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Environmental and occupational exposure to pesticides according to sociodemographic factors that affect cancer patients in Mato Grosso, Brazil

Exposição ambiental e ocupacional a agrotóxicos segundo fatores sociodemográficos em pacientes com câncer em Mato Grosso, Brasil

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ABSTRACT The goal of this study was to estimate the prevalence of environmental and occupational exposure to pesticides according to sociodemographic factors among cancer patients. It is a cross-sectional study with cancer patients in the state of Mato Grosso. The prevalence of environmental and occupational exposure to pesticides was calculated as to the variables gender, age, macro-region, and education. Pesticide use per agricultural crops in liters was estimated, and a thematic map was constructed following the macro-region of the agricultural economy. Of the 998 patients, most were female (54.9%), aged between 50 and 69 years old (50.1%), had less than eight years of schooling (60.7%), and resided in the South-Central macro-region (55.4%). Regarding environmental and occupational exposure, 53.1% of the patients live or have lived in a municipality with agricultural plantations; 17.4% lived near crops; 43.4% worked in agriculture, livestock, or extractivism; and 22.9% worked or work directly with pesticides. Environmental and occupational exposure was higher in males, in the older age groups, schooling from 0 to 4 years, and in the macro-regions with higher pesticide use. The study concluded that environmental and occupational exposure among cancer patients is associated to sociodemographic characteristics and macro-regions of the agricultural economy.

KEYWORDS Pesticides. Neoplasms. Occupational exposure. Environmental exposure.

RESUMO *O objetivo deste estudo foi estimar a prevalência de exposição ambiental e ocupacional aos agrotóxicos conforme fatores sociodemográficos entre pacientes com câncer. Trata-se de um estudo observacional de delineamento transversal com pacientes com câncer do estado de Mato Grosso. Foi calculada a prevalência de exposição ambiental e ocupacional aos agrotóxicos conforme as variáveis sexo, faixa etária, região e escolaridade. Foram estimados o uso de agrotóxicos por culturas agrícolas em litros e construído mapa temático segundo a macrorregião de economia agropecuária. Dos 998 pacientes, a maioria era do sexo feminino (54,9%), tinha entre 50 e 69 anos (50,1%), possuía menos de oito anos de escolaridade (60,7%) e residiam na macrorregião Centro-Sul (55,4%). Em relação à exposição ambiental e ocupacional, 53,1% dos pacientes moram ou moraram em município com plantação agrícola, 17,4% residiam próximo à lavoura, 43,4% trabalharam na agricultura, pecuária ou extrativismo e 22,9% trabalharam ou trabalham diretamente com agrotóxicos. A exposição ambiental e ocupacional foi maior no sexo masculino, nas faixas etárias mais elevadas, escolaridade de 0 a 4 anos e nas macrorregiões de maior uso de agrotóxicos. Conclui-se que a exposição ambiental e ocupacional entre pacientes com câncer se associou as características sociodemográficas e macrorregiões de economia agropecuária.*

PALAVRAS-CHAVE *Agrotóxicos. Neoplasias. Exposição ocupacional. Exposição ambiental.*

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Introduction

Brazil is the largest pesticide consumer in the world, and the State of Mato Grosso is the largest consumer in Brazil[1,2]. Such consumption is directly related to the agribusiness production process, which involves the large-scale use of pesticides in aerial, tractor, or manual spraying[2,3].

As to Pignati et al.[2] and Oliveira et al.[4], the contamination of the air, rainwater, rivers, springs, and soil results from the increase in pesticide drift and residues. This widespread chemical contamination scenario exposes human health to risks, and environmental health is harmed due to large-scale releases of new pesticides in Brazil in recent years. The underreporting of pesticide poisonings in Brazil and in the state of Mato Grosso[5,6] is also an issue. As to Bombardi[1], it is also possible to infer the presence of a large number of underreported pesticide poisoning episodes as to observe the ratio between the low number of reported intoxication and the pesticide sales volume.

Pignati et al.[2,3,5], Bombardi[1], Curvo et al.[7], Neves and Pignati[8], Costa et al.[9], Lara et al.[10], Soares et al.[11], Mostafalou and Abdollahi.[12], Guyton et al.[13], IARC[14], and Séralini et al.[15] have shown the most relevant acute and chronic poisoning effects on the health of workers, populations, and the environment due to the use of pesticides, fertilizers, and transgenic seeds, among them are: adult and child cancers, endocrine disorders, neurological and cognitive disorders, fetal malformation, mental illness, suicide, miscarriage, evolving in many cases to death or irreversible damage to the health of individuals. Nogueira et al.[16], Pluth et al.[17], Lerro et al.[18] and Moura[19] reveal the increased risk of breast, prostate, lung, bladder, and lymphoma cancers due to environmental and occupational exposure to pesticides.

Given the above – contributing factors to the processes of surveillance, notification, and expansion of information on the effects of acute and chronic poisoning by pesticides in Brazil –, this article aims to estimate the prevalence of environmental and occupational exposure to pesticides as per sociodemographic factors among cancer patients in Mato Grosso.

Material and methods

This study is part of the research project 'Cancer and its associated factors: analysis of population-based and hospital registry in Cuiabá-MT', developed by the Institute of Collective Health-UFMT, by means of NEAST – Center for Environmental, Health and Labor Studies and VIGICAN Project in partnership with the State Department of Health (SES-MT) and funded by the Ministry of Labor (MPT) 23rd Region.

This is an observational, cross-sectional study of cancer patients aged 18 years or older treated in oncology referral services in the state. The cancer care network in the state has five services qualified as UNACON, being three in the capital and two in the state[20] countryside. The institutions select for study[20] comprised the Júlio Muller University Hospital (HUJM), the teaching hospital of the Federal University of Mato Grosso (UFMT), and the Mato Grosso Cancer Hospital (HCan) – a High Complexity Oncology Care Unit (UNACON), reference in cancer care in the State, and responsible for about 70% of the total oncology care in Mato Grosso.

A convenience sample of patients aged 18 years or older under treatment for cancer seen at the outpatient clinics of HCan and HUJM, was selected during the period from November 2019 to March 2020. All those who were waiting for care on the day of data collection were invited to participate in the survey.

The maximum proportion ($p = 0.50$), a tolerable error (2.5%), and a confidence level (95%) were taken into account for the sample calculation of cancer patients interviewed in the two selected hospital units, the number of admissions from the hospital cancer registry (2015), of patients aged 20 years or older

units. The estimated sample size was 1,050 patients, considering 10% of losses. A total of 1,122 patients over 18 years of age were invited to participate in the survey, of whom six refused, 21 could not locate their records, and 83 had an unconfirmed cancer diagnosis. The final sample was made up of 1,012 patients, 968 of whom were treating at the HCan outpatient clinic and 44 at the HUJM. Of this total, 14 (1.4%) were excluded for living in other states, why 998 patients remained in the sample analyzed.

Data collection was performed by trained interviewers by means of face-to-face interviews in a place reserved for this purpose in the outpatient clinics, with the aid of an electronic data collector (Open Data Kit – ODK) installed on an Android tablet. We used a structured questionnaire divided into twelve blocks previously tested in the pilot study.

Environmental exposure to pesticides was measured by two questions: 'Are there agricultural crops in the municipality you live or have lived in last ten years? (soybean, corn, cotton, and sugarcane)?' (yes; no); and 'Is your residence close to any crops?' (yes; no). Occupational exposure to pesticides was measured by two questions: 'Has the respondent worked in agriculture, livestock or extractivism?' (yes; no); and 'Have you worked or do you work with pesticides: insecticides, fungicides, herbicides, acaricide?' (yes; no). The distance from the residence to the farm was also evaluated: less than 10 meters, 10 to 50 meters, 50 to 90 meters, 90 to 300 meters, 300 to 1,000 meters, and more than 1,000 meters.

The independent variables were gender: male and female; age group: 18 to 39; 40 to 49; 50 to 59; 60 to 69; 70 years or older; education: 0 to 4; 5 to 8; 9 to 11; 12 years or more; and municipality of residence following the macro-regions of agricultural economy: South Central; Middle North; Northeast; Northwest; North; West, and Southeast[21].

To estimate the use of pesticides by municipalities and agricultural crops, we collected information on the planted area in hectares as for the municipal agricultural production of IBGE/SIDRA and the Pignati et al.[22] method, which estimates the consumption of pesticides per liter according to permanent and temporary cultures and municipalities. After the calculation, carried out by multiplying the planted area per crop and the estimated pesticide use per liter, we summed up the consumption per year and per municipality and calculated the mean of the period for the seven macro-regions of the Agricultural Economics Institute (IMEA)[21].

Descriptive analysis was performed using absolute and relative frequencies and the calculation of the mean and Standard Deviation (SD). We estimated the prevalence and respective confidence intervals (95%CI) of environmental and occupational pesticide exposure according to gender, age group, education, and agricultural economy macro-regions. Pearson's chi-square test was applied to investigate the factors associated with exposure to pesticides. The analyses were performed in STATA software version 16.0 and R version 4.1.0. This study adopted a 5% significance level. The thematic map was constructed by using ESRII's ArcGis 10.5 geographic software and the digital mesh of municipalities in Mato Grosso[23].

The project and this study were approved by the Ethics Committee of the Júlio Muller University Hospital (CEP-HUJM) CAAE: 98150718.1.0000.8124, opinion number 3.048.183 dated 11/20/2018, and by the CEP SES-MT CAAE: 98150718.1.3003.5164, opinion number 3.263.744 dated 12/04/2019. They also received a public funding provided by the technical cooperation agreement No. 08/2019, signed between the Public Ministry of Labor of Mato Grosso, 23nd region, and the Institute of Collective Health of UFMT.

Results

The mean age among the 998 patients was 56.7 years old (SD: 14.3); the majority of females

(54.9%); age group between 50 and 69 years of age (50.1%), less than eight years of schooling (60.7%); residing in the Central-South macro-region (55.4%), where the capital Cuiabá is located (28.2%); it is followed by the Southeast macro-region (14.2%), and, in a smaller proportion, by the Northeast macro-region (3.5%; *table 1*).

Table 1. Sociodemographic characteristics of cancer patients treated at referral hospitals, Mato Grosso, 2019 to 2020

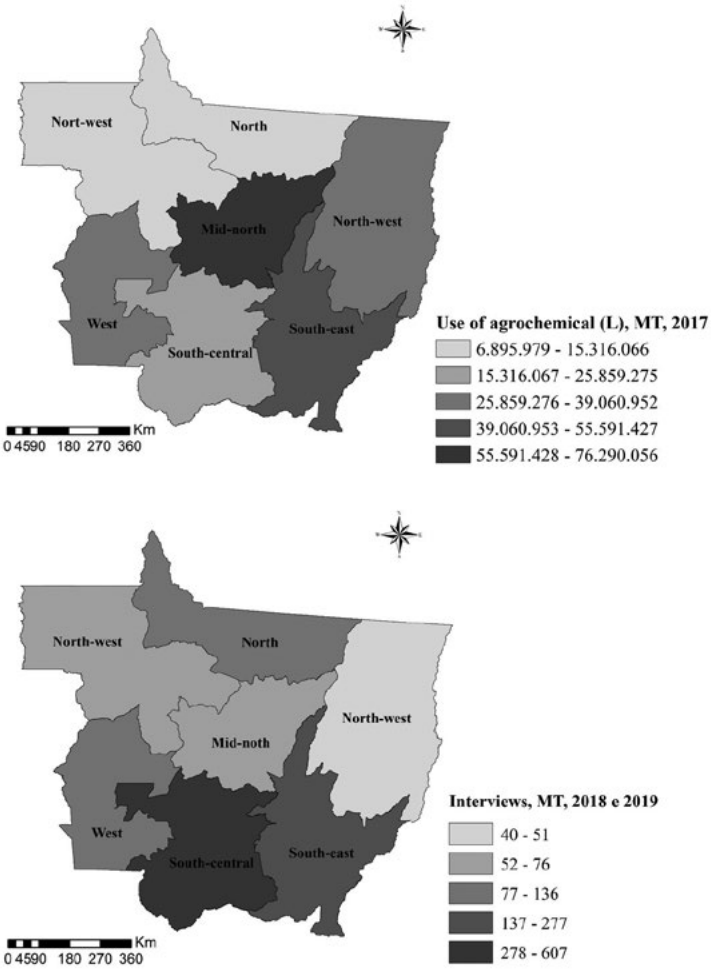
Variables	%	CI95%
Gender		
Male	54.9	51.7 – 57.9
Female	45.1	42.1 – 48.2
Age Group (years)		
18-39	13.3	10.4 – 17.0
40-49	16.8	13.4 – 20.7
50-59	24.5	20.5 – 28.9
60-69	25.6	21.6 – 30.0
70 or more	19.9	16.3 – 24.0
Education (years)		
0 to 4	49.3	44.5 – 54.2
4 to 8	11.4	8.7 – 14.9
9 to 12	27.0	22.9 – 31.5
12 or more	12.0	9.2 – 15.6
Macro-region		
Mid-North	5.6	3.5 – 8.8
Northeast	3.5	1.9 – 6.2
Northwest	5.6	3.5 – 8.8
North	8.1	5.5 – 11.7
West	7.5	5.1 – 11.0
Southeast	14.2	10.8 – 18.6
South Center	55.4	49.7 – 60.9

Source: Own elaboration.

CI95%: 95% confidence interval.

Regarding the spatial distribution of pesticide use according to the macro-region of the agricultural economy, we observed higher consumption in the mid-north macro-region, followed by the Southeast and West macro-regions (*figure 1-A*). Most of the patients surveyed reside in the South-Central macro-region, followed by the Southeast, West, and North macro-regions (*figure 1-B*).

Figure 1 . Spatial distribution of the quantitative use of pesticides and interviews with cancer patients in Mato Grosso, 2017 e 2019



Source: IBGE/SIDRA[24]

Regarding environmental and occupational exposure to pesticides, 53.1% live or have lived in a municipality with agricultural crops; 17.4% lived near a plantation; 43.4% have worked in agriculture, livestock, or extractivism; and 22.9% have worked or work with pesticides (*tables 2 and 3*). Among those who reported living near crops, 39.0% resided more than 1,000 meters away, 22.6% from 300 to 1,000 meters, 26.3% from 50 to 300 meters, and 11.6% less than 50 meters away.

Table 2. Prevalence of environmental and occupational exposure to pesticides according to sociodemographic variables in patients. Mato Grosso, 2019-2020

	Lives or has lived in a municipality with agricultural crops		Lives near a farm	
Variables	**%**	**CI95%**	**%**	**CI95%**
Total	**53.1**	**50.0 – 56.2**	**17.4**	**15.1 – 19.8**
Gender				
Male	59.1	54.5 – 63.6*	20.4	16.9 – 24.4
Female	47.2	43.0 – 51.3	14.8	12.1 – 18.0
Age Group (years)				
18-39	48.1	39.7 – 56.6	19.5	13.6 – 27.1
40-49	47.3	39.8 – 54.9	18.0	12.8 – 24.5
50-59	59.4	53.1 – 65.4	18.4	14.0 – 23.8
60-69	51.4	45.2 – 57.4	14.9	11.0 – 19.8
70 or more	53.0	46.1 – 59.9	17.2	12.5 – 23.1
Education (years)				
0 to 4	60.2	55.7 – 64.4*	19.3	16.0 – 23.0*
4 to 8	50.0	40.9 – 59.1	21.0	14.5 – 29.5
9 to 12	45.7	39.8 – 51.7	16.0	12.1 – 20.9
12 or more	40.0	31.6 – 49.0	9.2	5.1 – 15.8
Region				
Mid-North	91.1	80.2 – 96.2*	32.1	21.2 – 45.3*
Northeast	88.6	73.2 – 95.6*	31.4	18.3 – 48.3*
Northwest	69.6	56.4 -80.2*	16.1	8.5 – 28.1
North	69.1	58.3 -78.2*	12.6	7.6 – 22.9
West	76.0	65.1 – 84.3*	34.7	24.8 – 46.1*
Southeast	74.6	66.8 – 81.1*	25.3	18.8 – 33.1*
South Center	33.3	29.5 -37.4	11.2	8.9 – 14.1

Source: Own elaboration.

% - prevalence; CI95%: 95% confidence interval. * p<0.05 – Chi-square test.

The highest prevalence of living or having lived in a municipality with an agricultural plantation was among males, with 0 to 4 years of schooling and who did not reside in the South-Central macro-region. Living close to crops was more frequent among those with 0 to 4 years of schooling, 4 to 8 years of schooling, and who resided in the Western, Mid-Northern, and Northeastern macro-regions. Working in agriculture, livestock, or extractivism and working or having worked directly with pesticides was more frequent among males, older age group, increasing dose-response effect, from 0 to 4 years of schooling, who did not reside in the South-Central macro-region (*tables 2 and 3*).

Table 3. Prevalence of environmental and occupational exposure to pesticides according to sociodemographic variables in patients. Mato Grosso, 2019-2020

	Worked in agriculture, livestock or extractivism		Worked or works directly with pesticides	
Variables	**%**	**CI95%**	**%**	**CI95%**
Total	**43.4**	**40.3 – 46.5**	**22.9**	**20.4 – 25.6**
Gender				
Male	60.0	55.4 – 64.4*	38.9	34.5 – 43.4*
Female	29.6	25.9 – 33.5	9.0	6.8 – 11.6
Age Group (years)				
18-39	9.78	5.7 – 16.1	9.0	5.2 – 15.2
40-49	26.3	20.2 – 33.5*	18.0	12.8 – 24.5
50-59	45.9	39.7 – 52.2*	23.4	18.4 – 29.1*
60-69	55.3	49.1 – 61.3*	24.3	19.4 – 29.9*
70 or more	61.6	54.6 – 68.1*	31.8	25.7 – 38.6*
Education (years)				
0 to 4	62.2	57.8 – 66.3*	31.5	27.5 – 35.7*
4 to 8	37.7	29.3 – 46.9*	21.9	15.2 – 30.4
9 to 12	22.3	17.7 – 27.7	11.1	7.9 – 15.5
12 or more	17.5	11.7 – 25.4	11.7	7.3 – 18.7
Region				
Mid-North	51.8	38.9 – 64.4*	30.4	19.8 – 43.5
Northeast	60.0	43.2 – 74.7*	34.3	19.7 – 43.5*
Northwest	55.4	42.2 – 67.8*	39.3	27.4 – 52.5*
North	59.2	48.3 – 69.4*	39.5	29.4 – 50.5*
West	54.7	43.3 – 65.5*	32.0	22.4 – 43.3*
Southeast	52.1	43.9 – 60.2*	19.0	13.3 – 26.3
South Center	34.1	30.2 – 38.1	16.3	13.4 – 19.6

Source: Own elaboration.

% - prevalence; CI95%: 95% confidence interval. * p<0.05 – Chi-square test.

Discussion

The estimated population of Mato Grosso in 2020 was 3,526,220 inhabitants. The State is the third largest in the country; a density of 3.9 inhabitants per km²; 141 municipalities distributed in seven macro-regions with an agricultural economy[23]; the largest population concentration is found in the capital, Cuiabá, with 618,124 inhabitants[24]. The State has the highest consumption of pesticides and deforestation in the country, annually using more than 13 million hectares for the cultivation of monocultures, and a pesticide use that exceeds 207 million per year, being the mid-north region responsible for 28% of this consumption[22].

This geo-economic scenario is marked by the contamination of waters, environmental matrices[4,25] and food[26]. An increase in childhood cancer[7] cases, acute poisoning by pesticides[10], work accidents related to agricultural and agro-industrial activities[27], mental disorders, and suicide attempts[8], among other issues related to exposure to pesticides, have also been identified. The timber industry

production and mineral exploration in the State also generate chemical contaminants in their industrial processes, such as wood dust, silica, and heavy metals, which are associated with the occurrence of cancer[28].

Most of the study population currently resides in the center-south macro-region (55.4%), where the state capital is located, and the agricultural production does not predominate. This data may reflect the migration of patients from the countryside to the capitals for cancer treatment due to the inexistence of these services, as shown by Freire et al.[29]. The specialized oncology care services in the State are distributed in five health macro-regions and are concentrated in the North-Central macro-region, where the capital is located[30,31]. So, it is necessary to consider the history of environmental and occupational exposure to pesticides and their connections with cancer[32], considering the migration of patients to large centers and capitals for cancer treatment[29].

The prevalence of environmental and occupational exposure to pesticides in cancer patients in the state of Mato Grosso was higher in males and increased with older age groups, except for the variable of living near farms, which showed no significant association with gender and age group. Regarding schooling, the highest prevalence was observed in the lower schooling levels (0 to 8 years).

When analyzing the prevalence of environmental exposure to pesticides by region of residence, this study found that 53.1% live or have lived in cities with agricultural plantations, and 17.4% live near a farm, residing in cities of the Mid-North, North, West, and Southeast regions. Pignat et al.[21] pointed out seven municipalities in Mato Grosso macro-regions among the ten with the highest consumption of pesticides in Brazil. They are distributed among the mid-north: Sorriso, Nova Mutum, Nova Uniratã; west: Sapezal, Campo Novo do Parecis; southeast: Campo Verde; and center-south: Diamantino,

The results of this study corroborate Pluth et al.[17], who shows an association between living near farming crops or in regions of intense agricultural production and an increased risk of developing cancers. Soares[33] showed an increase in cancer morbidity rates in municipalities of the mid-north macro-region of Mato Grosso, as well as in the West and North macro-regions, which, in this study, showed prevalence of environmental (76%) and occupational (69.1%) exposure to pesticides.

When analyzing the prevalence of occupational exposure to pesticides by labor history, this study identified 43.4% respondents working in agriculture, livestock, or extractivism, and 22.9% who have worked or currently work with pesticides. The data converge to the evidence of Damalas et al.[32], Weichenthal et al.[34], Nogueira et al.[16], Moura et al.[19], and Pignati et al.[2].

Damalas et al.[32] indicate that the presence of pesticides in the work environment puts workers' health at risk, which increases whenever directly handling pesticides occurs. In this article, the prevalence of exposure to pesticides among participants who work or have worked directly with pesticide handling was 22.9%.

Moura et al.[19] showed an association between occupational exposure to organophosphates and the development of hematological neoplasms. Studies have pointed to the active ingredients of 2,4-D, diazinone, glyphosate, malathion and the development of different types of cancers[16,18]. Despite the higher prevalence of those who reported having worked in agriculture, livestock, or extractivism compared to the prevalence of those who reported working or having worked directly with pesticides, the findings corroborate evidence of the association between developing cancer and the use of pesticides, when glyphosate, diuron, 2,4-D, acephate, atrazine, and malathion have been the most commonly used pesticides in Mato Grosso, as for Pignati et al.[22].

Regarding the gender variable, the findings of this study corroborate the evidence of Oesterlund et al.[35] that point to a lower risk of symptoms related to occupational exposure to pesticides for females when compared to males. The authors criticize the small number of studies that compare different exposures by

gender or sex. Regarding schooling, this study showed a higher prevalence of occupational exposure among participants of low education, which may consequence of not understanding or being unaware of the use of PPE and the proper handling of pesticides[36]. The data corroborate Silva et al.[37], who showed more frequent environmental and occupational exposure among participants of less education. The authors argue that such occupational exposure may be related to jobs that require less schooling and are linked to directly handling pesticides.

As for age, this study found an increase in the prevalence of occupational exposure in older age groups. Regarding environmental exposure, the variable 'residing near the farm' showed no significant association with gender or age group. The result corroborates Silva et al.[37], who emphasize the increase in exposure with increasing age as an expected result.

Cross-sectional studies provide necessary information for planning and organizing health services; however, this study has the limitation of not having a counterpart group, i.e., participants who do not have cancer. However, the profile of environmental and occupational exposure to pesticides observed in this study was similar to the population without the studied effect, i.e., being a cancer patient. Finally, convenience sampling may also infer selection bias; this research was carried out in a reference hospital for cancer treatment in the State that provides services for patients from different regions or municipalities, which allows for a sample variety, so corroborates this bias reducing.

This study showed a higher prevalence of environmental and occupational exposure to pesticides in cancer patients in the state of Mato Grosso among male participants; and increasing in prevalence as a consequence of increasing in age, lower education, and greater use of pesticides in macro-regions.

The findings contribute to expanding the information needed to guide the formulation of policies, programs, and actions of health surveillance in the state of Mato Grosso, which is regarded by the literature as the largest Brazilian pesticide consumer and that carries out a high rate of pesticide poisoning underreporting, whether because the lack of worker health surveillance or of external pressures to notify the registry.

Data show evidence of the complexity in the evaluation of cancer associated to occupational and environmental exposure to pesticides, as they bring together interrelated variables from the causal, historical, economic, political, and geographical reasons that determine the conditions of exposure, illness, and death due to contamination by pesticides[38].

This study suggests also the implementation of health surveillance in the state of Mato Grosso inhabitants exposed to pesticides as the investigation of pesticide contamination biomarkers among the population of municipalities that intensely use pesticides in farming and among workers in these productive sectors. They are necessary for the production of new evidence and forms of action to be taken against the risks produced by environmental and occupational contamination resulting from the use of pesticides.

Collaborators

Soares MR (0000-0002-0417-2614)* contributed to the design of the Project, data collection and analysis, writing of the text and final approval of the version to be published. Corrêa MLM (0000-0001-7812-0182)*, Andrade ACS (0000-0002-3366-4423)*, Neves MS (0000-0001-9187-6283)*, Bel HD (0000-0003-2268-4266)*, Galvão ND (0000-0002-8337-0669)* and Rocon PC (0000-0003-2696-5786)*, contributed equally to draft preparation, critical review of the content, and participated in the approval of the final version of the manuscript. ■

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