

Analysis of the causes of pesticide poisoning underreporting in the healthcare network in a municipality in Southern Brazil

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Abstract *The intensive use of pesticides in agriculture is associated with several negative externalities, which affect both the environment and public health. It is known that the number of records is lower than that of pesticide poisonings, and that underreporting occurs. Aiming to understand this underreporting, we analyzed the data from two information systems for notifications and health injuries and a case study was carried out with professionals from the 5th Regional Health Center and the health network of a municipality in the state of Paraná. It was concluded that underreporting occurs in the information systems, confirming the inconsistency of data and the lack of communication between them, making it difficult to understand the reality of poisonings. In the case study, the occurrence of prior underreporting was identified: when many workers do not seek health systems; the training of professionals is insufficient and neutralized by high turnover, especially among physicians; the diagnosis, conduct and treatment of pesticide poisoning are not part of the curriculum of many courses in the health area; the capacity of health services in many municipalities falls short of the demand, causing work overload to the professionals and the consequent underreporting.*

Key words *Pesticides, Poisoning, Public health, Toxic contamination, Health surveillance*

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Introduction

The agriculture of Brazil has undergone a process of conservative modernization from the 1950s onwards, seeking to increase production and productivity through the mechanization and the use of synthetic fertilizers and pesticides. The subsidized rural credit and state technical assistance were the main mechanisms that induced the use of pesticides¹, currently added by the companies' private sales force². The intensive use of these products is associated with negative externalities, which have an impact on the environment and public health. There are direct effects on the workers and other residents of the rural areas, and indirect effects on the urban population through the contamination of food, drinking water and even rainwater¹⁻³. Considering the amplitude of the agricultural sector, the reality of poisonings is disseminated throughout the national territory¹. The actual dimension of this epidemic remains unknown. Underreporting has contributed to concealing the pressing need for surveillance actions and preventing the workers' access to their rights and health.

The term 'underreporting' is used when the reported numbers are below the actual occurrence, resulting in an epidemiological silence in regions where the occurrence of the disease/injury is known to occur¹. These facts make an early detection or, in most cases, the identification of the clinical syndrome difficult. The World Health Organization (WHO) recognizes that pesticide poisoning underreporting is around 1:50 for each recorded case¹. This article seeks to understand the underreporting of poisonings according to the view of health professionals, aiming to help elucidate this phenomenon, which contributes to the lack of knowledge about the severity of the problem.

Agricultural production and pesticide consumption in Brazil and in the state of Paraná

Brazil is one of the largest consumers of pesticides in absolute numbers^{4,6,8}. These pesticides are used to protect crops and livestock; however, they are aggressive to human health¹. The consumption of pesticides in Brazil reaches 33.1% of agricultural producers (1.68 million businesses). This number was 20% higher than in the 2006 census. Of the businesses that used pesticides, 16% of those responsible for their use were illiterate and, of these, 89% did not receive any

technical support. Of the 70% who had finished Elementary School at most (1,170,784) only 31% declared having received technical support¹, characterizing a serious situation at the end of consumption chain. The state of Paraná, Brazil, is the second largest producer of grains (16.23% of the total amount of grains in the 2017-2018 harvest) and the third largest consumer of pesticides in Brazil, with a total volume of 92,398 tons in 2017, representing an average consumption of 8.08 Kg per inhabitant/year¹⁻³.

The present study was carried out in the municipality of Laranjeiras do Sul, located in the 5th Regional Health Center, one of the 5 (five) regions that most commercialize pesticides in the state, consuming 31,554 tons in the period of 2014 to 2017¹¹. The municipality of Laranjeiras do Sul has agricultural characteristics, of which main production comprises soy, corn and wheat. Rural credit in the municipality ranged from R\$72.8 to 98.2 million between 2013 and 2015¹³. This resource increases the consumption of pesticides. In Laranjeiras do Sul, 6.84 kg of pesticides/inhabitant were used in 2013 and 7.40 in 2018. In the surrounding areas, there are municipalities that depend on their hospital care network. In 2013, some of them also reached a high consumption of pesticides per inhabitant/year, such as in the municipality of Cantagalo (47.39 Kg/inhabitant), Porto Barreiro (25.52 Kg/inhabitant) and Virmond (116.59 Kg/inhabitant). In 2018, consumption was still quite significant: Cantagalo (14.21 kg/inhabitant), Porto Barreiro (38.57 kg/inhabitant) and Virmond (29.44 kg/inhabitant) showed consumption averages that were much higher than the national ones^{11,1}. Therefore, it would be expected that the health network in Laranjeiras would be prepared to notify possible cases of pesticide poisoning.

Pesticides, poisoning and impacts on human health

Pesticides have an impact on human and environmental health, producing effects that vary according to the active ingredient, the absorbed dose and the form of exposure¹. This toxicity depends on the properties of the active ingredients and adjuvants of the product, which can lead to death². Exposure to pesticides can occur from contact with the skin, mucous membranes, by breathing and through the ingestion of contaminated food. Occupational exposure occurs during the dilution, preparation of the syrup, during and after the application of the products^{16,1}. The

pesticides can also drift out of the application area. The poisoning of family members have also been recorded, such as during the washing of the clothes used for the pesticide application¹.

The poisonings can be acute or chronic. Acute poisoning is the one that causes changes in the health status in one or more individuals, resulting from the harmful interaction of a substance with the living organism. It can be mild, moderate or severe, depending on the amount of absorbed poison, the absorption time, and the product toxicity, among others. It manifests as a set of signs and symptoms that have a sudden onset, i.e., minutes or hours after exposure. It is usually a single event and occurs within a period of up to 24 hours¹.

Chronic poisoning represents the change in the health status in one or more individuals, resulting from a harmful interaction with a substance. It occurs during the course of repeated exposures to the toxicant over long periods, including accumulation of genetic damage, resulting in undefined, confusing and very often irreversible clinical pictures. In this case, the diagnoses are difficult to be established and there is greater difficulty in establishing the cause/effect association, mainly when the patient is exposed to multiple products^{1,2,3,19}. The role of health professionals in identifying symptoms, characterization, referrals and recording is essential for one to have a reliable database.

It is difficult to associate pathologies such as cancer, malformations, allergies, depression, Parkinson's and other chronic diseases to the use of pesticides¹. In this condition, products such as glyphosate, accountable for half of the pesticides consumed in Brazil, go unnoticed, although classified as having low acute toxicity and probably carcinogenic to humans by the International Agency for Research on Cancer (IARC)^{8,9}. This is also the case with carbamates and other products that cause depression and induce suicidal ideation¹⁸.

Pesticide poisoning underreporting in the health network

Notification is the communication of the occurrence of a certain disease or health injury to the health authority by health professionals or any citizen, for the purpose of adopting relevant intervention measures. Historically, compulsory notifications have been the main source of epidemiological surveillance, from which the information-decision-action process is usually triggered¹.

Actions to monitor pesticide poisoning at the national level started in the 1980s, by the National System of Toxic Pharmacological Information (SINTOX, *Sistema Nacional de Informações Tóxico Farmacológicas*), constituted by the Ministry of Health and linked to the Oswaldo Cruz Foundation¹ (FIOCRUZ, *Fundação Oswaldo Cruz*) and the Notifiable Diseases Information System (SINAN) aims to record and process data on notifiable diseases/injuries throughout the national territory, being compulsory (see Table 1). Its purpose was to “coordinate the collection, compiling, analysis and dissemination of cases of poisoning and toxic contamination reported in the country”²⁴. The main notification systems for injuries caused by pesticide poisoning are summarized in Table 1.

In addition to these, it is possible to obtain data on poisoning from the Live Births Information System (SINASC, *Sistema de Informações sobre Nascidos Vivos* - fetal malformation data), linked to the Ministry of Health, and from the Work Accident Communication (CAT, *Cadastro de Acidentes de Trabalho*) of the Department of Labor. Therefore, there are several official systems that record pesticide poisoning; however, none of them adequately responds as a surveillance tool for this type of injury²¹.

Poisoning notifications in patients exposed to pesticides are the responsibility of health surveillance, which are in charge of data collection and processing, as well as analysis and interpretation of information, to recommend appropriate control measures for each region and assess whether they are effective and efficient⁶. The fulfillment of these functions depends on the availability of information to subsidize the triggering of actions. The quality of information depends on adequate collection of data that are generated at the site where the injuries occurred and facilitates the planning, assessment, maintenance and improvement of preventive health actions¹.

The information depends on training and motivation, preparing reliable professionals to correctly diagnose and notify and reliably perform the epidemiological investigation¹. The Protocol for the Assessment of Chronic Pesticide Poisoning¹⁹ recognizes that health professionals in Brazil lack the clinical instruments to guide the diagnosis of chronic poisonings and the criteria to define the establishment of the association of these poisonings with work and the environment. The underreporting also entails the invisibility of the costs of these poisonings for the Brazilian Unified Health System (SUS, *Sistema*

Chart 1. Brazil. Information systems for notifications of diseases/injuries caused by pesticide poisoning.

Data Collection System	Acronym/Site	Purpose	Responsible for filling out the data
National System of Toxic Pharmacological Information (Sistema Nacional de Informações Tóxico Farmacológicas)	SINITOX - http://sinitox.icict.fiocruz.br/	It coordinates the collection, compilation, analysis and dissemination of cases of toxic contamination and poisoning reported in the country	Ministry of Health and Fundação Osvaldo Cruz (FIOCRUZ). Rede Nacional de Centros de Informação e Assistência Toxicológica (Renaciat), consisting of several units present in all regions of Brazil
Notifiable Diseases Information System (Sistema de Informações de Agravos de Notificação)	SINAN - http://sinan.saude.gov.br/sinan/login/login.jsf	It aims to record and process the data on the notification of diseases throughout the country. It provides information for the analysis of the morbidity profile, and thus contributing to decision-making at the municipal, state and federal levels. Compulsory notification	Ministry of Health (MH). Basic Health Unit, Health Secretariat and Information and/or Epidemiological Surveillance services
Mortality Information System (Sistema de Informações de Mortalidade)	SIM - http://sim.saude.gov.br/default.asp	Its purpose is to gather quantitative, qualitative and regular data on mortality in the country. The Death Certificate (DC) must be completed by the attending physician, or in their absence, by two qualified persons who have witnessed the death	Municipal/State Health Secretariat
Hospital Information System (Sistema de Informações Hospitalares)	SIH - http://datasus.saude.gov.br/sistemas-e-aplicativos/hospitales / sihus	It stores data on hospital admissions within the SUS setting, reported monthly by all public health establishments, partners and contracted ones, which carry out hospital admissions and consolidated by municipalities and states	Hospitals and medical clinics

Source: DATASUS³⁵, FIOCRUZ³⁵, MINISTRY OF HEALTH³⁶.

Único de Saúde). This affects the implementation of public policies that support both the agricultural producer and society¹.

The analysis of the underreporting causes discloses a complex picture. Even if the notification initiative exists, there is no support for its materialization⁷. In addition to the difficulty in identifying and diagnosing poisonings, there are methodological, analytical and structural complicating factors that contribute worldwide to the inaccuracy of available data¹.

The notification is usually carried out in a precarious way, due to the lack of knowledge about its importance, the discredit of health services, the lack of monitoring and supervision of the service network and the lack of feedback of the collected data and actions that were generat-

ed by the analysis⁷. To decrease the underreporting, the standardization of care flows, the development of information materials containing worker health procedures and sporadic training for professionals and agricultural producers are indicated¹.

Studies have shown that the increase in notifications due to the increased use of pesticides did not motivate more effective health surveillance actions. Diverse and contradictory interests in the state apparatus hinder collective health protection¹. The underreporting worsens this scenario, making poisoning events invisible and contributing to the nonperformance of health surveillance actions among rural workers.

However, doubts about the degree of poisoning existing in the country should not pre-

vent immediate action by public agencies. Risk characterization, with abundant evidence, indicates the probability of harm. It is not necessary to prove the occurrence of health problems to trigger public health promotion and protection policies⁴. However, the scientific controversy scenario is used as a weapon by economic interest groups that actively influence the government and its public policies.

Methods

The study consisted of an exploratory, cross-sectional survey-type case study, with a quali-quantitative approach. It was based on the application of specific questionnaires between professional segments and health system levels, with closed and open questions, using a stratified non-probabilistic sampling, by adherence, with workers from different levels of the health system and different professional categories, which were applied from November 2015 to March 2016. Moreover, a documental and bibliographic research was carried out, and secondary data from the SINITOX and SINAN health systems were compared.

The interviews were conducted with professionals linked to the Health Secretariats at the state level, at the 5th Regional and at the Municipal Secretariat, in addition to professionals from health units and from the two hospitals that provide Urgency and Emergency Care in the municipality of Laranjeiras do Sul, state of Paraná. Overall, 45 respondents participated in the study, including 9 physicians, 10 nurses, 15 nursing technicians and assistants, 7 health system managers and 4 other professionals. Of the interviewed professionals, 35 worked on the front line (direct assistance), 7 at the system management level and 3 performed other auxiliary functions.

The obtained results should be taken as indicators on the topic and should not be generalized to other situations and contexts, although they can bring useful inferences. Some answers may have reflected factors such as the professionals' concern about self-protection in view of their legal qualifications on the subject. Once these aspects are clarified, the results contribute to a better perception of the problem.

Results and discussion

First, the results of the information systems on diseases and injuries caused by pesticide poison-

ing were analyzed. The second part of the study sought to understand, using an exploratory method, the health professionals' point of view about the possible causes of underreporting.

Analysis of the notifiable diseases information system (SINAN) for the notification of diseases/injuries due to pesticide poisoning

The data on human poisoning by pesticides recorded in the Notifiable Diseases Information System (SINAN) for the notification of diseases/injuries showed several nonconformities and inconsistencies. Initially, data from SINITOX in the main agricultural-producing regions of Paraná were compared with data from SINAN (in the years 2013-2017). It was observed that the Toxicological Information Center in the municipality of Cascavel, which consolidates data from several municipalities, including Laranjeiras do Sul, did not record any poisoning notification during that period. The same occurred in all other hub cities, responsible for data consolidation in the state of Paraná, according to SINITOX (Table 1). Whereas SINAN, which includes mandatory notification in primary health care, recorded hundreds of cases of poisoning in the state of Paraná during the same period. The contrast of data consolidates the view that SINITOX is unreliable, subject to gaps in communication and registration, contributing to feeding the criticism that official Brazilian data on pesticide poisoning does not reflect the reality. They would be insufficient, partial, fragmented, disarticulated, and dispersed in several data sources^{7,21}. However, it is necessary to assess whether the notifications recorded in SINAN are in accordance with reality.

It is the government's duty and the citizen's right to identify the real dimension of poisoning in the country, since, in addition to the human dramas involved in it, there is an impact on public health costs resulting from treatment. The sales of pesticides in Brazil have reduced state taxes and benefits regarding the federal tax burden. The strange combination of efficiency on the one hand (benefits to the sector) and inefficiency on the other (the monitoring of their harmful effects) reflects political power relations inherent in the agrarian issue in our country^{1,4}. There is a negative externalization of the costs related to loss of life and health expenses in the prices of inputs used¹ by agribusiness. The deterioration of environmental quality, the high costs of depollution and health care are not included

in the price of agricultural production. As for the agroecological production, an organic conformity seal is required, overburdening the costs for small farmers who produce clean food, while providing free access to the markets for contaminated products.

This tax and price system failure characterizes a subsidy to the destructive agribusiness model. The gratuitousness of environmental contamination and resulting poisoning contributes to perpetuate the occurrence of such a serious social practice and the high level of environmental degradation.

Professionals' perception about pesticide poisoning notification

The study sought to analyze the health professionals' perception aiming to identify the degree to which notifications are being made in the system (Table 2). The results demonstrate the professionals' recognition of the health system about the underreporting. Only 33% of the professionals linked to hospitals realize that poisoning is diagnosed and notified. The majority

(56%) sees only part of the poisonings being diagnosed and reported. The professionals' view of the municipal and regional health system shows even more pessimistic perceptions. These data reinforce the perception that SINAN is receiving poisoning records that is below the ones that actually occurred.

As the professionals enter the higher system hierarchy, the perception tends to become more critical. A possible explanation for this dissension may lie in the fact that the issue indirectly analyzes the conduct and training of top professionals and the identification of problems would attest against their own professional performance. This was made clearer in the physicians' response (who are directly responsible for the diagnoses), with less acceptance that there are diagnosis and notification errors.

As the existence of underreporting is recognized at all levels of the system, we sought to identify some causes, using the hypotheses previously suggested in other studies^{7,28,1}. We aimed to contrast the top professionals' perceptions and those of the health system hierarchy. Regarding three aspects ("the team's lack of knowledge

Table 1. Comparison of recorded cases of human poisoning by pesticides in SINITOX and SINAN from 2013 to 2017. State of Paraná, Brazil.

Year / System	Curitiba		Londrina		Maringá		Cascavel		Laranjeiras do Sul	
	SINITOX	SINAN	SINITOX	SINAN	SINITOX	SINAN	SINITOX	SINAN	SINITOX	SINAN
Total	-	60	-	198	-	183	-	138	-	41
2013	-	15	-	34	-	50	-	19	-	3
2014	-	10	-	48	-	27	-	32	-	15
2015	-	7	-	33	-	19	-	34	-	12
2016	-	24	-	16	-	46	-	27	-	3
2017	-	4	-	7	-	41	-	26	-	8

Source: Adapted from SINITOX²⁵ and SINAN³⁵.

Table 2. Laranjeiras do Sul, PR - Perception of the degree of diagnosis and notification of cases of pesticide poisoning in health units.

Affirmative	Searched places		
	5th Regional Health Center	Hospitals: São Lucas and São José	Municipal Health Secretariat
Diagnosed and notified	0%	33%	17%
Partially diagnosed? and partially notified	50%	56%	67%
Diagnosed but not notified	0%	0%	17%
Barely diagnosed	50%	11%	0%

Source: Tosetto, 2016³⁷.

about the importance of filling out the notifications”; “symptomatology mistaken for that of other pathologies”; and “lack of professional training to recognize poisoning cases...”) the perception among professionals working in hospitals linked to patient care, strongly disagreed with respondents in the upper system hierarchy. The high and middle hierarchy identify these aspects as causes of underreporting, in percentages ranging from 50 to 100% of the respondents, depending on the question and the segment (Table 3), while in hospitals only 5 to 21% of the professionals agreed with the perceptions.

The item that showed the greatest relevance regarding the perception of front-line professionals (time spent filling out the form and lack of feedback of the analyzed information), was contradictorily mentioned by management professionals. In the health network, there is an established flowchart for the feedback of data generated by poisoning. However, since many data

are not being notified during the process and there are no actions related to the notification results, public health actions related to the area are discouraged. This disconnection between the managers’ perception and the segment of professionals who provide health care to the exposed population can lead to misunderstandings in the planning of public health actions, such as the allocation of efforts where they are less relevant, thus leaving necessary points uncovered.

The study investigated acute poisonings (classified as mild, moderate and severe - Table 4). In cases of mild acute poisoning, only 29% of the professionals stated they are always diagnosed according to the protocol and in only 14% of cases the exposure is characterized and a causal link established, which confirms the difficulty of the diagnosis and the existence of underreporting, as the percentages of case records and database feeding are low (only 57% declare that they always record the cases). Related to this topic, 89%

Table 3. Perception of the causes of pesticide poisoning underreporting according to the allocation of health professionals. Laranjeiras do Sul and SESA/Paraná.

Causes	Assessed sites				
	SESA - PR	5th Regional Health Center -PR	Municipal Health Secretariat-Laranjeiras do Sul - PR (Managers)	Municipal Health Secretariat - Laranjeiras do Sul - PR (Professional Care)	Professionals from Hospital São Lucas and São José - Laranjeiras do Sul - PR
Health team’s lack of knowledge about the importance of filling out the poisoning notifications in official systems.	100%	100%	100%	57.14%	14%
Absence of conclusive laboratory tests	0%	75%	0%	14.29%	5.26%
Symptomatology mistaken for other common pathologies in rural areas.	50%	75%	100%	14.29%	21.05%
Lack of training of professionals to identify cases of poisoning	100%	50%	50%	57.14%	21.05%
Absence of more refined analytical procedures	0%	25%	0%	14.29%	10.53%
Absence of adherence to the notification, due to the time spent filling out the form and the lack of feedback of the analyzed information with the relevant technical recommendations	0%	50%	0%	42.86%	42.11%

Source: Tosetto, 2016³⁷.

Table 4. Comparison of the performance of the health units in mild, moderate and severe acute poisoning cases.

Actions	Mild Acute Poisoning Cases			Moderate and Severe Acute Poisoning cases		
	Not performed	Eventually	Always	Not performed	Eventually	Always
Diagnosed according to the protocol	14%	57%	29%	0%	57%	43%
Characterizes the exposure and establishes the causal link	29%	57%	14%	0%	71%	29%
Notifies the health surveillance	0%	43%	57%	0%	29%	71%
Conducts consultation with information centers	43%	57%	0%	43%	43%	14%
Records the case and feeds the database	14%	29%	57%	14%	43%	43%

Source: Tosetto, 2016³⁷.

of professionals allocated to the hospital network did not undergo any training related to pesticides in the last year.

Regarding the moderate and severe acute poisonings, possibly due to the greater severity of the impact on patients, the degree of underreporting significantly decreases and the perceived percentage of exposure characterization and surveillance notification increases. There have been several reports that patients are accompanied by family members and that they often bring the packaging of the pesticide that caused the poisoning. Complementary exams are rarely requested in cases of identification of severe exposure, and the patient is immediately referred for hospitalization to undergo clinical treatment. Only a few physicians reported performing acetylcholinesterase tests.

As for chronic poisoning, of which symptoms are more difficult to associate with pesticides, 43% of the interviewed health professionals stated they are always able to characterize exposure to pesticides, whereas 14% never do. The notification and recording in the information and injury systems is done by 43% of professionals, while 14% never do. Establishing the causal nexus of symptoms in relation to pesticides, on the other hand, is only occasionally done by 57% of the professionals, but never by 28%. In chronic poisonings, the absence of clinical procedures and conclusive laboratory tests hinders the association with pesticide exposure.

This set of qualitative and quantitative data confirms the hypotheses established in several previous studies on pesticide poisoning underreporting, even those found in SINAN. The data

bring light on key aspects to understand the dynamics of health systems in relation to the problem and allow the indication of new directions to address the issue.

Conclusions

The Brazilian agribusiness production system is based on the intensive and abusive use of pesticides, which directly and indirectly impact the health system. On the other hand, public policies encourage the use of these substances, while disregarding their effects on health and the environment. The study increased the knowledge on the issue of poisoning underreporting from the health professionals' perspective and the notification and information systems.

The outdated data of the SINITOX information system and the identification of underreporting in the SINAN database confirmed the inconsistency of the data and the lack of communication between them, resulting in the concealment of the actual occurrence of pesticide poisoning. The lack of reliable data makes it difficult to create and implement public health policies. The study corroborates previous ones, concluding that information systems do not adequately correspond to the role of surveillance systems, and need to be rethought and reconfigured. The existence of underreporting was confirmed and possible causes related to the internal dynamics of the health system were raised. Health professionals identified situations of lack of adequate training to carry out the diagnosis, lack of time

due to other demands of the system, and/or lack of personnel. Hypotheses related to causes presented by several researchers were confirmed, such as: lack of trained professionals to recognize cases of poisoning, insufficient training carried out in the health system, which are aggravated by the turnover of health professionals, especially physicians, in municipalities^{7,28,33}.

However, other causes were pointed out: 1) there are different perceptions of the problem at different levels of the health system, creating ambiguity in the diagnosis and referral of priority actions in relation to overcoming the underreporting problems; 2) the diagnosis, conduct and treatment of pesticide poisoning cases are not part of the curriculum of many courses in the health area; 3) the capacity of health services in many municipalities, which does not meet the demand, causes work overload for professionals and favors pesticide poisoning underreporting; 4) the population exposed to pesticides is not always identified when seeking care at the health unit, which hinders the correlation between health problems and pesticide use.

The study agrees with ABRASCO's idea that it is necessary to strengthen and create spaces in

the political and financial agenda of SUS for the structuring of surveillance, assistance and health promotion related to pesticides. Moreover, the intersectoral articulation and the adoption of Agroecology incentive policies are essential for the agricultural model to be changed¹. Finally, suggestions from both respondents and authors, based the study, are presented, aiming to reduce pesticide poisoning underreporting: 1) review of protocols and information flows between health units and toxicological information systems, considering the feedback to the entire system of the released information and the measures taken; 2) permanent training of health professionals on the diagnosis, notification and adequate treatment of pesticide poisoning, especially in agricultural regions; 3) establishment of a simplified protocol for pesticide poisoning notification, both for health system personnel and other people related to the activity; 4) carrying out specific awareness campaigns and actions, aimed at agricultural producers and the health system, considering agricultural cycles; 5) training of agricultural producers and pesticide trading personnel on the risks and good practices related to pesticide trading and use.

Collaborations

EE Tosetto: completed a Master's Degree thesis in Agroecology and sustainable rural development, which provided the basis for the article. She contributed with the research planning and field data collection, as well as data analysis, and the writing of the manuscript. AI Andrioli: study advisor, participated in the interpretation and analysis of the obtained data and in the writing of the manuscript. PI Christoffoli: co-advisor of the study, contributed with the study planning, guided the field data collection and part of the data analysis, and supported the data analysis and writing of the manuscript.

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