates: Poisonings for Region II, Nicaragua 1988. Asterisk (*): 633 workers surveyed; 47 "probable" poisonings during month prior to survey.

study represents the first attempt in Latin America to estimate the incidence of treated and non-treated pesticide poisonings based on combined survey and registry data. Our results are consistent with reports of high rates of poisoning in developing countries in Asia and Central America [Jayaratnam et al., 1987; Wesseling et al., 1993].

This method used self-reports of a locally common occupational illness in a sample of the population to estimate the degree of underreporting to a regional reporting system. We believe this method has general utility for evaluating underreporting of certain reportable diseases. The mathematical computations and results are equivalent to capture-recapture techniques for estimating underreporting, using multiple sources for case identification [Hook and Regal, 1982]. The use of a survey for case identification permits the collection of additional information on the disorder of concern, as exemplified by our calculations of incidence-density by age group. The survey format also permits its application in areas where a second independent source of incidence or prevalence data does not exist.

Prior to our application of this interview-based format, we explored utilizing clinic records as a source for cases. Unfortunately, records in rural clinics in Nicaragua varied substantially in quality and completeness. We concluded that comparing clinic visits to registry reports would potentially create a bias in that clinics with the best record systems would also be the most likely to report.

The use of population self-reports has important limitations. In order for the method to be applied with confidence, the outcome of interest must be easily identifiable by the respondent or the self-reports must be screened for accuracy. The underlying assumption of the method is that a clinician, faced with the same facts as obtained from the questioned subject, would diagnose the disorder and would report the case. Unfortunately, in the situation in which there are no pathognomonic characteristics of the disorder, meticulous screening can limit generalizability, because an ideal case may have greater likelihood of being reported than a less obvious case. It is our impression that anticholinesterase pesticide poisoning in Region II is well recognized by the population. The Ministry of Health, in conjunction with CARE International and several other nongovernmental organizations, conducts pesticide health and safety training for farmers on a regular basis, as this area of Nicaragua has a long history of significant problems with pesticide poisoning [Cole et al., 1988; Sweezy et al., 1986]. Clinicians in the region receive training about pesticide poisoning while in medical school, and in continuing medical education courses offered by the Ministry once in community practice. Because we screened our self-reports for symptoms and limited our estimates to only the group of cases who reported three or more symptoms, our estimates may be very conservative.

We believe that subjects had no reason to deny that they

had suffered a poisoning. We also believe it unlikely that a survey participant who had been diagnosed as suffering a poisoning would not have been aware of it. So, as an expediency, we recorded and searched the registry only for the names of individuals who described to us a pesticide poisoning in the month prior to the survey. We did not attempt to determine whether poisonings among our surveyed population had been recorded by the registry (reported) but not identified by the survey. Had we missed poisonings in our population sample, its effect would have been to reduce the number of poisonings upon which to base our estimates of underreporting and so decrease our survey efficiency and increase our confidence intervals, but failure to identify these cases would not have biased our underreporting estimates.

The representativeness of the sample with regard to the registry population is an important consideration in being able to extrapolate confidently. Our use of this particular convenience sample probably led to a conservative estimate of underreporting. The clinical catchment area for the sample is served by clinics with relatively frequent contact with the regional headquarters, and the regional hospital is about 30 minutes away by car. Such proximity is likely to facilitate case reporting.

Our finding that one quarter of our sample of agricultural workers described suffering a pesticide poisoning in the 12 months before the survey was surprising, as this is more than three times higher than the approximately 7% yearly rate of self-reported pesticide poisonings found in an investigation of Malaysian and Sri Lankan agricultural workers [Jeyaratnam et al., 1987]. Our decision to query principally cooperative-based farmers (an economic sector with heavy pesticide use) may have been responsible for this high rate. Cultural, or the educational factors already mentioned, may make Nicaraguan farmers more willing to admit previous intoxications. Nevertheless, because our sample may not have been representative (from the perspective of incidence of poisoning) of Nicaraguan agricultural workers in general, the survey based self-reported incidence of 25% may not reflect rates for the region or the Nicaraguan population.

While the rates of poisoning in our survey sample prevent generalizing from the survey alone to other populations, we believe they did not bias our registry-based extrapolations to treated-not reported. These extrapolations are based on the probability of a treated poisoning being reported to the registry, a more clinician-dependent event. We believe these processes are not confounded by the frequency of poisoning in the community from which the case derives.

As would be expected, most (85%) of those who reported seeing clinicians in the preceding month described three or more symptoms associated with the episode, but three or more symptoms were also reported by a high per-

centage (57%) of those not seeking professional care. While we can be more confident of our estimate of underreporting based only on individuals with three or more symptoms, this case verification measure may result in overestimating registry reporting if individuals with nonsystemic problems such as dermatitis alone or isolated symptoms are less likely to be reported. These individuals were excluded from our calculations of underreporting while still representing legitimate overexposures.

An important finding of our survey is the calculated incidence density of poisonings per years of pesticide work for each age group (Table I). Our findings that younger workers have higher incidence rates of poisoning than older ones may be explained by a variety of factors including recent increases in toxicity of products, changes toward more dangerous application methods, fewer reports by older workers due to incomplete recall of temporally remote events, and age-differential attribution of illness to pesticides by workers. However, memory bias and recent changes in toxicity and application methods appear to be unlikely explanations, as the poisoning rate for the last 12 months among younger workers is higher than among older workers (47% versus 38%). This higher rate in younger workers is consistent with a common perception that workers with less experience are at greater risk of intoxication. In fact, another study in this population, supports this impression. Younger and less experienced pesticide fumigation employees in Nicaragua were more likely to be assigned to the more dangerous, contaminated jobs, and were more likely than older workers to suffer an intoxication [McConnell et al., 1990].

CONCLUSION

In this survey study, in Nicaragua 1988, we found only 35% of treated "probable" poisoning had been reported by clinicians under the mandatory reporting system. We also found more than one untreated poisoning for every treated one. A wider study (with staged random sampling from the entire region) is planned, and should provide more reliable estimates of regional underreporting. However, even with the limitations of this study, our findings emphasize the enormity of the pesticide poisoning problem for an agricultural region in a developing country.

This high rate of poisoning is of particular concern in light of the fact that the use of pesticides in developing countries is rapidly increasing [World Health Organization, 1990]. Also, of particular concern is the evidence from our survey that younger workers are at increased risk of intoxication. The potential long-term effects of organophosphate pesticide poisoning have been demonstrated by numerous investigators [Savage et al., 1988; Rosenstock et al., 1991; Steenland et al., 1994; McConnell et al., 1994]. The high toxicity of pesticide products heavily marketed and used

widely in developing countries, the lack of training, the scarcity and expense of personal protective equipment, and the lack of resources to purchase and maintain modern, safe application equipment contribute to these high rates and portend an increasing problem for the majority of the developing world.

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