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Pesticides poisoning in a health macro-region in Santa Catarina, Brazil, from 2014 to 2018

Intoxicações por agrotóxicos em uma macrorregião de saúde em Santa Catarina, Brasil, no período de 2014 a 2018

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ABSTRACT

Introduction: Increasing human exposure to pesticides is an international public health concern. **Objective:** To evaluate the toxic effects of pesticides on humans based on data collected in the administrative health macro-region of Vale do Itajaí, Brazil, from 2014 to 2018. **Method:** A descriptive cross-sectional study was developed, using secondary data from national health information systems, focusing on notifiable diseases, mortality, and hospital admission. **Results:** The results showed that the profile of exogenous pesticide poisoning has a predominance of male adults, with low education level, exposed to agricultural pesticides, with acute single exposure, where most cases occurred at home and were cured without sequelae. There was also observed a predominance of poisoning due to accidental and non-work-related circumstances that confirms the suspicions of the quality of filling in the notifications. The harmful effects of handling agrochemicals on human health were mainly manifested in the digestive, respiratory, and neurological systems. **Conclusions:** In view of the extreme vulnerability faced by the population of Vale do Itajaí health macro-region to diseases and injuries associated with the use of pesticides, as well as the Brazilian population as a whole, it was concluded that regulatory guidelines and more restrictive legislation is urgently demanded.

KEYWORDS: Pesticides; Poisoning; Public Health; Information Systems

RESUMO

Introdução: A crescente exposição humana a agrotóxicos é uma preocupação para a Saúde Pública internacional. **Objetivo:** Avaliar os dados de intoxicação humana por agrotóxicos levantados na macrorregião de saúde do Vale do Itajaí, no período de 2014 a 2018. **Método:** Realizou-se um estudo descritivo transversal de dados secundários por meio dos sistemas de informações em saúde de notificação compulsória mortalidade e internação hospitalar. **Resultados:** Os resultados mostraram que o perfil das intoxicações exógenas por agrotóxicos tem predominância de adultos do sexo masculino, com baixa escolaridade, expostos a agrotóxicos de uso agrícola, com exposição aguda-única, e que a maioria dos casos ocorreu nas residências e evoluiu para uma cura sem sequelas. Constatou-se, também, a predominância de intoxicações por circunstâncias acidentais e não relacionadas ao trabalho, confirmando suspeitas da qualidade do preenchimento das notificações. Acerca dos efeitos prejudiciais à saúde humana relacionados à manipulação de agrotóxicos, evidenciou-se a sua manifestação, predominantemente, nos sistemas digestório, respiratório e neurológico, do corpo humano. **Conclusões:** Diante do cenário de extrema vulnerabilidade da população da macrorregião de saúde do Vale do Itajaí às doenças e agravos associados ao uso de agrotóxicos, diretrizes regulatórias e legislações mais restritivas são urgentes.

PALAVRAS-CHAVE: Agrotóxicos; Intoxicação; Saúde Pública; Sistemas de Informação

INTRODUCTION

The use of pesticides has played a fundamental role in the current hegemonic model of agricultural production since the Green Revolution of the 20th century. The global use of these products has increased steadily in recent decades to control pests and disease vectors[1]. The current development model in the country favors the use of pesticides and the production of agricultural and mineral *commodities*, with production processes that generate enormous socio-environmental impacts[2].

Exposure to pesticides can cause a series of diseases and health problems, depending on the product used, the length of exposure and the amount absorbed by the body[3]. Ordinance No. 777, of April 28, 2004, which sets out the technical procedures for compulsory notification of occupational health problems in a specific sentinel service network, includes exogenous poisoning by pesticides[4].

Exogenous intoxication is the clinical and/or biochemical manifestation of exposure to chemical substances such as pesticides. These intoxications can be expressed by acute or chronic health effects. Many diseases have an acute effect, i.e. when there is exposure to the active ingredient (or pesticide) in high doses and only once. However, many diseases, such as cancer, mentioned in studies and documents, are characterized by chronic effects, when exposure to the pesticide occurs repeatedly and in low doses[5].

Brazil stands out as one of the biggest consumers of pesticides, as a result of the development of agribusiness[6]. During 2019, a total of 562 new products were approved in the country and around a third of these contain active substances banned or severely restricted by the *European Chemicals Association*[7,8]. In 2021, the marketing of pesticides in Brazil reached 719,05 thousand tons and is growing annually[7]. The growing trend in the commercialization and permission of pesticides over the years is worrying due to the poisoning caused by exposure to these products[6,9]. The recognition of these risks has led the Unified Health System (SUS) to adopt measures to promote health, prevention and comprehensive care for populations exposed to pesticides[10].

Health Information Systems (HIS) play a role in formulating and evaluating health policies, plans and programs and thus support the decision-making process. Notification is the main source of morbidity to detect cases, institute control measures and strengthen the Health Surveillance System.

According to data from the Brazilian Institute of Geography and Statistics (IBGE), Santa Catarina (SC), along with the state of Rio Grande do Sul, has the highest percentage of rural properties that use pesticides (70%) compared to the national average (32%). This represents 129,372 rural establishments[11]. Among the most recent publications from the State Epidemiological Surveillance Directorate (DIVE), the growing use of pesticides in the state stands out: in 2018, poisonings were concentrated in the health regions of Oeste, Planalto, Vale do Itajaí, and Great Florianópolis. The municipalities with the highest number of cases in the macro-region studied were Rio do Campo (18) and Ibirama (11)[12]. The Itajaí Valley macro-region was chosen because of its position in terms of incidence and the location of the Alto Vale campus of the Santa Catarina State University in this macro-region.

According to information provided by the Brazilian Institute of Environment and Renewable Natural Resources (Ibama), 12,442.98 tons of active ingredients were sold in the state of Santa Catarina in 2019[7]. In addition, surveillance and inspection actions are needed in the municipalities, since data on the high volume of sales of these products reveals a high risk of exposure to pesticides by farmers and information on the consequences of the extensive use of these products in the region is scarce. The aim of this study was to evaluate data on human poisoning by pesticides in the Vale do Itajaí health macro-region in Santa Catarina from 2014 to 2018.

METHOD

This is a cross-sectional, descriptive study using secondary data on cases of pesticide poisoning recorded between 2014 and 2018 in the Vale do Itajaí health macro-region in the state of Santa Catarina, Brazil.

The notifications were obtained from the national database of the Notifiable Diseases Information System (SINAN) using the Tabnet tool, free *software* developed by DATASUS, by accessing the DIVE (SC) website. As it is linked to the Santa Catarina State Health Department (SES/SC), the Tabnet - DIVE (SC) system provides up-to-date data, available in a database generated by combining the information contained in the specific notification and investigation forms for the disease.

Data related to the occurrence of exogenous poisoning caused by pesticides can be recorded in cases of outpatient and inpatient clinical care, hospital admissions and deaths. For this reason, several SIS work to identify the epidemiological profile of cases of exogenous pesticide poisoning, such as Sinan, the Santa Catarina Toxicological Information and Assistance Center (CIATox/SC), the Mortality Information System (SIM), and the Hospital Information System (SIH).

The notifications related to the CIATox/SC database are not freely accessible and were requested from the service coordinator. This service is the only one that collects data on symptoms during the service, which is why the information was taken from this database. The CIATox/SC records come from telephone calls, via the 0800 free phoning service, for acute poisonings with signs and symptoms present. In the Sinan records, the case is notified directly by the professional during or after the service using the exogenous intoxication form. The data used was obtained without identifying the patient, from secondary databases, which is why the work was not submitted

to the Research Ethics Committee. Both databases used data from the period between January 1st, 2014, and December 31, 2018. The databases were consulted between December 2019 and June 2020.

RESULTS AND DISCUSSION

For the Itajaí Valley health macro-region, a total of 594 cases of exogenous pesticide poisoning were recorded on SINAN during the study period and 640 cases on the CIATox/SC database (Table 1). The year in which the most cases were reported to CIATox/SC was 2017, with 150 occurrences. On Sinan, 2018 had the highest number of total occurrences, with 167 cases recorded. The heterogeneity of the total number of cases recorded in the two systems demonstrates the incompleteness and inconsistencies in the information. This is due to the fact that, in some cases, the health professional sees the patient but fails to report the case due to faulty diagnosis, i.e. if the patient has symptoms and the health professional does not characterize the case as exogenous intoxication.

Regarding the underreporting of pesticide poisoning, it is estimated that for every event, there are another 50 unreported[13,14]. Another cause that can lead to underreporting is the lack of demand for health services (hospital or basic health unit, emergency call via 0800). Therefore, the data on morbidity and mortality from pesticides in the country does not reflect the epidemiological reality, as it is estimated that this is an underreported condition[13,14]. The results found by the general distribution of frequencies by group of variables are shown in Table 1.

With regard to the characteristics of poisoning during the period and in the study region, the majority of records for both systems were male. These results agree with information previously reported in studies carried out in Brazil[15,16,17]. Despite the fact that farming is a family cycle in these small farming communities (a characteristic present in Santa Catarina), in which all members participate, the data shows that there is a predominance of men working in agriculture. In contrast to this study, Albuquerque et al.[18] described a predominance of females in pesticide poisonings in the state of Pernambuco. Silva and Costa[19], who looked at the total number of exogenous poisonings in the state of Santa Catarina (not just those caused by pesticides), also concluded that females were predominant.

The population most affected by poisoning associated with pesticide use was the 20-49 age group, which represents the economically active population. Similar results were obtained by Malaspina et al.[17] and Albuquerque et al.[18], which could be related to the fact that this age group is characterized as the average age of workers in the field[20].

The data on schooling shows a high number of ignored/blank cases, which accounted for 79.5% at CIATox/SC. The large number of cases in this category may be due to the fact that there are flaws in the way they are filled in, since the situation is recorded by telephone and is often not noted by the employee who opens the form, on repeated occasions because they consider it to be of lesser importance. However, the highest percentage recorded by SINAN (46.3% of reported cases) refers to individuals with low levels of education, with only primary schooling. According to Bohner et al.[21] and Tofolo et al.[22], low schooling can increase insecurity in the workplace, as it makes

Table 1. Morbidity profile according to characteristics of exogenous poisoning cases for the Itajaí Valley health macro-region in Santa Catarina between 2014 and 2018.

Features	Sinan		CIATox/SC	
	n°	%	n°	%
Pesticide poisoning (total)	594	100,0	640	100,0
2014	120	20,2	113	17,7
2015	80	13,5	129	20,1
2016	87	14,6	133	20,8
2017	140	23,6	150	23,4
2018	167	28,1	115	18,0
Sex				
Female	231	38,9	204	31,9
Male	363	61,1	436	68,1
Age group				
< 10 years	35	5,8	67	10,4
10-19 years	90	15,2	44	6,9
20-49 years	356	59,9	361	56,4
50-79 years	109	18,4	156	24,4
> 80 years	4	0,7	8	1,3
Ignored/blank	-	-	4	0,6
Education				
Illiterate	5	0,9	4	0,6
Elementary school	275	46,3	56	8,8
High school	151	25,4	56	8,8
Higher education	18	3,0	15	2,3
Ignored/blank	145	24,4	509	79,5
Occupation				
Occupation in agriculture	-	-	143	22,3
Student	-	-	19	3,0
Housewife	-	-	25	3,9
Retired	34	5,7	18	2,8
Other occupations	508	85,5	350	54,7
Ignored/blank	52	8,8	85	13,3

Source: Sinan and CIATox/SC, 2020.
(-): Data not recorded in the information system; SINAN: Notifiable Diseases Information System; CIATox/SC: Santa Catarina Toxicological Information and Assistance Center/2020.

it difficult to access important information, such as reading the labels of toxic products.

With regard to occupation, CIATox/SC records showed that the majority of people who were poisoned worked in agriculture (22.3%), in agreement with the study by Albuquerque et al.[18]. Despite this, the largest number of records (350) corresponded to the "other occupations" category, which is due to the grouping of variables. The SINAN database does not record occupation, only the situation in the labor market, i.e., whether there are situations of unemployment, retirement or whether the employee is registered. For this reason, it was necessary to group the variables for greater organization, but the analysis was hampered since an essential field on the SINAN notification form was not filled in.

Considering the information from Sinan, the municipalities with the highest number of poisoning notifications in the health macro-region analyzed were: Rio do Campo, Blumenau, Ibirama, Rio do Sul, Salete, Presidente Getúlio, Brusque, and Indaial. In CIATox, the municipalities of Vidal Ramos, Trombudo Central, Timbó, Taió, Santa Terezinha, Salete, Rio dos Cedros, Rio do Sul, and Rio do Oeste stand out. This reinforces the fragility of the information which, despite using a registration form similar to the one used for notification of exogenous intoxication, has a different basis for entering the data, with a different total of cases between the two bases. This divergence indicates that the data does not migrate from CIATox/SC to SINAN, an action that the municipality that activated the 0800 service should do at the same time as the notification.

Analyzing the origin of the notifications, it is clear that there is a divergence of data between the two databases in relation to the notifying municipality. In CIATox/SC, which focuses on higher-risk cases (emergency via 0800), the municipality of Rio do Campo has only 15 records. However, on Sinan, this municipality was responsible for 184 (30.9%) notifications. In contrast, the municipality of Vidal Ramos was responsible for 135 (22.1%) notifications on CIATox/SC, compared to just three on Sinan. This shows that small, agriculturally-based municipalities such as Vidal Ramos (6,329 inhabitants) and Rio do Campo (5,902 inhabitants) need more attention from the municipal and state agricultural and health sectors. After all, the information gathered points to an excessive number of poisonings caused by pesticides, indicating a lack of: control over the use of these agents and/or a situation of vulnerability; the use of personal protective equipment (PPE); and knowledge on the part of farmers about the rules and precautions needed when handling chemical products[16,21].

In terms of the morbidity profile (Table 2), according to the characteristics of the poisoning, there were significant differences between the two systems. In Sinan, the agents responsible for the largest number of poisonings were agricultural pesticides (12.0%), followed by domestic pesticides (3.1%), rodenticides (2.5%) and veterinary products (0.4%). In terms of the circumstance of pesticide use, 86.0% of poisoning cases in Sinan were accidental and the highest proportion (38.4%) of cases in CIATox/SC were suicide attempts. With regard to the type of exposure and the place of exposure, there is agreement between the data from the two systems, with the majority of poisonings occurring through acute-single exposure and in the home. In terms of type, acute (single) exposure accounted for 74.6% and 88.1% of cases, for Sinan and CIATOx/SC, respectively. Regarding the place of exposure, the majority of poisonings occurred in the home (64.0 and 70.3%, according to Sinan and CIATOx/SC, respectively), a reality that was already observed in the work by Pires et al.[15]. Regarding the circumstances in which pesticide poisonings occur, according to Faria et al.[23], the relative proportion of cases of attempted suicide tends to be lower than occupational cases.

Cases of exposure in the workplace account for 30.3% and 20.6%, respectively, between the information systems. This percentage is lower than expected among those notified, given that these workers are more vulnerable when dealing directly with pesticides. The study by Magalhães and Caldas[24] described cases of occupational exposure to chemical products in the Federal District between 2009 and 2013, in which 219 (57.3%) workers suffered poisoning from exposure to the products.

It was observed that for the route of exposure variable, the data collected on SINAN did not generate information, due to the high percentage of ignored or blank notifications (64.6%) (Table 2). The absence of information when filling in the form can hinder a more in-depth analysis of the situation. CIATox/SC found that 50.6% of reported poisonings occurred via the digestive route. This is associated with the fact that the relative proportion of suicide cases generated more records in this system and that it is more reliable because the case form was filled in during the 0800 telephone call. With regard to the routes of administration, pesticides cause very similar warning signs and symptoms, which makes it difficult to recognize the causative agent of the poisoning (by clinical manifestations alone). In addition, the combined use of several products is common, which makes it difficult to manage exogenous poisoning[16].

In view of this, the signs and symptoms recorded at CIATox/SC were identified and classified according to the systems of the human body (Figure 1).

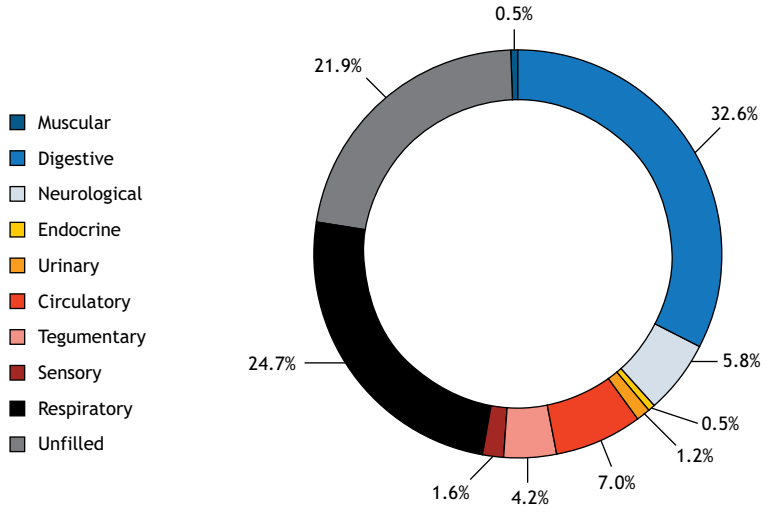
The most frequently identified signs and symptoms are related to the digestive system (32.6%), respiratory system (24.7%), neurological system (5.8%), integumentary system (4.2%), sensory system (1.6%), urinary system (1.2%), endocrine system (0.5%) and muscular system (0.5%). As for illnesses associated with agricultural work, men are the most victimized by suicide, while women are the most affected by neurological disorders[20]. For the cases most strongly related to the respiratory system, the lack of use of PPE is noteworthy, predisposing to accidents when handling pesticides[20].

Out of a total of 640 cases of acute poisoning, 246 (38.4%) were from suicide attempts. This result is related to the percentage of signs and symptoms identified for the digestive system, in which,

Table 2. Morbidity profile according to intoxication-related characteristics for the Vale do Itajaí health macro-region in Santa Catarina, from 2014 to 2018.

Features	Sinan (total number = 594)		CIATox/SC (total number = 640)	
	n°	%	n°	%
Circumstance*				
Regular use	17	2,9	-	-
Accidental	511	86,0	220	34,4
Environmental	58	9,8	-	-
Therapeutic use	6	1,0	-	-
Occupational	-	-	153	23,9
Suicide attempt	-	-	246	38,4
Other	2	0,3	21	3,3
Type of exhibition				
Acute-single	443	74,6	564	88,1
Acute-repeated	135	22,7	31	4,9
Chronicle	4	0,7	9	1,4
Acute over chronic	2	0,3	15	2,3
Ignored/blank	10	1,7	21	3,3
Exhibition venue				
Residence	380	64,0	450	70,3
Work environment	180	30,3	132	20,6
Work commute	1	0,2	-	-
External environment	16	2,6	37	5,8
Other	11	1,9	2	0,3
Ignored/blank	6	1,0	19	3,0
Exposure route				
Digestive	7	1,2	324	50,6
Cutaneous	111	18,7	108	16,8
Respiratory	82	13,8	192	30,0
Ocular	8	1,4	12	1,9
Parenteral	2	0,3	2	0,3
Other	0	0,0	1	0,2
Ignored/blank	384	64,6	1	0,2
Outcome of poisoning cases				
Ignored/blank	18	3,0	5	0,8
Cure without sequelae	550	92,6	611	95,5
Healing with sequelae	10	1,7	7,0	1,0
Death	14	2,4	16	2,5
Loss of follow-up	2	0,3	1	0,2
Hospitalization				
Yes	300	50,5	137	21,4
No	292	49,2	490	76,6
Ignored/blank	2	0,3	13	2,0

Source: Sinan and CIATox/SC, 2020.
(-): Data not recorded in the information system; *The circumstance variable showed a lower total than expected for 2015 and 2016; SINAN: Notifiable Diseases Information System; CIATox/SC: Santa Catarina Toxicological Information and Assistance Center, 2020.



Source: Prepared by the authors, 2022.

Figure 1. Signs and symptoms identified and classified according to human body systems at CIATox/SC.

through ingestion, the individual immediately introduces a high concentration of the target compound into the body and may be killed. According to Queiroz et al.[25], easy access to pesticides in the home environment is associated with a higher number of cases of attempted suicide.

Another place of exposure is the external environment, which accounted for 2.7% and 5.8% of the records in Sinan and CIATox/SC, respectively. It is important to note that pesticides become a source of contamination when they are released into the environment or through chemical agent residues in empty containers which, under the action of rain, can contaminate the soil, surface water and groundwater[26].

According to Table 2, the majority of cases resulted in a cure without sequelae for 92.6% of the records in Sinan and 95.5% in CIATox/SC. The relative frequency of cures with sequelae was 1.7% on SINAN and 1.1% on CIATox/SC. These figures point to chronic effects that can be reported. With regard to death, the absolute values from Sinan and SIM correspond, but CIATox/SC had a higher value. Thus, the databases have many inconsistencies, as the SIM should account for all deaths due to the recording of this information on the death certificate.

For hospital admissions, 50.5% of cases were identified on Sinan and 21.4% on CIATox/SC, which may indicate the seriousness of acute poisonings. However, the inconsistencies with SIH are even greater, hindering the analysis.

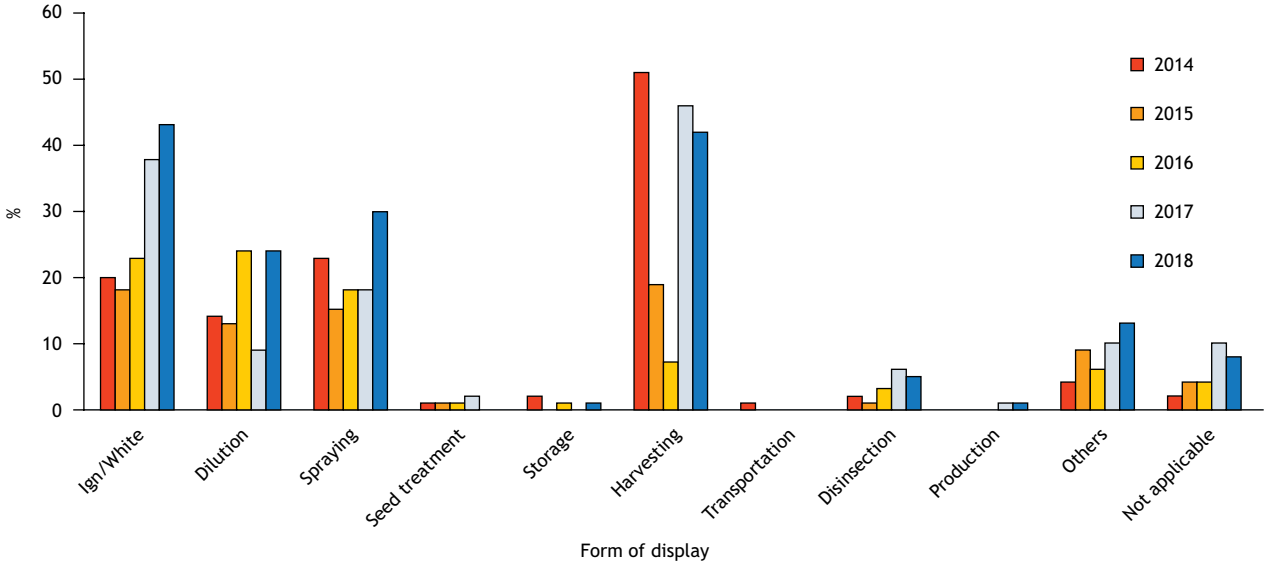
According to Rebelo et al.[27], the ease with which pesticides can be obtained and their variability on the market contribute to the high incidence of poisoning. Despite the fact that pesticides are bought with an agronomic prescription, prescribed by professionals in the field, there is often a lack of instruction for users on how to handle the products safely. This highlights the importance of using PPE to minimize the risk and reduce the occurrence of poisoning and other accidents at work. According to labor laws, this equipment must be provided by the employer[28].

Considering the activities carried out at the time of poisoning, according to SINAN data, it can be concluded that the greatest exposure to pesticides occurs at the harvest stage (27.7%), followed by spraying (17.5%) and diluting the product (14.4%), but the data is still incomplete (28.6%), ignored/blank or not applicable (Figure 2).

According to CIATox/SC records, the main pesticides involved in poisonings (in ten or more cases) and the consequences for human health were described (Chart). This analysis was not applied to Sinan due to the lack of product identification (common name) in the database.

With the exception of paraquat, the other three herbicides highlighted for being responsible for ten or more cases of poisoning in the study region are permitted in Brazil. This product is not permitted in the European Union[34,] and its use is restricted in the United States of America (USA)[35]. For the herbicides 2,4-D, diurom and glyphosate, the permissions are discordant since these products are permitted in the European Union[34,] while in the USA they are under a registration review process to ensure that they meet current scientific and regulatory standards[35].

The herbicide glyphosate was the most cited pesticide (194 cases) in the records. In Brazil, 217,592.24 tons of glyphosate and its salts were sold in 2019[7]. Also noteworthy is the fact that this product has been listed among the carcinogenic pesticides for humans, due to the mechanisms of genotoxicity and oxidative stress evidenced, and the limited evidence for non-Hodgkin's lymphomas (NHL), by a subdivision of the World Health Organization (WHO) made up of experts in the field of toxicology[30]. However, organizations such as the European Food Safety Authority (EFSA) and the Joint Food and



Source: Prepared by the authors, 2022.

Figure 2 Forms of exposure in cases of exogenous poisoning for the Itajaí Valley health macro-region in Santa Catarina between 2014 and 2018.

Chart. Pesticides involved in the highest number of poisonings recorded by CIATox/SC and the respective effects on human health for the Itajaí Valley health macro-region in Santa Catarina, from 2014 to 2018.

Class		Herbicide				Insecticide					
Common name		2,4-D	Diurom	Glyphosate	Paraquat	Carbofuran	*Chumbinho*	Cypermethrin	Deltamethrin	Fipronil	Imidacloprid
Toxicological classification (a)		Class I	Class III	Class IV	Being reclassified since 2018	Canceled rating	Clandestine/ unregistered product	Class II	Specific to each product	Class II	Class III
No. of registered cases		18	12	194	31	11	16	16	54	20	11
Carcinogenic potential	IARC (b)	Possibly carcinogenic	NC	Probably carcinogenic	NC	NC	NC	NC	NC	NC	NC
	EPA (c)	NC	NC	Probably not carcinogenic	NC	NC	NC	NC	NC	NC	NC

Source: Prepared by the authors, 2022.
(a) Brazilian National Health Surveillance Agency (Anvisa)[29]; (b) *International Agency for Research on Cancer* (IARC)[5,30]; (c) *United States Environmental Protection Agency* (EPA)[30,31,32,33]; NC: nothing reported.

Agriculture Organization (FAO) at the WHO Meeting on Pesticide Residues (JMPR) determined that glyphosate was unlikely to pose a carcinogenic risk to humans[36,37]. In 2017, the US Environmental Protection Agency (EPA) also classified glyphosate as probably not carcinogenic to humans[32]. In 2020, this agency issued a provisional decision for registration review in which it continues to state that there is no risk of concern for human health when glyphosate is used according to its current label and states that this product is unlikely to be a human carcinogen[38]. With regard to the association between exposure to glyphosate and NHL, the agency evaluated the recent studies by Zhang et al.[39] and Leon et al.[40] and stated that neither study had any impact on the risk assessment of glyphosate and, therefore, on the agency's position.

The herbicide 2,4-D, which is widely used around the world and is part of the phenoxyacetic chemical group and toxicological class I, had 18 occurrences. In 2019, 52,426.92 tons of this product were sold, which ranks second among the best-selling pesticides[7]. The *International Agency for Research on Cancer* (IARC)[5] classifies this agent as possibly carcinogenic to humans and, along with glyphosate, it has been one of the main targets of research into the etiology of different types of cancer, such as NHL, which may stimulate future research and support the regulation of more restrictive measures that take into account the reality of exposure to pesticides[41].

The herbicide diurom from the urea chemical group, toxicological class III, according to the Brazilian National Health Surveillance Agency (Anvisa), is widely accepted in different countries and had 12 occurrences in the period analyzed. Despite the fact that few acute effects and no chronic effects have been described by reference institutions in Brazil, the USA and Europe, the "List of active ingredients widely consumed in Brazil

with Anvisa authorization" drawn up by the Brazilian National Cancer Institute (INCA)[3] contains a classification based on the EPA, giving diurom a relationship with cancer (neoplasia, without defined location).

The herbicide paraquat, which belongs to the bipyridyl chemical group, had 31 occurrences. It was banned in Brazil as of September 22, 2020, as a result of a toxicological reassessment carried out by Anvisa, according to Collegiate Board Resolution (RDC) No. 177, of September 21, 2017[42]. The active ingredient has already been banned in the European Union and has a restricted use classification (only under the direct supervision of a certified applicator) in the USA.

In relation to products used as insecticides, deltamethrin was recorded in 54 occurrences. As a result of Anvisa's toxicological re-evaluation of active ingredients and in accordance with RDC No. 294 of July 29, 2019, the toxicological classification of this agent is specific to each product. It is allowed in other countries and, with regard to carcinogenic potential, no studies were found by the reference institutions[29]. The clinical manifestations of acute health effects are the same as for cypermethrin, another active ingredient in the pyrethroid chemical group, which in turn had 16 registrations.

The insecticide fipronil, with 20 occurrences, has a toxicological classification of II by Anvisa. It is permitted in the USA, but has been banned in the European Union. With regard to carcinogenic potential, no reports were found from reference institutions, and for acute effects on humans, information was very limited. However, this product has neurotoxic properties, but the literature in this area only deals with the effects on animals[43,44].

With regard to the carbamate group, despite being banned in Brazil, according to RDC No. 185 of October 18, 2017[45], carbofuran was responsible for 16 occurrences in the 2014-2018 period in the study region. This agent has also been banned in the European Union and the USA and has restrictions on its use.

The insecticide *chumbinho*, which can belong to both the carbamate and organophosphate chemical groups, with 16 recorded occurrences, is a clandestine product that is irregularly used as a rodenticide. It is not registered with Anvisa or any other government body. The main products used in the formulations are: aldicarb (banned in Brazil), carbofuran (carbamate), terbufos (organophosphate), phorate (organophosphate), monocrotophos (organophosphate), and methomyl (carbamate).

The insecticide imidacloprid, with 11 occurrences, from the chemical group of neonecotinoids, has a toxicological classification of III by ANVISA and is widely permitted in different countries. Pesticides from this chemical group have received attention due to their adverse effects on organisms and ecosystems, including potential risks to the health of applicators[46].

Restrictions on these insecticides are stricter in the US, with fipronil being the only product allowed and the others falling under non-carcinogenic (NC), restricted or registration review.

Although the signs and symptoms shown in Figure 1 are more commonly identified in acute poisoning, with heavy and prolonged use they can cause chronic poisoning with the risk of developing serious illnesses and cancer. Some of these products have carcinogenic potential according to the toxicological classifications defined by Anvisa, the EPA and the IARC (Chart 1).

In general, the signs and symptoms reported in acute cases are common to most pesticides, which makes it difficult to identify the causative agent. Usually, mild cases are characterized by nausea, vomiting, headache, dizziness, skin and mucous membrane irritation[3]. Moderate to severe cases show signs related to the level of consciousness with disorientation, hyperexcitability, paresthesia, convulsions, difficulty breathing, muscle contractures, hemorrhage and, in severe cases, death if the affected person is not taken to a health service. Chronic effects occur from prolonged exposure to the chemical[14] and can last for weeks, months, years or even generations after the contact period. The consequences are neurological, hematological, respiratory, cardiovascular and cancer problems. In addition, these intoxications can lead to genetic problems, such as congenital malformations[3] in fetuses exposed during pregnancy.

CONCLUSIONS

The data revealed incomplete and inconsistent information, a lack of data integration between information systems and a high level of underreporting. It is necessary to strengthen the HIS in order to generate information to support health policies for the population groups involved, and different public and occupational health actions are needed to reduce the risks. The health sector needs to continue investing in training for health professionals in order to improve the way they fill in the data in these systems. In this sense, surveillance and inspection actions are necessary in the municipalities from the point of view of organizing the work process, since the data revealed a high risk of exposure. It is also important to encourage preventive actions, as cases of intentional poisoning (suicide attempts) are frequent.

With regard to the harmful effects of handling pesticides on human health, it has been shown that they predominantly affect the digestive, respiratory and neurological systems of the human body.

The proper handling of chemical waste is an important environmental sanitation issue, as is the need to implement comprehensive training for users in order to increase protection and damage control measures and the implementation of reverse logistics in relation to product packaging. In addition, more resources could be directed not only towards reducing the toxicity of the products, but also towards finding agro-ecological production alternatives. Given the extreme vulnerability of the population of the Vale do Itajaí health macro-region, and of the Brazilian population as a whole, to diseases and illnesses caused by pesticides, regulatory guidelines and more restrictive legislation are urgently needed.

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Authors' Contribution

Bet F - Acquisition, analysis, data interpretation, and writing of the work. Ortiga AMB - Conception, planning (study design), analysis, data interpretation, and writing of the work. Serbent MP - Conception of the study and writing of the work. López SR - Analysis, data interpretation, and writing of the work. Schütz GE - Data interpretation and writing of the work. All the authors have approved the final version of the work.

Conflict of Interest

The authors inform that there is no potential conflict of interest with peers and institutions, political or financial, in this study.