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by [Wesseling C](#), [Castillo L](#), [Elinder CG](#)

Affiliation: Programa de Plaguicidas, Desarrollo, Salud y Ambiente (PPUNA), Escuela de Ciencias Ambientales, Universidad Nacional, Heredia, Costa Rica.

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Pesticide poisonings in Costa Rica

by Catharina Wesseling, MD,^{1,2} Luisa Castillo, MSc,¹ Carl-Gustaf Elinder MD^{3,4}

WESSELING C, CASTILLO L, ELINDER C-G. Pesticide poisonings in Costa Rica. *Scand J Work Environ Health* 1993;19:227-35. A descriptive epidemiologic study, conducted in Costa Rica, investigated the incidence of pesticide poisonings with special attention to agricultural workers and occupational exposure. Information from three national registers (occupational accident and disease reports, hospitalizations, and deaths) were used. During 1986, 1800 occupational accidents caused by pesticides were reported; between 1980 and 1986 altogether 3330 persons were hospitalized and 429 died. Cholinesterase inhibitors caused 71% of the reported occupational accidents, 63% of the hospitalizations, and 36% of the deaths. Paraquat caused 21% of the occupational accidents, 24% of the hospitalizations, and 60% of the deaths. Hospitalizations and deaths were 13 and 11 times, respectively, more frequent among agricultural workers than among the rest of the population. High-risk groups for occupational poisonings included agricultural workers aged 15-29 years, female workers, and banana plantation workers. The yearly incidence of symptomatic occupational pesticide poisonings among agricultural workers was estimated at 4.5%.

Key terms: agricultural workers, descriptive epidemiology, developing country, occupational exposure, pesticide poisonings.

Pesticide poisonings have been recognized as an important public health problem, especially in third world countries. Figures of the World Health Organization (WHO) claim that globally three million severe poisonings occur yearly, of which 220 000 are fatal (1), and that 25 million are occurring that are symptomatic occupational pesticide poisonings among agricultural workers in developing countries (ie, 3% of the agricultural labor force) (2).

The people of Costa Rica, a Central American developing country with an agricultural export-based economy and a population of 2.4 million at the time of the study, are exposed excessively to pesticides (3). As much as 4 kg of pesticides per capita was used annually during the last decade, eight times the 0.5-kg estimated for the whole world population and twice the average use of the total Central American region (1, 4). An average input of 6 kg of active ingredient per hectare of arable land was used in 1989, twice the amount for intensive agricultural regions in industrial countries (5). At least 44 kg per hectare is sprayed each year on banana plantations (4).

Some of the most used substances are highly toxic according to the hazard classification of WHO (6). Costa Rica, like other developing countries, has serious problems controlling pesticides and many poisonings occur (1, 3), but no adequate epidemiologic surveillance system exists, and little is known about the health impact of pesticides. This study investigated the incidence of acute pesticide poisonings in Costa Rica, with special emphasis on agricultural workers and occupational exposure.

Materials and methods

In order to calculate the number of pesticide poisonings treated in different medical health services, we used information from three national registers on the following topics: (i) compulsory occupational accident and disease reports on wage earning workers, (ii) hospitalizations, and (iii) deaths. A form was designed for each register and information was obtained about the age, gender, and occupation of the victims, the pesticides involved, the crop, the county, and the circumstances of poisoning. Some aspects of the data varied between the three registers because of differences in organization and quality, and each register had data gaps for one or more of the study variables.

Occupational accident and disease reports

The National Insurance Institute [Instituto Nacional de Seguros (INS)] provided information about occupational accidents and diseases caused by pesticides among wage-earning workers. Costa Rican employers are legally obliged to report occupational accidents or disabilities of their employees to the INS, which covers medical costs and compensations.

¹ Programa de Plaguicidas: Desarrollo, Salud y Ambiente (PPUNA), Escuela de Ciencias Ambientales, Universidad Nacional, Heredia, Costa Rica.

² Department of Epidemiology, Institute of Environmental Medicine, Karolinska Institute, Stockholm, Sweden.

³ Department of Renal Medicine, Karolinska Institute, Huddinge Hospital, Stockholm, Sweden.

⁴ Department of Occupational Medicine, Karolinska Hospital, Stockholm, Sweden.

Reprint requests to: Dr C Wesseling, Programa de Plaguicidas: Desarrollo, Salud y Ambiente (PPUNA), Escuela de Ciencias Ambientales, Universidad Nacional, Heredia, Costa Rica.

In each of the 15 INS agencies the reports are filed by consecutive number without any coding according to type of accident or disability. As the pesticide-related reports had to be selected manually from the total amount of records, the review was limited to the 75 000 reports from 1986 in 13 agencies dispersed over the country. The almost 41 000 records in the two offices in the capital, San José, were omitted because it was assumed that they would not contain a considerable number of pesticide poisoning reports. In the reviewed INS reports, information on the age of the poisoned worker was missing in 323 (18%) of the 1800 cases, and data on the involved pesticide or chemical group were not found for 986 (55%).

Hospitalizations

The Costa Rican Social Security System [Caja Costarricense del Seguro Social (CCSS)] provided information about hospitalizations due to pesticide poisonings in the total population of Costa Rica. The social security system in Costa Rica covers a vast majority of the population. As early as 1980, CCSS covered over 92% of "hospital days," and in 1985 96.6% of the hospital beds in the country were included (7).

On request the Biostatistical Department of CCSS edited a list of file numbers of patients with records of poisonings in the seven years between 1980 and 1986 for all of the CCSS hospitals in the country (pesticide poisoning categories 989.2, 989.3 and 989.4 of the IXth International Disease Classification of the Pan American Health Organization, as well as other possible poisoning categories). The clinical record of each patient was reviewed in the archives of the 26 hospitals with case reports. Because of a recent change from the social security number to a personal identification number in record filing without the implementation of a correlating system and because of local filing problems in some hospitals, one-third of the records (1036 of 3330) could not be located. For these cases information concerning age, gender, occupation, county, and the outcome of the poisoning at discharge was obtained through the Biostatistical Department. In some of these cases information on the cause of poisoning was also available. Altogether, there was insufficient information in the CCSS records to determine the cause for 764 (23%) of the 3330 poisonings, and the involved pesticide or chemical group was not available for 1152 (35%).

Fatalities

The Forensic Medical Department of the Judicial Investigation Organism [Medicatura Forense del Organismo de Investigación Judicial (OIJ)] provided information about deaths due to pesticide poisonings in the total population of Costa Rica. According to Costa Rican law, autopsy and toxicologic analyses

must be performed by its Forensic Medical Department in the capital San José in all cases of violent death, including fatal poisonings.

All of the autopsy records with a final diagnosis of poisoning in the seven years between 1980 and 1986 were reviewed. The forensic pathologists reported "death by suicide" for 84% (238 of 283) of the pesticide poisoning autopsies. In many cases this definition did not concur with the described circumstances in the hospital records for the same poisoning. Therefore, the accidental, occupational, or suicidal nature of all of the poisonings were reviewed for the final data analysis by two of the authors (CW and LC) using the information available both in the clinical histories of the hospital records and in the autopsy records. In 31 (13%) of the 238 cases which were originally classified as suicides by the pathologists, the cause was redefined as a nonoccupational accident, in 12 (5%) it was redefined as an occupational accident, and in 69 (29%) the available information was considered insufficient to determine the circumstances with a reasonable degree of certainty. In almost every case classified by the pathologists as nonsuicidal or without specified cause, the authors' definition of the cause concurred. In 85 of the total 283 cases (30%) we were unable to define the cause.

The census of 1984 provided information for population groups by gender, age, and work activity for the 82 counties of the country. The census provided data for the year 1984, and all rates between 1980 and 1986 have been based on these figures.

The poisonings were divided into occupational and nonoccupational (accidental, suicidal, and homicidal) cases, and the population into agricultural workers (all jobs classified into the agricultural branch by the census), nonagricultural workers, and nonlabor population. The combination of the nonagricultural workers and the nonlabor population is referred to in the text as the general population without the agricultural labor sector. The 82 counties were grouped according to the six "economic planning regions" of the country. The data obtained in the review of the three registers were coded and introduced in computer files for analysis. The incidence rates by age, gender, and region were calculated for each register with the numbers of occupational and nonoccupational poisonings as numerators and the aforementioned segments of the population as denominators. Rate ratios (RR) were calculated from a comparison of incidence rates for the same types of poisonings among different population groups (I_1/I_2). Table 1 provides the size of the principle population groups considered in the calculations of the incidence rates in this study.

Results

Incidence rates of pesticide poisonings

Occupational accident and disease register. During 1986, a total of 1800 acute poisonings and dermal

Table 1. Size of the different population segments in Costa Rica.

	Agricultural sector	Nonagricultural sector	Total
1. Wage-earning economic active population	129 523	417 015	546 538
2. Wage-earning economic active population (excluding San José)	115 908	221 803	337 711
3. Nonwage-earning economic active population	112 576	87 746	200 322
4. Unemployed	7 301	40 265	47 566
5. Total economic active population (1 + 3 + 4)	249 400	545 026	794 426
6. Economic active population exposed to pesticides (1 + 3)	242 099	Unknown	? + 242 099
7. Nonlabor population	.	.	1 622 383
8. Total population excluding agricultural sector (9—5/agricultural sector)	.	.	2 167 409
9. Total population of Costa Rica	.	.	2 426 809

and eye injuries due to occupational pesticide exposure were reported to the 13 INS agencies included in the study. Excluding the catchment area for the two unreviewed San José offices, the annual pesticide poisoning rate for the total wage-earning labor force was 5.3 per 1000 workers; 1745 (97%) of these occurred among workers employed in different types of agriculture-related jobs (annual rate 15 per 1000 agricultural wage-earning workers) and 55 among nonagricultural workers (annual rate 0.25 per 1000).

The highest incidence occurred among young adult agricultural workers aged 20—29 years (23 per 1000). Female agricultural workers showed a higher incidence rate than the males in every age group (25 per 1000 female workers for all age groups together, RR females:males 1.7).

Although only the two offices in the Capital were excluded from review and the survey was carried out in the remaining 13 offices scattered over the entire Costa Rican territory, 45 out of the 82 counties had rates of less than 1.5 per 1000 wage-earning agricultural workers (32 without any report), a figure which should be compared with the 15 per 1000 calculated for the entire country excluding San José. The Atlantic Region and the Sarapiquí Department in the North Huetar Region, the principal banana producing areas, showed the highest pesticide poisoning incidence in the country: 63 per 1000 employed agricultural workers for the total banana region. Figure 1 presents the incidences of occupational accidents and diseases caused by pesticides for the six economic planning regions of the country.

Hospitalizations. In the seven years between 1980 and 1986, 3330 pesticide poisonings were found in the social security hospital discharge register with an average annual rate of 20 per 100 000 inhabitants. Sixty percent (1999 of 3330) corresponded to the agricultural labor force, which accounts for an average annual rate of 115 per 100 000 workers for all

Figure 1. Incidence rates (annual rate per 1000 wage-earning workers) of occupational accidents caused by pesticides for the six economic planning regions of Costa Rica in 1986.

poisonings; 40% corresponded to the general population without agricultural workers with an average annual rate of 9 (RR 13). Hospitalizations due to occupational poisonings were 30 times more frequent among agricultural workers than among the remaining labor force (93 and 3 per 100 000, respectively) and, within the former group, 1.7 times more frequent among wage-earning agricultural workers than among independent farmers (115 versus 68 per 100 000). Nonoccupational poisonings were also more likely to happen to agricultural workers than to the rest of the population, the rate for hospitalizations due to accidental and suicidal pesticide poisonings among agricultural workers being three times the rate among the rest of the population (24 and 8 per 100 000 respectively, RR 3) (figure 2).

The highest incidence of occupational poisoning occurred among agricultural workers aged 20—29

Figure 2. Incidence rates (annual rate per 100 000) of hospitalizations from pesticide poisonings in Costa Rica in 1980–1986.

Figure 3. Hospitalizations among agricultural workers (annual rate per 100 000) caused by occupational and nonoccupational poisonings from pesticides in Costa Rica in 1980–1986 in relation to age. (closed circles = occupational poisonings, open circles = nonoccupational poisonings)

years (130 per 100 000). Hospitalizations from occupational pesticide exposure also occurred among children under 15 years of age (72 per 100 000). The nonoccupational poisoning rate for agricultural workers in the hospitalization register was low for young workers (11 per 100 000 agricultural workers under 20 years of age) and peaked at ages 20–29 years with an incidence rate of 41 per 100 000 (figure 3). The hospitalization rates for the female population were similar to those of the males for all types of poisoning and all population groups.

The main banana production area, the Atlantic Region, showed a rate ratio close to unity for all types of poisoning and population groups compared with the corresponding rates for the rest of the country.

Fatalities: Between 1980 and 1986, 283 fatalities from pesticide poisoning were autopsied in the OIJ with an average annual rate of 1.7 per 100 000 inhabitants. More than half (56.5%) of the victims were agricultural workers with an average annual rate of 9.2 per 100 000. The average annual rate for the general population without agricultural workers was 0.8 (RR 11). All work-related fatalities autopsied in the OIJ occurred in the agricultural labor sector (1.8 per 100 000 agricultural workers). Deaths due to accidents and suicides were also more likely to occur among the agricultural population than among the rest of the population (7.4 and 0.8 per 100 000, RR 9) (figure 4).

The occupational fatalities were the most frequent at ages 15–19 years (2.9 per 100 000 agricultural workers). No deaths from occupational pesticide exposure were found in this series among children under 15 years of age. The nonoccupational fatalities due to pesticide exposure among agricultural workers were infrequent under 20 years of age (1.0 per 100 000), nine times less than the 9.4 per 100 000 for all other age groups together. No deaths due to occupational pesticide exposure were observed among female workers. The rate for nonoccupational fatalities among women was 60% of that among men.

The Atlantic Region registered a 1.5-fold increase in the incidence rate for all fatal poisonings compared with that of the rest of the country.

Causes and circumstances

Occupational accident and disease register. Ninety percent (1617 of 1800) of the occupational poisonings occurred among agricultural field workers, 87% of them during the application of pesticides and 13% during mixing, the carrying of containers or cleaning equipment, or during work in or near areas being

Figure 4. Incidence rates (annual rate per 100 000) of fatalities from pesticide poisonings in Costa Rica in 1980–1986.

sprayed or after reentrance into recently sprayed crops. Seven percent (128 of 1800) of the poisonings occurred in other types of agriculture-related workers: fruit and flower packers, pesticide formulators, pesticide storekeepers, airstrip workers, pesticide salesmen, agricultural equipment mechanics, agronomists, and gardeners. Three percent (55 of 1800) of the reports corresponded to occupations that were not agricultural, especially harbor workers and carpenters but also a wide variety of other employees like salesmen, laundry personnel, cooks, and cleaning personnel.

Information on type of production was obtained from a high proportion (79%) of the occupational accident and disease reports. Banana production was by far the most mentioned economic activity in the reports (72%), followed by decorative plant and flower production (7%), sugarcane (6%), coffee (5%), pineapple (4%), and pesticide formulator factories (2%). Poisonings of female workers occurred mainly in the production of decorative plants and flowers (43%), bananas (39%), or pineapples (13%).

No crop- or job-specific rates could be calculated as the population data were not available for these variables.

Hospitalizations. About 50% (1294 of 2566) of the hospitalizations in which the cause could be identified corresponded to occupational pesticide poisoning, about 25% (650 of 2566) to nonoccupational accidents, and about 24% (621 of 2566) to suicidal poisonings. One attempted homicide was registered in this series.

Ninety-one percent (1175 of 1294) of the occupational poisonings occurred in farm laborers and independent farmers, 93% of these during spraying (often with leaking backpack sprayers and clogging

nozzles or under inadequate climatic conditions such as rain, wind, or high temperatures) and 7% under other circumstances, like mixing or entrance into a recently sprayed field. Four percent (52 of 1294) occurred in other agriculture-related workers (pesticide formulators and storekeepers, airstrip workers, fruit and flower packers, mechanics, and pilots), and 5% (67 of 1294) corresponded to occupations that were not agricultural (harbor workers, industrial workers, cleaning personnel, malaria sprayers, and domestic service workers).

Many of the nonoccupational accidents were consequences of inadequate labor management, even if the accident took place at home. Inadequate storing caused confusion with food, beverages, liquor, or medicines by adults and children in 40% (224 of 565) of the accidental cases in which the medical records contained some details about the circumstances of the poisoning. Several other factors indirectly related with work caused 28% (157 of 565) of the accidental poisonings: the handling and use of contaminated materials like empty pesticide containers, the presence of children and wives at the workplace where pesticides were being sprayed or stored, the intake of agricultural produce harvested after recent spraying, the breathing of pesticide drift from nearby crops, the transportation of pesticides together with persons, drinking from contaminated waterways, and the washing of contaminated workclothes. In 10% (56 of 565) of the accidental poisonings the pesticide had been used for "medical" treatment (lice, intestinal parasites, or dermal lesions). Another 8% (47 of 565) of these cases resulted from domestic use (mainly spraying against cockroaches and mosquitos but also ectoparasite treatment of pets and malaria spraying). In 14% (81 of 565) infants were poisoned after having swallowed pesticides at home (without further explanation in their medical histo-

Figure 5. Relative frequencies (%) of different types or groups of pesticides causing occupational accidents (1986), hospitalizations (1980–1986), and fatalities (1980–1986) in Costa Rica. (org phos = organophosphate)

ries); these pesticides included rodenticides and insecticides approved for domestic use but also pesticides registered only for agricultural purposes.

Fatalities. Of the 198 deaths in which the cause of poisoning was defined, 123 (62%) were suicides, 52 (26%) were due to nonoccupational accidents, and 22 (11%) were caused by occupational accidents. One proved homicide was registered in this series.

Sixty-eight percent (15 of 22) of the occupational fatalities occurred among field workers during spraying; 18% during mixing procedures, including two cases of siphoning paraquat from one container to another by means of a hose; the remaining three (14%) died after ingesting pesticides instead of food or water during work because of the use of pesticide containers for storing lunch or refreshment bottles for taking pesticides to the field.

Seventy-eight percent (38 of 49) of the nonoccupational accidents with further specified circumstances were the result of inadequate storing practices and consequent confusions with liquor, food, or medicine. Other agriculture-related accidents (10%) included two cases of the handling of pesticide containers and equipment by children, the presence of a child in the field, the intake of recently sprayed food, and a car accident in which a pesticide was being transported together with passengers. In three cases paraquat was added to beer as a joke or for unproved homicide purposes. Pesticides used for “medical” treatment and domestic spraying caused the remaining three cases.

Types of pesticides

Occupational accident and disease register. In the occupational accident and disease register 71% (575 of 814) of the poisonings with an identified causative agent were related to organophosphate and carbamic cholinesterase inhibiting insecticides and nematicides [aldicarb (195 of 814), fenamiphos, ethoprophos, methyl parathion, carbofuran, methamidophos, methomyl and terbufos], 21% (173 of 814) were caused by paraquat, and 8% (66 of 814) by other types of pesticides [the organochlorines pentachloronitrobenzene, chlorothalonil, and endosulfan; the benzimidazole fungicides benomyl and thiabendazole; the phenoxyacid herbicide 2,4-dichlorophenoxyacetic acid (2,4-D); and the herbicides pendimethalin, glyphosate and picloram, among others] (figure 5).

Hospitalizations. In the hospitalization register 63% (1379 of 2178) of the poisonings with identified causative agents were caused by cholinesterase-inhibiting pesticides (methyl parathion, methomyl, methamidophos, trichlorfon, carbofuran, fenamiphos, propoxur, phorate and dichlorvos, among others), 24% (516 of 2178) by paraquat, and 13% (283 of 2178) by a variety of other pesticides [the phenoxyacid herbicides 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), the organochlorine insecticides aldrin and dichlorodiphenyltrichloroethane (DDT), lead arsenate and copper fungicides, and hydroxy coumarin rodenticides among others] (figure 5).

Fatalities: All of the OIJ fatality cases had an identified causative agent. The principle substance was paraquat (60%, 169 of 283), followed by the cholinesterase inhibitors (36%, 101 of 283) methyl parathion, methomyl, trichlorfon, methamidophos, dichlorvos, coumaphos, propoxur, and carbofuran. Other pesticides which produced poisonings with a fatal outcome were the rodenticide strychnine, the herbicide 2,4-D, and the organochlorine insecticide endosulfan (figure 5). Paraquat produced more deaths than any other pesticide no matter what the cause of the poisoning (53% of the suicides, 77% of the non-occupational accidents, and 86% of the occupational accidents).

Discussion

Despite existing concerns about public health problems in developing countries as regards pesticides (1, 2, 8), the literature on this topic contains limited analysis of population groups at risk and the circumstances of poisonings. This study allowed the identification of some high-risk populations and the analysis of several risk factors.

The agricultural labor force was identified as the population at highest risk, not only for occupational

poisonings, but also for nonoccupational poisonings, in the hospitalization and the fatality registers, and this finding is related to the overall presence of these toxic substances in daily life. Nonoccupational accidents are frequently the consequence of work practices, and suicides are readily committed due to unrestricted access.

Severe pesticide poisonings are often linked to suicides (1, 2, 8). Surveys carried out in Asian countries report suicide proportions among hospital admissions to be as high as 73% (9, 10). Our results are different in that only 24% of the hospitalized cases with a known cause were suicidal. The proportion of suicides among fatalities of the Medical Forensic Department (62%) was also considerably lower than the most recent WHO figure of 91% of suicidal cases among fatal pesticide poisonings (1). The absence of information on the cause of poisoning in 33% of the hospitalizations seems to make the validation of our result more difficult, but our result was based on a large number of cases and the missing data were not related to the cause of the poisonings. A better health care system with a tendency to hospitalize milder poisonings than in other countries does not seem a satisfying explanation for these differences, as the hospital case-fatality rate in Costa Rica is only slightly lower than in Sri Lanka despite the high suicide proportion in the latter country (8.2 and 9.4%, respectively) (10). Paraquat, the most identified causative agent among the severe hospitalized and fatal poisonings, has been pointed out as causing mainly suicidal poisonings (1, 2, 11). However, in Costa Rica only 25% (127 of 504) of the hospitalized paraquat poisonings were suicide attempts, and even among the fatality cases almost half of the paraquat poisonings were unintentional. These figures contrast to those of reports from Malaysia, where 73% of the paraquat poisonings were due to suicides (11).

It is well known that it often is difficult to distinguish between suicides on the one hand and accidents on the other (12). Any classification between the two is, to a certain extent, subjective. We have done our best to scrutinize available information and do not think that our review of the cause of death has inflated the real proportion of nonsuicidal fatal poisonings. Misclassification was obvious in several cases; for example, all cases of fatal pesticide poisoning with alcoholic ingestion had been classified as suicidal by the pathologists, in spite of testimonies of family members or a medical history in the hospital records about confusion because of pesticide storing in liquor bottles. Even several cases of sudden death at the workplace were classified as suicidal without further investigation of possible occupational causes. We took care not to classify uncertain cases, and therefore the cause was considered nonspecific in 30% of all the cases. However, further validation is desirable.

For several reasons the present study is likely to provide underestimates of the true number of pesti-

cide poisonings in Costa Rica. Only poisonings with some type of medical attention were detected, and several important underreporting aspects prevailed for medically treated poisonings in each of the three registers.

To eliminate the bias introduced by the lack of reporting in certain regions in the occupational accident and disease register, we recalculated the rates after excluding counties with less than 10% of the national rate. As the banana regions showed much higher rates compared with regions with other crops, the rate among agricultural workers in nonbanana regions was calculated separately (11 per 1000). The combining of this figure with the rate for the banana regions (63 per 1000, mentioned in the results) allowed a conservative estimate of 18 occupational pesticide poisonings per year per 1000 wage-earning agricultural workers in Costa Rica.

In the subset of the hospitalization register which we examined in the archives of the hospitals, we found 12% of additional cases in categories other than the pesticide poisoning categories of the International Disease Classification in local hospital filing systems and in the medical records under review. On the other hand 1% of the hospitalizations in the pesticide poisoning categories corresponded to misclassification or were readmissions of the same poisoning. Thus we estimated that, with a similar tendency among the unlocated reports, the annual incidence of hospitalizations caused by pesticides among agricultural workers would presumably be about 130 per 100 000.

Among the fatalities an important under registration was also observed. After the fatal cases in the CCSS register and the Medical Forensic Department were matched by gender, age, residency, date of death, and name, a total of 429 fatalities (average 61 per year) was identified, and this change would cause the bars in figure 4 to increase by about 52%. This underregistration in the fatality register was the most obvious in isolated areas. Thus the banana plantation region doubled its already high average annual mortality rate from 2.4 to 4.8 per 100 000 inhabitants after the matching.

There were other, not quantifiable, sources of underregistration, such as a lack of reporting by employers or direct reporting to the unreviewed capital offices of the INS; prolonged treatment in the emergency rooms at CCSS, and the impossibility to retrieve nonsystemic poisonings, like severe chemical burns and eye injuries by paraquat, from the hospital files. Misclassification of poisoning symptoms as other diseases probably occurred both at the hospital and at the fatality registry. Loevinsohn (13) observed an increase in mortality from causes likely to be confused with poisonings in correlation with pesticide use patterns in the Philippines and has suggested misclassification of deaths due to pesticide poisoning. At the Medical Forensic Department no sophisticated toxicologic laboratory support is avail-

able for investigating obscure death causes and, even in the best situation, the analysis is limited to a few toxic substances. This situation suggests that poisonings, especially occupational and accidental ones, might be overlooked or misdiagnosed.

More accurate estimates are not possible due to these unquantifiable underreporting aspects. However, considering that CCSS covers over 96% of the hospital beds (7), our rates probably reflect all actually diagnosed and hospitalized systemic poisonings very closely. In the same way, it seems a reasonable assumption that the matched figures of OIJ and CCSS include almost all of the diagnosed fatalities. The degree of underreporting of diagnosed and treated poisonings in the occupational accident and disease register is unknown, but is probably high.

With these validity considerations in mind, total numbers of occupational pesticide poisonings among wage-earning agricultural workers and independent farmers can be estimated as follows. The recalculated rate of 18 per 1000 wage-earning agricultural workers in the occupational accident and disease report system, which includes all types of medical treatment, is about 15 times higher than the hospitalization rate (115 of 100 000) for this same population group. If the hospitalization rate for independent farmers (68 of 100 000) is multiplied by this same factor, an estimated rate of 11 occupational poisonings per 1000 independent farmers is obtained, which includes hospitalized cases and unhospitalized cases given medical attention but not admitted to a ward. Based on these two figures, the annual rate for all occupational poisonings given medical attention within the total agricultural labor sector in Costa Rica can roughly be estimated as 1.5 per 100.

No information is available in Costa Rica about the frequencies of untreated poisonings. A WHO expert group (1) recently reviewed estimates of proportions for hospitalized and unhospitalized cases in occupationally exposed populations in several studies on pesticide poisonings. The proportions ranged from 1:6, 1:10, and 1:45 up to 1:100. We assume that there are at least two times more workers with poisoning symptoms who do not see a doctor than those who get medical attention. In view of the fact that our medically treated occupational accident reports are already about 15 times higher than the hospitalizations, our best guess is that the approximate number of 250 occupational hospitalizations annually [(93 of 100 000) · 1.11 · 242 099] could be extrapolated to a total number of about 11 250 (250 · 15 · 3) symptomatic occupational poisonings. Therefore about 4.5% of all agricultural workers in Costa Rica suffer an episode of occupational pesticide poisoning per year. Indeed reported occupational accidents from pesticides in banana producing regions soared at 6.3%. For young workers this figure is likely to be even higher.

Despite the limitations of this study, the actually observed and the deduced incidences show clearly

that pesticide poisonings are a major health problem in Costa Rica. The Costa Rican figures of occupational poisonings, especially in banana areas, are among the highest reported (2, 9, 10, 14–17). Our estimate of 4.5% poisonings per year among agricultural workers is somewhat higher than the WHO estimate of 3% in developing countries (2). The accuracy of our estimate for Costa Rica should be assessed by future surveys and monitoring studies. On one hand, it is likely that medical care is more available in Costa Rica than in the countries on which the WHO estimate is based; hence, this 4.5% could be an overestimate. On the other hand, Costa Rica consumes huge amounts of highly toxic pesticides (4).

A final thought must be given to the fact that the poisonings described in this report only show part of the problem and that long-term effects might imply an even greater health hazard. Recent studies in Nicaragua have shown persistent nervous system damage in workers previously poisoned with organophosphate pesticides (18), which is a serious concern for the hundreds of organophosphate poisoning victims detected by this study. An increasing amount of research is being conducted on other long-term health effects related to pesticide use, and serious questions have been raised about cancer and birth defects in agricultural settings (19–22).

This study covers the period 1980–1986. Since then, there has been improvement in certain banana companies in the control of spraying extremely toxic cholinesterase-inhibiting nematicides. However, no changes have been observed in the handling of paraquat and other pesticides on these same plantations, and few improvements have been observed in the handling of any pesticide on other crops. In spite of the extensive training programs on safe pesticide management that have been carried out by the government and industry sectors since 1990, our opinion is that the overall situation of pesticide use in Costa Rica has not changed considerably (4, 5, 23, 24). Over 60 fatal and about 400 hospitalized pesticide poisonings occur in Costa Rica every year. Actions to stop this epidemic of unnecessary disease and fatalities caused by pesticides in Costa Rica and in many other developing countries is urgently needed.

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