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Poisoning by pesticides among family fruit farmers, Bento Gonçalves, Southern Brazil

ABSTRACT

OBJECTIVE: To describe the occupational exposure to acute poisoning by pesticides, especially organophosphates, and its incidence.

METHODS: A descriptive study was carried out on 290 family fruit farmers in the municipality of Bento Gonçalves, Southern Brazil, conducted in two stages in 2006. Two hundred and forty-one of these workers completed the two stages, which corresponded to periods of low use and intense use of pesticides. Data on the property, occupational exposure to pesticides, sociodemographic data and frequency of health problems were gathered using a standardized questionnaire. Poisoning was characterized by reports of episodes, symptoms relating to pesticides and plasma cholinesterase examinations. Cases were classified according to the matrix proposed by the World Health Organization (WHO).

RESULTS: On average, each property used 12 different types of pesticides, consisting mainly of glyphosate and organophosphates. Most of the workers used tractors for pesticide application (87%), set aside the containers for selective garbage collection (86%) and used protective equipment during activities involving pesticides ($\geq$ 94%). Among these family farmers, 4% reported occurrences of poisoning by pesticides over the 12 months preceding the investigation, and 19% at some time during their lives. According to the criterion proposed by WHO, 11% were classified as probable cases of acute poisoning. Among the workers who had used organophosphates over the ten-day period preceding the examination, 2.9% presented two or more symptoms relating to pesticides and a 20% reduction in cholinesterase.

CONCLUSIONS: The poisoning occurrences according to the workers' perceptions were within what was expected, but the estimate based on the WHO classification picked up a larger proportion of the cases. A fall in the harvest reduced the use of insecticides and may explain the low occurrence of abnormalities in the laboratory results. The criteria for defining pesticide poisoning, as well as the official monitoring parameters, should be reevaluated in order to increase the workers' protection.

DESCRIPTORS: Poisoning, epidemiology. Pesticides, poisoning. Occupational Exposure. Accidents, Occupational. Occupational Risks. Occupational Health. Epidemiology, Descriptive.

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INTRODUCTION

The use of pesticides is intensive throughout Brazil, which is one of the largest markets for these products in the world.[17] Among family farms in the Serra Gaúcha region, 95% of them use pesticides frequently.[8]

Despite the intensive consumption of pesticides, the official records regarding poisoning are limited to acute cases and they are almost nonexistent for cases of chronic poisoning. Although the National System for Disease Notification (*Sistema Nacional de Notificação de Agravos*, Sinan) is the official notification system for pesticide poisoning, in practice the system most used is the National Toxicological-Pharmacological Information System (*Sistema Nacional de Informações Tóxico-Farmacológicas*, Sinitox). Sinitox mainly picks up the more severe cases, with an approximate coefficient of eight cases per year/100,000 inhabitants, among which suicide attempts predominate.[9] In Bento Gonçalves (Rio Grande do Sul, RS), from the municipal information system on cases of poisoning and an active search in emergency service medical records, a coefficient of 65 cases of pesticide poisoning/100,000 inhabitants/year was found, with predominance of occupational cases.[9,11] However, individuals with mild or moderate poisoning do not always seek health services or are not diagnosed as cases of poisoning.

Case definition has been a challenge for research and for health services. Exposure is usually multichemical and, in many cases, no biomarkers are available. Thus, workers' reports are fundamental for diagnosing cases of poisoning, even with the frequent information problems. Furthermore, insufficiencies in human and laboratory resources for establishing diagnoses may interfere in identifying the poisoning.[21] Aiming to overcome these difficulties, the World Health Organization (WHO) recently put forward a tool that standardizes the definition of cases of acute poisoning and contributes towards improving the estimates for the incidence of pesticide poisoning.[21]

The present study had the objective of describing the occupational exposure to pesticides and the incidence of acute poisoning caused by pesticides. Results from biological monitoring of organophosphates were also evaluated in relation to pesticide-related symptoms.

METHODS

This was a cross-sectional descriptive study conducted in two districts of Bento Gonçalves, among farmers and farm workers with frequent exposure to pesticides. The region is characterized by small and medium-sized family farms, with predominance of fruit-growing. Peach cultivation was defined as the criterion for selecting the farms, because this activity uses greater volumes of organophosphate insecticides.

The sample size was calculated using EpiInfo-2000, considering the following parameters: farm population (around 3,000 people); estimate for poisoning cases = 3%; margin of error = two percentage points; confidence level = 95%. After adding 10% for possible losses, the sample size was calculated as 282 farm workers.

The sample selection was done using a list of peach-producing family farms that was drawn up in a partnership involving agronomists from the Technical Assistance and Rural Extension Company (*Empresa de Assistência Técnica e Extensão Rural*, EMATER) and healthcare teams. Each family farm, out of a total of 235, indicated at least one worker who was among the ones with greatest exposure.

The fieldwork was done in two stages: firstly, during a period with low exposure (June-July 2006) and, secondly, during a period with intensive exposure to pesticides (November-December 2006). The interviews were conducted by professionals from primary healthcare units, after specific training.

The questionnaires sought sociodemographic information, data on the family farm and characterization of the use of pesticides in the farm. Smoking, alcoholic drink consumption, histories of hepatitis or other chronic diseases and use of medications were also investigated. Alcohol consumption was considered to be a risk factor when greater than or equal to three doses/day for men or two doses/day for women (one dose = one half-bottle or one can of beer; or one glass of wine; or one measure of distilled drinks).[a] High-risk alcohol consumption, defined as more than three doses/day, was also examined.

Occupational exposure to pesticides was measured according to the type of exposure (applying, mixing, helping in application, equipment cleaning, transportation and storage, reentering locations after application, veterinary use and washing contaminated clothes), duration of exposure (in days, months and years of exposure), use of personal protection equipment and chemical types used during the 20 days prior to each stage.

The criterion for acute pesticide poisoning defined by WHO was used: any disease or effect on health resulting from suspected or confirmed exposure to pesticides that occurs within 48 hours (with the exception of rat poison). The effects could be local and/or systemic and included toxic reactions in the respiratory, cardiovascular, neurological, urinary and endocrine systems and allergic reactions.[21]

The incidence of pesticide poisoning was related to six and twelve-month periods preceding the interviews and throughout life. Acute conditions of poisoning were evaluated using a questionnaire on 22 recent symptoms that are common in cases of pesticide poisoning (occurring over the 10 days preceding the interview) and laboratory cholinesterase assays.

[a] Adapted from: Ministério da Saúde. Instituto Nacional do Câncer. Inquérito domiciliar sobre comportamentos de risco e morbidade referida de doenças e agravos não transmissíveis. Brasil, 15 capitais e Distrito Federal. Rio de Janeiro; 2003.

Each symptom was classified as related to the use of pesticides, when it started or worsened after the use of these products. In accordance with WHO's proposal, a criterion was fulfilled in relation to each of three categories, obtained as follows:

1) Exposure: a plausible description of the exposure based on information reported by workers, with recording of pesticide usage (farm workers were generally the individuals with greatest exposure).

2) Effects on health: possible cases were considered to consist of complaints of two or more subjective symptoms; probable cases were considered to consist of complaints of three or more symptoms compatible with pesticide exposure.

3) Causality: temporal cause and effect relationships between exposure and effects on health that were consistent with the known toxicology of the pesticide. Only symptoms that appeared or worsened after working with pesticides were analyzed.

Cases in which the workers did not have any recent exposure to pesticides were left out. Everyone who reported having two or more symptoms relating to pesticides was evaluated in relation to other health problems. Cases in which another health problem could also explain the reported symptoms were considered doubtful.

To evaluate the inhibition of plasma butyrylcholinesterase (BChE), the assay obtained during the period of low insecticide exposure was used as the reference measurement. The second sample was collected at the peak of insecticide use. Tests were performed using the kinetic enzymatic method. Several cutoff points were evaluated to define poisoning: the official criterion, i.e. Regulatory Norm 7 (NR7),[a] consisting of a 50% reduction in BChE; and other parameters such as a reduction of 20 to 30%.[3,15]

The statistical analysis included central trend and dispersion measurements for continuous variables and proportion analysis. Associations were evaluated using the chi-square, linear trend and Pearson's correlation tests. The results were discussed with the farm workers and with rural extension professionals. Unknown data were excluded from the calculation, for all variables.

This project was approved by the ethics committee of the School of Medicine of the *Universidade Federal de Pelotas*. Each participant was informed about the ethical commitments and voluntarily signed a informed consent statement.

RESULTS

In the first stage, 290 workers from 235 family farms participated (16.7% losses). In the second stage, 246 workers from 197 family farms participated. In total, 241 workers had their cholinesterase measured in both stages.

With regard to the characteristics of the family farms, the mean area of the properties was 18.4 hectares (standard deviation, sd = 11.4) and the maximum was 59 hectares. The main fruits planted in the farms were: peaches (selection criterion) and grapes (91%), plums, kakis and kiwis (25% to 31%).

Most of the farms handed over the pesticide containers for selective collection (86.3%) and received copies of agronomical prescriptions (84.6%) (Table 1). The farmers bought pesticides from several places, but almost half (49.2%) purchased them from salesmen who visited the property. The pesticides were applied using a tractor (87.2%), hoses with nozzles (spraying bars) (44%) and backpack spraying equipment (23.1%).

All of the family farms used several types of pesticides. On average, 12.2 types of pesticide were used (sd = 4.8), ranging from four to thirty. On the 20 days preceding the second stage, a mean of 4.6 different commercial products were used (maximum of 23).

In total, 180 different commercial brands of pesticides were declared, classified into 37 chemical groups. Among these commercial names, three (1.7%) were prohibited products or products with registrations that had been cancelled; 32 (17.8%) were identified but were not included in the Pesticide Information System (*Sistema de Informação sobre Agrotóxicos*, SIA);[b] 17(9.4%) were not identified in any source; and 127 (70.6%) were available in the SIA list.

Table 2 presents the main products used on the properties. Prominent among these were the herbicide glyphosate (98.3%) and organophosphate insecticides (97.4%). The use of arsenic as ant poison was reported by 19.6% of the properties.

With regard to the workers' characteristics, the sample was basically male (95.2%) (Table 3). The mean age was 38.5 years (sd = 11.1), ranging from 16 to 71 years. Three people (1%) were under 18 years of age and four (1.4%) were over 60 years of age. Most of them (88.2%) were from the family that owned the property, 9.3% were tenants or partners and only 2% were employees. The mean schooling level was 6.8 completed years (sd = 2.5); three had only had up to one year of schooling, three had concluded university-level education and 114 (39.7%) had had eight years of schooling or more (Table 3).

[a] Ministério do Trabalho e Emprego. Normas Regulamentadoras de Segurança e Saúde no Trabalho [internet] [cited 2008 Jul 25]. Available from: http://www.mte.gov.br/legislacao/normas_regulamentadoras/default.asp
[b] Ministério da Agricultura. Agência Nacional de Vigilância Sanitária. Sistema de Informação sobre Agrotóxicos (SIA). Brasília; 2007.

Table 1. Characteristics of the family farms (n = 235) and the pesticide exposure among the workers interviewed (n = 290). Bento Gonçalves, Southern Brazil, 2006.

Variable	n	%
Dados da propriedade		
Equipment used for application[a]		
Applied using tractor	204	87,2
Hoses and nozzles	103	44,0
Backpack spraying equipment	54	23,1
Where it was bought[a]		
Agricultural stores	10	5,1
Cooperative	10	5,1
Salesman visiting the property	10	5,1
Other municipalities	165	84,6
Received agronomical prescriptions		
Never/almost never	47	23,9
Sometimes	80	40,6
Usually	97	49,2
Always	27	13,7
Disposal of empty containers[a]		
Selective collection	202	86,3
Burned	23	9,8
Buried	3	1,3
Stored on property	9	3,8
Workers' individual exposure (n; %)		
Types of exposure[a]		
Application	272	94,4
Solution preparation	264	91,7
Helping in application	148	51,4
Equipment cleaning	261	90,6
Veterinary treatment	7	2,4
Contaminated clothes	48	16,7
Reentry	149	51,9
Technical advice for pesticide use[a]		
Never received	21	8,6
Directly from the salesman	130	53,3
Technicians from the cooperative	48	19,7
Technicians from EMATER	42	17,2
Another person from the property	32	13,1
Neighbors and other friends	19	7,8
Other agronomists	15	6,1
Exposure to pesticides (years)		
2 to 10	77	26,7
11 to 20	103	35,8
21 to 30	75	26,0
31 to 40	30	10,4
41 to 50	3	1,0

Continua

Table 1 continuation

Variable	n	%
Reported "always" using personal protection equipment[a]		
Boots	284	98,3
Hat	280	96,9
Protection clothes	276	95,5
Gloves	271	94,1
Pesticide masks	275	95,2

[a] Opções não excludentes entre si. Obs: Os dados ignorados foram excluídos do cálculo; prop= propriedade/unidade produtiva
EPI: Equipamento de proteção individual
EMATER: Empresa de Assistência Técnica e Extensão Rural

Risky alcohol consumption was reported by 17.8% of the men and 14.3% of the women. High-risk consumption (over three doses/day) was admitted by 8.3% (all men).

The prevalence of regular smoking (at least one cigarette/day) was 8.3%. Putting together the regular smokers and the occasional smokers, the prevalence of smokers was 12.8% and 11.8% were former smokers.

Amongst the interviewees, 27.7% said they had a chronic disease: cardiovascular 11.3%), depression (3.1%), arthrosis/osteoporosis (1.7%) and asthma/allergies (2.8%). Hepatitis was reported by 24 people (8.4%): seven with type A, five with type B, two with type C and 11 with non-identified hepatitis.

In each family farm, an average of two people worked directly with pesticides. Working with pesticides began before the age of 15 years for 20.1% and by the age of 17 years for 53.1%. The mean length of time with exposure to chemicals was 19.4 years (sd = 10.5). During the months of intensive use, they usually applied pesticides on eight days per month (maximum of 25 days). More than 94% of the workers reported that they "always used" personal protection equipment (Table 1).

Most of the workers (70%) also handled other chemical products: 68.3% fuels (gasoline and diesel), 4.8% solvents (kerosene and thinner), 3.1% paint and 2.4% degreasers. No association between the use of these products and cases of poisoning, nor with reduced cholinesterase levels, was found.

In evaluating cases of pesticide poisoning in the first stage, 43 workers (14.9%) said they had previously been poisoned, including 11 (3.8%) who reported occurrences of poisoning over the 12 months preceding the first interview. During the period between the two stages, seven people (2.8% of the valid cases) reported that they had suffered new episodes of poisoning (two had had previous episodes). Over these 18 months, 16 workers (6.5%) with recent poisoning were identified.

Table 2. Main chemical groups used on properties. Bento Gonçalves, Southern Brazil, 2006. N = 235[a]

Chemical group[b]	n	% of properties
Glyphosate and glycines (herbicides)	231	98.3
Organophosphates (insecticides)	229	97.4
Used 3 or more types of organophosphates	136	57.4
Dicarboximides (captan, folpet, iprodione and other fungicides)	207	88.8
Dithiocarbamates - total (fungicides)	204	86.8
Dithiocarbamates associated with other products	61	26.0
Pyrethrins or pyrethroids (insecticides)	130	55.3
Fipronil (insecticides and ant poison)	120	51.1
Imidazoles (benznidazole and other fungicides)	113	48.1
Copper sulfate and copper compounds (fungicides)	101	43.0
Inorganic (sulfur sulfate, zinc, lime, tin and others)	87	37.0
Bipyridylium – paraquat (herbicides)	78	33.2
Anthraquinone (fungicides)	68	29.0
Triazoles (tebuconazole and other fungicides)	67	28.5
Arsenicals (insecticides and ant poison)	46	19.6
Alaninate (fungicides)	32	13.6
Other agriculture pesticides	30	12.8
Growth regulators (cyanamides and others)	15	6.4
Mixtures of chemical groups	14	5.9
Veterinary products	14	5.9
Various ant poisons	10	4.3
Urea compounds	5	2.1
Antibiotics	3	1.3
Biological control product	3	1.3
Unidentified product	3	1.3

[a] Unknown data were excluded from the calculation
[b] Triazines, dodine (guanidine), phenoxyacids: one property (0.4%)

Table 3. Sociodemographic characteristics of the farm workers. Bento Gonçalves, Southern Brazil, 2006. N = 290[a]

Characteristic	n	%
Sex		
Male	276	95.2
Female	14	4.8
Age group (years)		
16 to 29	77	26.6
30 to 39	72	24.9
40 to 49	92	31.8
50 or more	48	16.6
Schooling level (years)		
Up to 3	14	4.9
4 to 7	159	55.4
8 (elementary school completed)	58	20.2
9 to 10	19	6.6
11 or more (high school completed, or more)	37	12.9
Smoking		
Never smoked	218	75.4
Smoked up to 10 cigarettes/day	24	8.3
Smoked over 10 cigarettes/day	13	4.5
Former smoker (stopped over a month ago)	34	11.8
Alcoholic drink consumption/ alcoholism		
Never drank	27	9.3
Occasional use/little quantity	130	45.0
Usually had one to two doses/day	83	28.7
Usually had three doses/day	25	8.7
Usually had over three doses/day	24	8.3

[a] Unknown data were excluded from the calculation.

In total, 48 workers (19.4%) reported lifetime poisoning episodes.

Over the two stages, 56 products were indicated as causing poisoning: 29% dithiocarbamates; 16% organophosphates; 11% glyphosate; 9% cyanamide; 7% arsenic, 4% paraquat and others.

After excluding the doubtful cases, the possible cases of poisoning (WHO criteria) in stages one and two accounted for, respectively, 18.5% and 20.4%. Probable cases represented 11.1% and 10.6%. The symptoms most commonly relating to working with pesticides were ocular, headache, dizziness and dermatological symptoms (Table 4).

The proportion of possible cases of poisoning was higher among women in both stages. Schooling level was shown to have a protective effect against poisoning occurrences during the stage with high exposure to chemicals (Table 5). Age and number of years of working with pesticides did not show any association with poisoning cases.

Higher numbers of days per month of working with pesticides was shown to be associated with lifetime pesticide poisoning episodes and with possible poisoning cases, with a linear trend in the second stage (Table 5). The use of hoses with spraying nozzles presented an association with possible cases of poisoning in both stages.

Table 4. Prevalence of recent symptoms relating to pesticide exposure. Bento Gonçalves, Southern Brazil, 2006. (First stage: Jun/Jul, n = 287; second stage: Nov/Dec, n = 245)

Symptom	First stage n (%)	Second stage n (%)	p-value
Ocular irritation	79 (27.5)	47 (19.2)	p < 0.05
Watery eyes	45 (15.7)	28 (11.4)	NS
Headache	39 (13.6)	20 (8.2)	p < 0.05
Skin lesions/"allergies"	21 (7.3)	15 (6.1)	NS
Dizziness/vertigo	11 (3.8)	14 (5.7)	NS
Excessive sweating	28 (9.8)	10 (4.1)	p < 0.001
Skin burns	23 (8.0)	10 (4.1)	NS
Nausea/sickness	16 (5.6)	8 (3.3)	NS
Coughing	4 (1.4)	7 (2.9)	NS
Salivation	12 (4.8)	7 (2.9)	NS
Shortness of breath/ dyspnea	4 (1.4)	6 (2.5)	NS
Agitation/irritability	15 (5.2)	5 (2.0)	p < 0.05
Catarrh	2 (0.7)	5 (2.0)	NS
Blurred vision	10 (3.5)	4 (1.6)	NS
"Numbness/ tingling"	9 (3.1)	4 (1.6)	NS
Abdominal pain	6 (2.1)	4 (1.6)	NS
Tremors	2 (0.7)	4 (1.6)	NS
Diarrhea	4 (1.4)	3 (1.2)	NS
Vomiting	3 (1.0)	3 (1.2)	NS
Cramps	3 (1.0)	2 (0.8)	NS
Digestion difficulties	9 (3.1)	1 (0.4)	p < 0.05
Wheezing/whistling	0	1 (0.4)	NS

p-value: difference between stages.
NS = Nonsignificant difference

Possible cases were more frequent among workers who did not use masks (p = 0.02) and head protection (p = 0.07). There were fewer occurrences of poisoning over the 18-month period reported by the workers who said that they "always" used masks, head protection and protective clothes (p < 0.01). The use of masks was shown to be associated with fewer occurrences of two or more pesticide-related symptoms in stage two (p = 0.03) and specifically with the symptom of coughing (p = 0.005). More than 92% of the individuals who were probable cases said that they always used all of the personal protection equipment.

High-risk alcohol consumption was detected in 8.3% of the whole sample, in 12.3% of those who presented a reduction in BChE of more than 10% and in 21.4% of those with a reduction of more than 20%. In addition, there was an association with increased numbers of possible cases in the second stage (Table 5).

With regard to exposure to organophosphates, a fall in the peach harvest greatly reduced the workers' exposure in the second stage. In the group that stated that they used organophosphates over the ten days preceding the second stage, the best cutoff point was two or more pesticide-related symptoms (p = 0.056). In this group, in the stage with intensive use of pesticides, 29 possible cases (27.9%) and 17 probable cases (16.3%) were identified. Among the possible cases, three workers presented decreases in BChE of at least 20%, i.e. 2.9% of the 103 workers who used organophosphates over the ten days preceding the second stage (excluding unknowns). All of them said that they "always" used personal protection equipment. None of the probable cases showed a larger decrease in BChE than 20%. The only worker with a BChE decrease greater than 50% did not fulfill the poisoning criteria: this individual had high-risk alcohol consumption and hepatitis B and did not report pesticide-related symptoms or exposure to organophosphates before stage two (he used other products).

DISCUSSION

The present study characterizes various aspects of occupational pesticide exposure within the context of family fruit-growing. The frequency of acute pesticide poisoning can be measured from several parameters:

Table 5. Factors associated with occurrences of pesticide poisoning (possible cases according to the World Health Organization criteria – stages 1 and 2). Bento Gonçalves, Southern Brazil, 2006.

Variable	n	Possible case first stage[a]	Possible case second case[a]
General sample	290	6.5%	19.4%
Sex		p = 0.06	p = 0.04
Male	276	48 (17.5%)	45 (19.2%)
Female	14	5 (38.5%)	5 (45.5%)
Schooling level (years)		p = 0.60	p = 0.01 (pt = 0.003)
Up to 5	118	24 (20.7%)	29 (28.7%)
6 to 8	113	21 (18.6%)	17 (18.1%)
9 or more	56	8 (14.3%)	4 (8.3%)
Alcohol		p = 0.70	p = 0.05
Up to two doses/day	240	43 (18.1%)	36 (18.1%)
Three or more	49	10 (20.4%)	14 (31.1%)
Hepatitis B, C or undetermined		p = 0.02	p = 0.80
No	272	46 (17.1%)	47 (20.3%)
Yes	18	7 (38.9%)	3 (23.1%)
Smoking		p = 0.14	p = 0.07
Never	218	43 (19.8%)	32 (17.4%)
Smoker	37	8 (21.6%)	11 (34.4%)
Former smoker	34	2 (6.1%)	7 (25.0%)
Exposure (days/month)		p = 0.01	p = 0.04 (pt = 0.01)
Up to 4	92	25 (27.2%)	9 (12.0%)
5 to 8	105	11 (10.6%)	19 (20.9%)
9 or more	85	17 (20.0%)	21 (28.8%)
Applied using hose with nozzle		p = 0.04	p = 0.004
No	162	23 (14.3%)	18 (13.6%)
Yes	127	30 (23.8%)	32 (28.6%)
Personal protection equipment: pesticide mask usage		p = 0.66	p = 0.02
No	275	3 (23.1%)	6 (42.2%)
Yes	14	50 (18.2%)	44 (19.0%)

p = p-value from chi-square test; pt = p-value from linear trend test

[a] Unknown data were excluded from the calculation

reported information, recent symptoms and laboratory tests. Furthermore, for the first time in Brazil, the matrix proposed by the WHO was tested.[21] This makes it possible to estimating the frequency of acute poisoning resulting from several types of chemicals, as well as those not picked up from the reported information.

Organizing this study into two stages made it possible to use each worker's own measurements as reference values for cholinesterase. These were obtained during the stage with low insecticide exposure and can be considered to be the gold standard.[15] This criterion reduces the problems relating to the large variability in cholinesterase levels between individuals.[11] However, 17 workers said that they had used organophosphates over the 15 days preceding the first data gathering. This exposure may have underestimated the decrease in relation to the reference measurement.

In addition, late frost caused a fall in peach production of 77% in relation to the previous year. This led to a marked decline in the use of pesticides, especially organophosphates, which was the focus of the laboratory evaluation. Thus, the data on pesticide poisoning must be considered to be minimum estimates. In ordinary years, the numbers of episodes would probably be greater.

Although adequate for the descriptive results, the sample size was insufficient for some analyses. Selection of workers with greater exposure may have emphasized the healthy worker bias. Even though reported information is recognized as a source of reasonable accuracy in studies involving agricultural work,[6,12] there may have been errors of classification or memory failures in the information.[4,16]

Regulatory norm 31 prohibits people under the age of 18 years or over the age of 60 years from doing work involving pesticides.[a] The proportion of workers exposed to pesticides in these age groups is probably greater than what was found, because in addition to the selection of workers with greater exposure, more than half of workers began their occupational exposure to these products before the age of 18 years. Health protection in these age groups is a complex challenge in family agriculture settings, where adolescent participation is generally encouraged and elderly people's work is essential.

These agricultural workers had high pesticide exposure. On average, they used 12 different types of products. Products with little toxicological information available, such as fipronil, were used in most properties. At the same time, prohibited products with high toxicity were also used frequently: around 20% of the farms reported that they used arsenic, but the real estimate is probably higher. For most of these chemical types, no biomarkers are available in either public or private laboratories.

The profile of the interviewees was shown to be very different from the profile of agricultural workers from other regions of the country: around 20% had gone beyond the elementary school level, thus contrasting with the rate of 3% to 8% found in other studies[2,8,10,13,20] or with a study from Pernambuco (Northeastern Brazil), where 41% were illiterate and 42% had only been to school for up to 4 years.[1] The high proportion of the workers that applied pesticides using tractors, handed over the containers for selective collection, received copies of agronomical prescriptions and used personal protection equipment reveals that they had greater access to technical advice and better working conditions. However, as only 40% had completed elementary school, schooling level showed a protective effect against pesticide poisoning, thereby agreeing with other studies on agricultural workers.[14,19]

Adherence to the use of personal protection equipment in applying and preparing the solutions was confirmed by other local sources (technical assistance companies, unions and healthcare teams). However, this care was hardly ever taken when reentering locations that had been sprayed, during the crop thinning or during the harvest, which would be the times of skin exposure. Despite the great adherence to the use of personal protection equipment and the higher proportion of poisoning cases among individuals who did not use personal protection equipment, several cases of poisoning occurred among workers who always used these protection methods. Thus, the real protection provided by personal protection equipment remains undefined, because it was not possible to confirm whether the equipment used was adequate for the risk. Moreover, other sources of non-occupational exposure (environmental or food sources) may have interfered in these results.

The frequency of symptoms relating to pesticides was greater in the first stage than in the second, thus suggesting lower exposure than what was expected. This result can partially be explained by the reports from workers who correlated ocular and dermatological symptoms to the "winter treatments" (lime sulfur solutions and copper, among others).

The use of symptom questionnaires as case definition criteria was shown to be a valuable strategy, considering the biomarker limitations. A list of 22 symptoms was tested and, for exposure to the organophosphates, the best criteria were combinations of two or more symptoms with a reduction in cholinesterase levels of at least 20%, thus supporting the criteria for possible cases suggested by WHO.[21]

The reported estimates for pesticide poisoning (3.8% over 12 months and 19.4% at some point in life) was consistent with a previous study in the same region.[8] The latter included all agricultural workers and identified poisoning rates of 2% and 12%, respectively. On the other hand, the incidence of probable cases according to the WHO classification (11%) was higher than the figure from the farmers' information, thus suggesting that this criterion is more sensitive.

The BChE measurement mainly represents the exposures that occurred over the ten days preceding the data gathering, because after this period, the phase of cholinesterase level replacement began.[15] Among the probable cases of organophosphate exposure over the preceding ten days, there was no decrease in BChE. Likewise, other authors did not find substantial decreases in BChE, although they found important neuropsychiatric effects.[7,18]

Another point to be discussed further is the cutoff point in relation to BChE. The definition from NR7[d] states that the maximum biological index permitted for organophosphates is a decrease in plasma cholinesterase to levels greater than or equal to 50%. The parameters used by other authors were more conservative: the best cutoff point was considered to be a decrease in BChE (and/or erythrocyte cholinesterase) of 25%[5] or 30%,[15] as the criterion for mild poisoning. In the United States, government agencies and states such as California and Washington have defined a decrease in BChE of 20% as the criterion for verifying protection measures and reevaluating workers and a decrease of 40% as the criterion for stopping the exposure until the measurements have returned to normal values.[3] The Extoxnet network of American universities has indicated that the exposure should be removed if there is a decrease in cholinesterase

[a] Ministério do Trabalho e Emprego. Normas Regulamentadoras de Segurança e Saúde no Trabalho [internet] [cited 2008 Jul 25]. Available from: http://www.mte.gov.br/legislacao/normas_regulamentadoras/default.asp

of 30%.[a] The maximum biological index permitted by NR7 defines a limit under which occupational exposure should be considered "safe" for workers. Thus, a more conservative criterion could stimulate earlier implementation of protection actions and decrease the effects relating to organophosphate poisonings.

The higher proportion of high-risk alcohol consumption in the group with decreased BChE and the association with possible cases in the second stage suggests that there is a relationship between alcoholism and poisoning. This association was found in the municipalities of Antonio Prado and Ipê, where alcoholics accounted for twice as many cases of pesticide poisoning (adjusted odds ratio 2.07; 95% CI 1.21-3.56[b]). In Nova Friburgo (State of Rio de Janeiro), 32% of the workers with decreased BChE presented alcoholic liver disease.[2] These results indicate the importance of taking into consideration alcohol consumption in evaluating pesticide poisoning, because of the liver overload and neurotoxicity that result from the action of both of these substances.

Within the context of family agriculture of good agroeconomic level, amongst the several criteria for defining acute pesticide poisoning, the matrix proposed recently by WHO has been found to be a viable instrument for epidemiological studies and health services.[21]

It is recommended that this matrix should be tested in different agricultural contexts, with samples that are adequate for examining associations. Another suggestion is to perform a study with appropriate methodology for validating a symptoms questionnaire relating to multichemical exposures. For this, laboratory evaluations must include not only cholinesterase but also other biomarkers, to reflect the regional chemical diversity.

Taken as the tip of the iceberg of the health problems relating to pesticides, acute poisoning remains a challenge for Brazilian public health.

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[a] The Extension Toxicology Network. Toxicology Information Briefs Cholinesterase inhibition [internet]. 1993 [cited 2008 Dec 21]. Available from: http://extoxnet.orst.edu/tibs/cholines.htm

[b] Unpublished data.

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