Original article

Exposure to pesticides and acute intoxication in a region of intense agricultural production in Mato Grosso, Brazil, 2013*

doi: 10.5123/S1679-49742019000300013

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Abstract

Objective: to estimate the prevalence of acute poisoning by pesticides and associated factors in Mato Grosso, Brazil. **Methods:** this was a cross-sectional study, the outcome of which was acute intoxication in the month prior to the interview, as diagnosed by a physician; multivariate analysis was performed using Poisson regression. **Results:** we interviewed 753 individuals; acute intoxication occurred at a rate of 17%; the main associated factors were living near plantations (PR=2.81 – 95%CI 1.79;4.41), having incomplete high school education or less (PR=1.80 – 95%CI 1.22;2.71), living less than 500 meters from maize crops (PR=1.57 – 95%CI 1.05;2.35) and cotton plantations (PR=1.43 – 95%CI 1.02;2.02). **Conclusion:** Individuals living near to corn and cotton plantations reported higher occurrence of acute intoxication.

Keywords: Pesticides; Environmental Pollution; Environmental Health Surveillance; Primary Health Care; Cross-Sectional Studies.

*Manuscript originated from the Master´s dissertation by Daniely Oliveira da Silva, entitled "Prevalence of self-reported acute poisoning by pesticides and associated factors in Mato Grosso", defended at the Postgraduate Program in Collective Health of the Federal University of Mato Grosso (UFMT) in 2018.

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Introduction

Brazil has been leading the international ranking as the biggest consumer of pesticides in the world since 2008. The country accounts for 86% of all pesticides used in Latin America.[1,2]

Data from the Brazilian Chemical Industry Association (ABIQUIM) show that, in the period between 2007 and 2013, the amount of pesticides traded increased from 643 million to 1.2 billion kilos. In 2014, sales of pesticides increased 13% in Brazil. This represented net revenue of approximately BRL 25 billion.[3]

> *In Mato Grosso state, soybean, corn and cotton crops stand out as heavy users of pesticides*

Mato Grosso is in first place among the Brazilian states that most consume pesticides, with around 207 million liters used in its plantations; Paraná (135 million liters) and Rio Grande do Sul (134 million liters) are in second and third place.[(4)] According to the Brazilian Health Regulatory Agency (ANVISA), out of 50 most used pesticides in the country, 22 are prohibited by the European Union. This makes Brazil the biggest consumer of pesticides already banned by other countries.[5]

Notwithstanding intensive and uncontrolled pesticide use, Bill of Law No. 6.299/2002 has been under analysis in the National Congress since 2002 and proposes changes in the pesticide regulation system, pesticide components and the like. This Bill seeks to institute a range of measures with the objective of loosening the regulatory framework and reducing costs for the productive sector, neglecting environmental and health impacts on populations.[6,7]

Added to this context of proposals to loosen regulatory framework for pesticide use and trading, is the lack of financial resources invested in the Brazilian National Health System and, as a result, the risk of pesticide intoxication increases. According to the National Toxicological Information System (SINITOX), indiscriminate use of pesticides makes this category the third largest cause of intoxication in Brazil.[8]

In 2013, the exogenous pesticide intoxication incidence rate was 6.23 cases per 100,000 inhabitants. In the period from 2007 to 2014, notified cases increased 87%, totaling 68,873 cases.[9]

While agribusiness strengthens its expansion, investments in health decrease.10 As a consequence, evidence increases on how pesticides promote negative impacts on health: deaths, acute intoxications, chronic effects, besides all the environmental harm.[(10)]

In Mato Grosso state, soybean, corn and cotton crops stand out as heavy users of pesticides[(4),(11)] However, efforts are being made to implement actions in Mato Grosso state to strengthen health surveillance in populations exposed to pesticides, as a way of expanding mechanisms of health surveillance action and participation in territories impacted by agribusiness.[(12)]

The objective of this study was to estimate the prevalence of acute pesticide intoxication and associated factors in a region of intense agricultural production in the state of Mato Grosso, Brazil.

Methods

This was a cross-sectional study using data from a survey carried out in six municipalities elected as a priority for the implementation of the Health Surveillance of Populations Exposed to Pesticides (VSPEA) model. This falls under the responsibility of the Health Surveillance Superintendency Sector of the Mato Grosso State Health Department (SVS/SES/MT) and is funded by the Ministry of Health's National Health Fund.[13]

Mato Grosso is Brazil's third largest state in terms of territorial extension, with an estimated population of 3,441,998 inhabitants in 2018 and population density of 3.36 inhabitants/km2. According to the 2010 demographic census,[14] in that year, approximately 82% of the state's inhabitants lived in urban areas and its Human Development Index (IDH) was in 11th place among the 27 Brazilian Federative Units.[15]

The municipalities evaluated were Diamantino, Nova Mutum, Pedra Preta, Campo Verde, Sorriso and Primavera do Leste, which together are responsible for around 70% of the state's agricultural production.[(16)] The survey was carried out in the first quarter of 2013, under the responsibility of the respective Municipal Health Departments. After systematizing the information, SVS/SES/MT had a convenience sample of 753 individuals to be interviewed and provided this study's researchers with a copy of the respective database in CSV format.

On order to carry out field work, the municipalities recruited and trained Community Health Agents (CHA) as interviewers. Interviewees were asked if they had worked in a place where there were pesticides, if they had worked directly with pesticides and if they had washed clothes that had been worn for working with pesticides. The target population was selected considering Family Health Strategy (FHS) coverage areas under greater direct or indirect exposure to pesticides. The following criteria were used to select individuals to be interviewed: (i) living in the outskirts of the municipality, next to plantations; (ii) living in rural area served by FHS; and (iii) living in an FHS area where pesticide handling activities take place (sales, stocking, transportation, disposal of used packaging etc.).

The database was comprised of six groups of questions on the following topics: sociodemographic characteristics; direct and/or past exposure to pesticides; current occupation; use of pesticides in the workplace; handling contaminated clothing; and rural or urban area workplace.

The dependent variable for this study was having reported any acute intoxication symptom in the month prior to the interview and which had been diagnosed by a doctor. We considered the following symptoms found to have occurred in the respondents' medical history: convulsions, coma, vomiting, headache, disorientation, dizziness, breathing difficulties, nausea and skin problems. We did not ask whether those symptoms were related to pesticides or not. The independent variables were comprised of socioeconomic aspects: sex (male; female); age group (in years: up to 17; 18-29; 30-39; 40-49; 60 or more); education level (incomplete and complete elementary education; incomplete and complete high school education; incomplete and complete higher education); and ethnicity/skin color (white, black; brown; Asian; indigenous). We also considered aspects related to occupation: length of time working in agriculture and other activities with pesticide use; current occupation sector; and workplace location.

In order to calculate the crude prevalence ratio for acute intoxications, the variables were categorized as: sex (male; female); age group (in years: 30 and more; up to 29); education level (up to incomplete high school; complete high school and above); current occupation (agriculture and similar activities; other); living less than least 500 meters from a plantation (yes; no); workplace location (urban; rural); living next to soybean crops (yes; no); living next to maize crops (yes; no); living next to cotton plantations (yes; no); and living next to bean crops (yes; no).

We also asked about the kind of crops grown and the type of pesticide used on them.

We conducted descriptive analysis for the distribution of simple frequencies. In the bivariate analysis, we carried out the Mantel-Haenszelem test and all comparisons. Variables having statistical significance with p-value <0.20 were included in the multivariate analysis model, using Poisson regression. We used the backward model, whereby variables were gradually removed from the final model after adjustment. Only variables with statistical significance ($p<0.05$) were kept in the model.

This study was conducted by the Ministry of Health, based on the National Guidelines for Health Surveillance of Populations Exposed to Pesticides, jointly with SVS/SES/MT which is responsible for Health Surveillance in Mato Grosso, collected the data and authorized its use.[11] Since it is a public domain free access existing secondary database, there was no requirement to submit the study project to the Research Ethics Committees system nor to the National Research Ethics Committee (CEP-CONEP), as per National Health Council (CNS) Resolution No. 510, dated April 7, 2016.

Results

A total of 753 people were interviewed from six municipalities elected as a priority for the implementation of VSPEA actions. More than half of the participants were male (59.2%), with predominance of the 30-49 years age group (50.4%). Regarding education level, 40.2% had not completed elementary education. In relation to current occupation, more than a third of participants worked in the agriculture sector and similar activities (38.9%), with commerce being the second most reported occupation sector (18.8%). Fifty-three percent of those who worked in agriculture and the like lived in rural areas (Table 1).

Among the population studied, 17.0% (95%CI 8.5;25.5) of the interviewees reported they had received a diagnosis of acute pesticide intoxication issued by medical professionals in the month prior to the interview. The main symptoms reported were dizziness (23.1%), headache (22.2%) and nausea (15.8%) (Table 1).

Table 2 shows the crude prevalence ratio for acute pesticide intoxication associated with the interviewees' sociodemographic characteristics. Occurrence of acute intoxication was 3.47 (95%CI 2.24;5.35) times higher among males when compared to females. The 30 years old or over age group was the most exposed (PR=1.60 – 95%CI 1.01;2.54). Among the participants with low education level, acute intoxication was more prevalent in those who had incomplete high school education (PR=2.19 – 95%CI 1.46;3.30) when compared to those having complete high school or higher education.

With regard to current occupation, workers in the agricultural sector or similar had 2.52 (95%CI 1.83;3.46) times higher occurrence of acute intoxication when compared to workers in other occupations. Similarly, living next to plantations (less than 500 meters away) (PR=2.39 – 95%CI 1.61;3.53)

Table 1 – Sociodemographic and occupational profile and prevalence of self-reported intoxication among inhabitants (n=753) of six municipalities in Mato Grosso, Brazil, 2013

Variables	n	%
Municipalities		
Campo Verde	49	6.5
Nova Mutum	262	34.8
Pedra Preta	35	4.6
Primavera do Leste	230	30.5
Sorriso	121	16.1
Diamantino	56	7.4
Sex (751)[a]		
Male	445	59.2
Female	306	40.8
Ethnicity/skin color (720)[b]		
White	342	47.5
Black	47	6.5
Brown	327	45.4
Asian	3	0.4
Indigenous	1	0.1
Age group (in years) (753)		
<17	6	0.8
18-29	145	19.3
30-39	197	26.2
40-49	182	24.2
50-59	126	16.7
≥60	97	12.9
Education level (750)[c]		
Incomplete elementary school	303	40.2
Complete elementary school	113	15.0
Incomplete High School	83	11.0
Complete High School	182	24.2
Incomplete higher education	23	3.1
Complete higher education	49	6.5
Current occupational sector (753)		
Commerce	137	18.8
Health	38	5.1
Agriculture and similar activities	293	38.9
Unemployed/retired	27	3.6
Public service/urban services[d]	151	20.4
Household services	107	14.2

a), b), c), e) No information for some variables.
d) Except health workers.
f) Only among those who worked with pesticides.
g) Individuals may have reported more than one intoxication symptom.

continue

Table 1 – Sociodemographic and occupational profile and prevalence of self-reported intoxication among inhabitants (n=753) of six municipalities in Mato Grosso, Brazil, 2013

Variables	n	%
Current occupation (753)		
Agriculture and similar activities	293	38.9
Others	460	61.1
Workplace location (753)		
Urban area – central area	285	37.8
Urban area – outskirts	94	12.5
Rural area – village	124	16.5
Rural area – farm	250	33.2
Work zone (753)		
Urban	379	49.7
Rural	374	50.3
Living less than 500 meters away from crops (703)[e]		
No	286	40.1
Yes	421	59.9
Have you had acute intoxication in the previous month (diagnosed by doctor) (753)		
No	620	82.3
Yes	133	17.7
Time spent with activities related to pesticide use (283)[e,f]		
Less than 1 year	52	18.4
1 to 5 years	92	32.5
6 to 10 years	53	18.7
11 years or more	86	30.4
Living near soybean crop		
No	338	44.9
Yes	415	55.1
Living near maize crop		
No	404	53.6
Yes	349	46.4
Living near cotton crop		
No	651	86.4
Yes	102	13.6
Living near bean crop		
No	708	94.0
Yes	45	6.0
Use of personal protective equipment when handling pesticides (335)		
No	189	56.4
Yes	146	43.6
Washing of clothes contaminated by pesticides (335)		
No	191	57.0
Yes	144	43.0
Self-reported acute intoxication symptoms (329)[g]		
Convulsions	6	1.8
Headache	73	22.2
Dizziness	76	23.1
Nausea	52	15.8
Disorientation	14	4.3
Breathing difficulties	35	10.6
Skin problems	25	7.6
Vomiting	48	14.6

a), b), c) , e) No information for some variables.
d) Except health workers.
f) Only among those who worked with pesticides.
g) Individuals may have reported more than one intoxication symptom.

and working in a rural area (PR=2.35 – 95%CI 1.67;3.31) were also situations associated with higher prevalence of acute intoxication (Table 2).

Participants who worked near bean crops (PR=3.28 – 95%CI 2.35;4.59), soybean crops (PR=2.46 – 95%CI 1.71;3.56) and maize crops (PR=2.26 – 95%CI 1.62;3.14) had higher prevalence of acute intoxication when compared to other participants (Table 2).

In the final model, after adjustments, the following variables remained statistically associated with acute pesticide intoxication: having incomplete high school education (PR=1.80 – 95%CI 1.22;2.71); living near any kind of crop (PR=2.81 – 95%CI 1.79;4.41); and living less than 500 meters away from maize crops (PR=1.57 – 95%CI 1.05;2.35) and living less than 500 meters away from cotton plantations (PR=1.43 – 95%CI 1.02;2.02) (Table 3).

Discussion

This study found 17% prevalence of self-reported acute intoxications. Living near any crop, especially

Table 2 – Prevalence and prevalence ratio of acute intoxications according to sociodemographic. occupational and environmental characteristics among inhabitants (n=753) of six municipalities in Mato Grosso. Brazil. 2013

Variables	%	Crude PR[a] (95%CI[b])	P -value[c]
Sex			
Male	24.9	3.47 (2.24;5.35)	<0.001
Female	7.2	1.00	
Age group (in years)			
≥30	19.1	1.60 (1.01;2.54)	0.022
<30	11.9	1.00	
Education level			
Up to incomplete High School	21.6	2.19 (1.46;3.30)	<0.001
Complete High School and above	9.8	1.00	
Current occupation			
Agriculture and similar activities	28.0	2.52 (1.83;3.46)	<0.001
Others	11.1	1.00	
Living less than 500 meters away from crops (703)[e]			
Yes	23.7	2.39 (1.61;3.53)	<0.001
No	9.9	1.00	
Work zone			
Rural	24.9	2.35 (1.67;3.31)	<0.001
Urban	10.6	1.00	
Living near soybean crop			
Yes	24.1	2.46 (1.71;3.56)	<0.001
No	9.3	1.00	
Living near maize crop			
Yes	25.2	2.26 (1.62;3.14)	<0.001
No	11.1	1.00	
Living near cotton crop			
Yes	30.4	1.93 (1.37;2.73)	<0.001
No	15.3	1.00	
Living near bean crop			
Yes	51.1	3.28 (2.35;4.59)	<0.001
No	15.5	1.00	

a) PR: prevalence ratio.
b) 95%CI: 95% confidence interval.
c) p<0.05 considered to be statistically significant.

Table 3 – Multivariable Poisson regression results for acute intoxication caused by pesticides among inhabitants (n=753) of six municipalities in Mato Grosso, Brazil, 2013

Variables	Adjustada PRa	95% CIb	P-value
Living near maize crop	1.57	(1.05;2.35)	0.026
Living near cotton crop	1.43	(1.02;2.02)	0.037
Living near any kind of crop	2.81	(1.79;4.41)	<0.001
Education level up to incomplete high school	1.80	(1.22;2.71)	0.003

a) PR: prevalence ratio, adjusted per sex and living in rural/urban area.
b) 95%CI: 95% confidence interval.

maize and cotton plantations, and having low education level were variables associated with higher occurrence of acute intoxications.

Our study found that approximately one in every six participants reported having received medical diagnosis of acute pesticide intoxication in the month prior to the interviews. A study by Gonzaga[16] on the profile of pesticide intoxication in Mato Grosso, in the period 2001 to 2004, had already shown considerable prevalence of notifications (63.1%), although it used data provided by the Ministry of Health via the Notifiable Diseases Information System (SINAN). Today, more than ten years after Gonzaga's study, it can be seen that acute pesticide intoxication is still a public health problem to be overcome in the region.[17]

In our research, the main symptoms of acute intoxications reported by participants were dizziness, headache and nausea. These findings are in agreement with Taveira and Albuquerque[(18)] who, when analyzing a pesticides use database, showed symptoms of dizziness and nausea, among others, to be the most reported in the Brazilian state of Paraná.[18]

The findings of this study revealed greater occurrence of acute intoxication in males than in females. Silva[(19)] also found that males working in agriculture had higher intoxication incidence rates and considered them to be a group at greater risk. The predominance of male cases, almost 3 males to 1 female, found by us does not differ from Gonzaga's findings.[16] These results strengthen the hypothesis that potential intoxication in males is higher than in females. This situation may be explained by work division in rural areas, where men usually carry out activities with more direct contact with pesticides, such as working in chemical storerooms mixing pesticides, use of backpack sprayers, driving tractors and harvesters, equipment maintenance and equipment washing. Women, in turn, usually carry out activities with less direct exposure to pesticides: administrative departments, production quality control, packing and so on.

Acute intoxication prevalence was highest in people in the 30 to 39 years age group. Silva[20] and Araújo et al.[(21)] also found a higher proportion of intoxications in this age group. The data is alarming in that it shows that in different territories, a significant part of young adult rural workers get sick because of direct or indirect contact with pesticides.

Interviewees who reported living near crops had higher occurrence of acute intoxication, when compared to those who did not live near crops. This data is important, mainly because of two aspects. First of all, it is known that use of pesticides near schools, residences, towns and water sources is still a reality in Mato Grosso. Additionally, this fact gets worse with aerial, tractor or manual spraying, contaminating breast milk, blood and urine of the surrounding population, besides contaminating water, air and food consumed by them.[(11)] Secondly, although the objective of the Bill of Law is to loosen the regulatory framework for pesticide use in crops all over Brazil,[6] the situation identified in the state of Mato Grosso is even more serious than this. According to a Normative Instruction and Decree issued by the Ministry of Agriculture, Livestock and Food Supply (MAPA), it is prohibited to use pesticides in areas less than 500 meters away from villages, cities, towns, neighborhoods and water catchment sources for supplying the population.22 Contrary to this ruling, a significant number of state laws and decrees have reduced the minimum distance for pesticide use from 500 to 90 meters.[20] This measure represents a severe setback because it neglects possible impacts on human and environmental health.

The entire context described above constitutes a scenario of chronic exposures to pesticides, resulting in health problems, including transgenerational health problems and cancer in particular. A study carried out in eight municipalities in Mato Grosso state in relation to the period 2000 to 2009, identified 100% more occurrences of congenital malformation among children of mothers exposed to pesticides during the periconceptional period, in relation to other expectant mothers.[23] Another study, carried out in the semi-arid region of the Brazilian state of Ceará, showed a cancer mortality rate 38.0% higher in three municipalities neighboring large crop areas, when compared to the corresponding rate found in a further 11 control--municipalities; according to the same study, neoplasm hospitalization rates in the first three municipalities were 1.76 times higher than those of the other 11 municipalities studied, which did not have agribusiness in their territories.[17]

The institutional weaknesses of pesticide use monitoring in Brazil can be seen more clearly when taking as an example health surveillance measures related to drinking water quality control. Of Brazil's 5,570 municipalities, only 25.1% analyze and monitor residual pesticides in drinking water; and in only 2.3% of these municipalities is this done jointly by the water supply service and the health surveillance service.[24]

Another variable associated with occurrence of acute intoxication is low education level. In this study, interviewees with incomplete high school education had more acute intoxications when compared to participants with complete higher education. Data from notifications of exogenous intoxications by pesticides in the Brazilian state of Bahia for the period 2007-2011, showed that approximately 40% of registered cases were individuals who had only elementary education. Moreover, when workers have low education levels this makes it difficult for them to understand security information contained in pesticide package labels.[25] In this sense, implementation of public policies, especially those aimed at rural workers' access to education, is a measure that promotes health and prevents disease.

Workers and people in general who lived near maize and cotton crops had almost twice the number of acute intoxications, when compared to other participants. Beyond the issue of crops being close to housing, this data should also be analyzed in the light of the volume and potential toxicity of active ingredients used in both crops: pesticides used in seed treatment and in the maize crop itself, such as triazoles and strobilurin, are among products that are very hazardous (Toxicity Class II) and hazardous (Toxicity Class III) for human health.[26] In 2017 alone, consumption of agricultural supplies used in growing maize in Mato Grosso was the second largest in Brazil. Moreover, the country's Midwest region is the largest maize producer.[28]

Mato Grosso has the country's biggest cotton plantations.[29] This monoculture demands high pesticide use, with intense polluting potential. Many chemical products are used in cotton seed treatment, especially fungicides and insecticides, increasing risk of intoxication among workers directly involved, as well as inhabitants of regions neighboring this kind of crop.[4] Furthermore, herbicides and insecticides are used in cotton plantations: organophosphates are the main type of pesticides used in cotton growing culture, besides being among the main causes of acute intoxication, according to the literature.[26]

This study has some limitations. The first of them is inherent to studies using secondary data. Record retrieval and quality may lead to statistical treatment quality loss. Moreover, this study is not representative of the entire state of Mato Grosso: we selected six municipalities with the largest pesticide consumption in the state. For this reason, this selection may be biased, especially with regard to the generalization of results to the total Mato Grosso population. A further possibility of selection bias relates to the deliberate choice of the study participants. Nevertheless, it is our understanding that the study has good internal validity for populations of municipalities with high pesticide use.

The study's cross-sectional design, when evaluating exposure factors and outcomes simultaneously, may result in reverse causality, which occurs when exposure changes from cause to outcome, after the individual knows their disease status. As an example, an interviewee's knowledge about acute intoxications may alter conditions of variables classified as exposure variables, such as moving house to live farther away from crops where pesticides are used. Another limitation to be considered is self-reported information, even if confirmed by medical diagnosis, since it may underestimate the real prevalence of possibly underdiagnosed intoxications.[30]

With the increase of pesticide use in Brazil in the last decade, together with its excessive use and, to some extent, lack of control by government organs, not only in agribusiness but also in family farming, evidence is growing that the use of pesticides is ceasing to be an issue specific to agricultural production and is becoming a Public Health problem.

The results presented in this manuscript indicate that pesticides intensely used in agricultural production in the region studied lead to more occurrences of acute intoxications in workers and nearby populations. Some elements may contribute to understanding this phenomenon. Health and safety actions involving rural workers are often limited to inspection of personal protective equipment (PPE). Their lack of knowledge about the risks of contact with pesticides owing to their low education level and living near maize and cotton crops should not be neglected because they are among the main problems associated with the growing number of acute pesticide intoxications and, consequently, with the increase in the occurrence of adverse health outcomes in rural populations, especially agricultural workers in the 18 to 59 years age range.

Finally, we recommend new studies to achieve improved evaluation of exposure to pesticides by the population we studied and by other Brazilian rural populations, using a longitudinal design, with biological markers capable of measuring and providing understanding, with wider range and greater accuracy, of the complexity of acute exposure to pesticides and their effects on health. It is important that interventions be made in the short, medium and long-term in order to reduce harm to the health of populations facing this risk.

Acknowledgments

To the Health Surveillance Superintendency Sector of the Mato Grosso State Health Department (SVS/SES/MT), for kindly providing access to the database and authorizing our research. To the General Coordination of Environmental Health Surveillance, Health Surveillance Secretariat, Ministry of Health (CGVAM/SVS/MS), for funding actions for Health Surveillance of Population Exposed to Pesticides.

Authors' contributions

Silva DO and Silva AMC contributed to the conception and design of the article, data analysis and interpretation and final revision of the manuscript. Ferreira MJM and Santos MA participated in the study design. Silva SA was responsible for data collection and preparation of the questionnaire, training the Community Health Agents of the municipalities selected in the project. Hoffmann-Santos HD was responsible for database organization and preparation of data reports. All authors have approved the final version of the manuscript and declared themselves to be responsible for all aspects of the study, ensuring its accuracy and integrity.

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Received on 08/01/2019
Approved on 24/05/2019

Associate Editor: Bruno Pereira Nunes – orcid.org/0000-0002-4496-4122