

Exposure to pesticides or agroecological practices: suicidal ideation among peasant farmers in Brazil's semi-arid region

Carla Wernecke Padovani Gonzaga (<https://orcid.org/0000-0003-0263-6021>)¹

Marcelo Perim Baldo (<https://orcid.org/0000-0002-7673-3580>)¹

Antônio Prates Caldeira (<https://orcid.org/0000-0002-9990-9083>)¹

Abstract Health risks faced by peasant farmers may vary depending on the type of agriculture they practice. This study examined the association between suicide ideation and exposure to pesticides by comparing two groups of peasant farmers of both sexes living in the semi-arid region of the north of Minas Gerais, Brazil: exposed to pesticides and adopting agroecological practices without the use of pesticides. Group participants were selected using convenience sampling and data was collected using a previously validated questionnaire administered through face-to-face interviews. Bivariate analysis was performed, followed by logistic regression. A total of 547 peasant farmers were interviewed (311 in the group exposed to pesticides and 236 in the group adopting agroecological practices). Respondents from the group exposed to pesticides were more likely to report suicidal ideation (OR=2.30; 95%CI 1.16-4.56), harmful alcohol consumption (OR=2.30; 95%CI 1.18-4.48), and lifetime acute pesticide poisoning (OR=8.58; 95%CI 2.98-24.72). The findings suggest that agricultural practices that lead to chronic pesticide exposure are associated with a greater likelihood of suicide ideation, regardless of previous episodes of acute pesticide poisoning or harmful alcohol consumption.

Key words Suicide, Environmental exposure, Acute poisoning, Sustainable agriculture, Rural populations

¹ Universidade Estadual de Montes Claros. Av. Prof. Rui Braga s/n, Vila Mauriceia. 39401-089 Montes Claros MG Brasil.
carlawpado@gmail.com

Introduction

The health effects of pesticides are a growing concern as their use increases worldwide, most emphatically in Brazil, which has been the world's largest consumer of these products since 2008^{1,2}. The country reported around 40,000 cases of pesticide poisoning between 2007 and 2017 and an average of 148 deaths per year over the same period³. Growing evidence points to an association between pesticide exposure and health problems such as cancer^{4,5}, endocrine disruption^{6,7}, neurological disorders^{8,9}, behavioral and neuropsychiatric changes¹⁰⁻¹², and neurodevelopmental disorders¹³.

Pesticide use is intertwined with the complexities of life and labor relations in rural areas. In this regard, it is important to highlight certain differences between different models of agricultural development and their respective impacts on the health of peasant farmers. Industrial agriculture and agroecological farming are at opposite poles, especially when it comes to their relationship with ecosystems¹⁴. Industrial agriculture is characterized by large-scale monoculture, intensive pesticide use, and division of labor aimed at maximizing productivity, while agroecological farming takes into account biodiversity and promotes interaction between plants and other organisms to generate fertility, preserving ecosystems, guaranteeing livelihoods, and retaining more people in rural areas¹⁵. Agroecology dispenses with pesticide use, and the literature has documented a diverse range of experiences and initiatives that seek to strengthen family farming¹⁶.

Studies indicate that working in agriculture is a risk factor for suicide^{17,18} and that the risk of death due to suicide is greater among rural workers living in areas with higher levels of pesticide exposure¹⁹. Suicide and attempted suicide are usually preceded by suicide ideation, which is having active or passive thoughts about taking your own life. Studies in South Korea and China have reported suicide ideation prevalence rates of around 5%^{20,21}. However, this issue has been little explored among rural populations in Brazil. Influenced by a complex set of factors, suicide ideation is a risk factor for suicide, morbidities in general, and all causes of mortality²². Studies have indicated an association between acute pesticide poisoning and psychiatric disorders²³⁻²⁵. However, there is a gap in the literature when it comes to the association between psychiatric disorders and chronic exposure, or long-term cumulative exposure to low doses of pesticides²⁶. This

study therefore sought to compare the frequency of suicide ideation between peasant farmers subjected to environmental exposure to pesticides and those adopting agroecological practices.

Methods

We conducted a cross-sectional analytical study between January and March 2019 with peasant farmers living in the semi-arid region of the north of the State of Minas Gerais, Brazil. Two groups were selected using convenience sampling: 1) farmers adopting traditional and agroecological farming practices; and 2) farmers subjected to environmental exposure to pesticides from industrial agriculture.

The selection of two groups of farmers from the same region and with similar historical origins was intended to ensure a sample with similar ethnic, sociodemographic, and cultural characteristics, except for the agricultural practices adopted over the last 40 years.

Study area

The valley of the River Gorutuba is home to a federal irrigation project supplying water to monoculture production systems using industrial farming practices characterized by the intensive use of pesticides. The peasant farmers living in the area encompassed by the project, implemented after the completion of the Bico da Pedra dam in 1979, are either employed as agricultural workers on the banana and other fruit plantations or, to a lesser extent, owners of smallholdings. Their homes are built within the agricultural areas and are contiguous to the plantations, making the residents vulnerable to contamination from aerial spraying, which is practiced routinely in the region²⁷. The water from the River Gorutuba is used for both agricultural and domestic purposes (bathing, washing clothes and dishes, and cooking) and flows through channels that cut across the region open to pesticide drift. The region is therefore subject to a high level of pesticide exposure, including contamination of the soil, air, water, food, animals, and local residents.

Outside the perimeter of the irrigation project, the region is home to traditional communities of family farmers who adopt sustainable agricultural and extractivist practices without the use of pesticides.

The underlying assumption of this study is that the peasant farmers living within the perim-

eter of the irrigation project have experienced long-term exposure to pesticides through respiratory, transdermal, and oral absorption, regardless of whether they work directly on the plantations^{28,29}.

Study population

In January 2019, 755 families (1,264 people) were living in the area within the perimeter of the irrigation project, which consisted of 4,242 hectares of banana and other fruit plantations. The sample included both men and women aged 18 years and over who had been living in the region for over two years, regardless of whether they worked directly with agriculture. The study included the 10 micro areas of the Family Health Strategy in the area encompassed by the irrigation project. The participants were interviewed by local community health agents who agreed to collaborate with the study. People working within the perimeter of the irrigation project who did not live within the area were excluded.

For the group adopting agroecological practices, we selected peasant farmers from four traditional communities: Comunidade do Touro, in Serranópolis; Comunidade Córrego Verde, in Grão Mogol; and Comunidade Fazenda Velha and Comunidade Nossa Senhora das Oliveiras, both in Riacho dos Machados. The participants were identified by the local residents' associations as adopting agroecological practices and sustainable management of natural resources without pesticide use.

Peasant farmers aged 18 years and over were invited to participate in the study during meetings held in the community to present the research project. The following individuals were excluded: 1) those employed in a local mining company, given that mining activities can give rise to a range of health problems and thus cause bias; and 2) those working outside the community in the coffee and sugarcane harvests in the last two years, due to the possibility of exposure to pesticides.

Official registers of the adult population living within the perimeter of the irrigation project (1,264 people) were not available. The participants of both groups were selected using convenience sampling because of the random distribution of households in the rural areas encompassed by the study. However, efforts were made to obtain a representative sample of the micro areas of the Family Health Strategy within the perimeter of the irrigation project using

the knowledge of the community health agents of the region. The population of the four traditional communities was estimated at 600 people, based on the information provided by the communities. All individuals who met the inclusion criteria were included in this group.

Data collection instrument

The data collection instrument was developed based on previously validated instruments to obtain the following information: socioeconomic and demographic characteristics – sex (male/female), age (18 to 39 years and ≥ 40 years), skin color (white and brown/black/indigenous/yellow), marital status (living with partner and without partner), and level of education (literate and illiterate); and health characteristics – variables that may influence suicide ideation (smoking, harmful alcohol consumption, and previous pesticide poisoning), using questions answered yes or no.

Suicide ideation was assessed using the following contextualized question from the Brazilian version of the World Health Organization's (WHO) Self-Reporting Questionnaire-20 (SRQ-20)³⁰: "Has the thought of ending your life been on your mind during the last 30 days?"; answered yes or no. The SRQ-20 is used to assess common, non-psychotic mental disorders in primary care settings.

Acute pesticide poisoning is an indicator of high levels of pesticide exposure. Lifetime acute pesticide poisoning was assessed using a question from the Paraná State Chronic Pesticide Poisoning Assessment Protocol³⁰, answered yes or no.

Harmful alcohol consumption was assessed using the Alcohol Use Disorders Identification Test (AUDIT), developed by the WHO to detect harmful alcohol consumption in primary care settings. A score greater than or equal to 8 is a predictor of alcohol-related social and medical problems in both sexes³¹. Smoking was detected using questions from the Paraná State Chronic Pesticide Poisoning Assessment Protocol³⁰.

Data collection

The data were collected between January and March 2019 using face-to-face interviews administered by a team made up of community health agents and local residents previously trained to apply the interviews in their communities. The interviewers were instructed to carry out the interviews in the participant's home, where more

than one adult could be interviewed, at a time that was convenient for the respondents. Around 5% of the questionnaires were randomly selected to assess the quality of information collected. No errors or inconsistencies were found.

Data analysis

A descriptive analysis of the sample characteristics was performed using frequency distribution. Bivariate analysis was performed of the categorical independent variables to compare the two groups (peasant farmers from traditional communities adopting agroecological practices versus peasant farmers potentially exposed to pesticides from industrial agriculture) using Pearson's chi-squared test.

All the variables were included in the initial binary logistic regression model. Variables with a p-value of greater than 0.05 were excluded from the final model, except for age and sex, which were maintained as adjustment factors regardless of their statistical significance.

The data were analyzed using SPSS® version 18.

Ethical aspects

The research project was approved by Montes Claros State University's Research Ethics Committee. All respondents signed an informed consent form. Presentations on the health risks of pesticide exposure were given in the communities at the end of the data collection phase.

Results

A total of 547 people were interviewed (311 in the group exposed to pesticides and 236 in the group adopting agroecological practices). The socioeconomic and demographic characteristics of the sample are presented in Table 1. The groups were similar in terms of sex and age. In both groups, around 40% of the respondents lived in households with a monthly family income of less than one minimum salary and more than 85% were brown, black, yellow, or indigenous. The prevalence of illiteracy and people living without a partner was greater in the group adopting agroecological practices (Table 1).

Table 2 shows the health characteristics of the two groups. The prevalence of harmful alcohol consumption, smoking, previous pesticide poisoning, and suicide ideation during the

last 30 days was greater in the group exposed to pesticides. All these differences were statistically significant. Only 1.7% of the group adopting agroecological practices reported lifetime acute pesticide poisoning (before the adoption of agroecological practices).

In the logistic regression model adjusted for age and sex, peasant farmers in the group exposed to pesticides were more likely to be living without a partner and literate and to show harmful alcohol consumption, lifetime acute pesticide poisoning, and suicide ideation during the last 30 days (OR=2.30; 95%CI 1.16-4.56) (Table 3).

Discussion

The findings show that the frequency of suicide ideation was greater in the group exposed to pesticides than in the group adopting agroecological practices. This association, which indicates chronic pesticide exposure, had not been previously reported in the country, although a study with agricultural workers living in areas with high levels of pesticide use in the highland region of Rio de Janeiro reported higher risk of mortality and hospitalization due to suicide attempts and that the risk of death increased with increasing pesticide exposure¹⁹. A study in Mato Grosso do Sul found that prevalence of suicide attempts and suicide was greater in areas with high levels of pesticide use than in areas with low use³², while an ecological study in Spain with 17,429 people reported higher rates of suicide and suicide attempts in agricultural areas with intensive pesticide use⁹.

A cross-sectional population-based study in China with 10,000 people from rural communities reported an association between pesticide exposure and suicide ideation during the last two years²¹, while research in the United States showed that occupational pesticide exposure was associated with increased risk of depression³³. A study in Canada observed an increased risk for suicide associated with herbicide and insecticide spraying among a subgroup of farm operators who were most likely to be directly exposed to pesticides³⁴.

The literature associates suicide ideation with episodes of acute pesticide poisoning. A cross-sectional study with banana workers in Costa Rica showed that organophosphate poisoned workers were more likely to have suicidal thoughts during the last month than workers without any history of acute poisoning with or-

Table 1. Socioeconomic and demographic characteristics of the peasant farmers and association with agricultural practices (agroecological practices versus pesticide exposure) in the semi-arid region of the north of Minas Gerais, 2019 (n=547) (Bivariate analysis).

Variables	n (%)	Agroecology	Pesticides	OR	IC95%	p*
		Crude	95%CI			
Sex						
Male	232 (42.4)	92 (39.0)	140 (45.0)	1	-	
Female	315 (57.6)	144 (61.0)	171 (55.0)	0.78	0.55-1.10	0.16
Age group						
18 to 39 years	251 (47.0)	111 (47.0)	140 (45.0)	1	-	
≥40 years	296 (53.0)	125 (53.0)	171 (55.0)	1.09	0.77-1.52	0.64
Skin color						
White	48 (8.08)	26 (11.0)	22 (7.1)	1	-	
Non-white	499 (91.2)	207 (87.7)	288 (92.6)	1.63	0.90-2.95	0.11
Marital status						
With partner	362 (66.2)	143 (60.6)	219 (70.4)	1	-	
Without partner	185 (33.8)	93 (39.4)	92 (29.6)	0.65	0.45-0.92	0.02
Level of education*						
Literate	480 (89.2)	201 (85.5)	279 (92.1)	1	-	
Illiterate	58 (10.8)	34 (14.5)	24 (7.9)	0.51	0.29-0.88	0.02
Family income (minimum salary)						
1 or more	314 (57.4)	137 (58.1)	177 (56.9)	1	-	
<1	233 (42.6)	99 (41.9)	134 (43.1)	1.05	0.74-1.48	0.79

*Variation in n=547 due to missing information

Source: Elaborated by the authors.

Table 2. Health characteristics of the peasant farmers and association with agricultural practices (agroecological practices versus pesticide exposure) in the semi-arid region of the north of Minas Gerais, 2019 (n=547) (Bivariate analysis).

Variables	n (%)	Agroecology	Pesticides	OR Crude	95%CI	p*
		n (%)	n (%)			
Harmful alcohol consumption						
No	491 (89.8)	221 (93.6)	270 (86.8)	1	-	-
Yes	56 (10.2)	15 (6.4)	41 (13.2)	2.24	1.21-4.15	0.01
Smoking*						
No	467 (85.8)	209 (89.7)	258 (83.0)	1	-	-
Yes	77 (14.2)	24 (10.3)	53 (17.0)	1.79	1.07-3.00	0.03
Acute pesticide poisoning						
No	499 (91.2)	232 (98.3)	267 (85.9)	1	-	-
Yes	48 (8.8)	4 (1.7)	44 (14.1)	9.56	3.39-27.00	0.00
Suicide ideation during the last 30 days*						
No	490 (90.1)	221 (94.4)	269 (86.8)	1	-	-
Yes	54 (9.9)	13 (5.6)	41 (13.2)	2.59	1.35-4.96	0.00

*Variation in n=547 due to missing information.

Source: Elaborated by the authors.

ganophosphates²⁵. In South Korea, risk of suicidal ideation over the preceding year increased with the severity of acute poisoning and history of

hospitalization for acute pesticide poisoning²⁰. A study by Faria et al.¹⁷ reported an association between pesticide exposure and standardized sui-

cide rates in different regions of Brazil, showing that the magnitude of the association was greater for acute pesticide poisoning.

Although our study did not assess the dosage of pesticide metabolites, the contamination of the air, water, soil, and food, and the proximity of the respondents' homes to the plantations are sufficient to assume exposure^{1,3,5,9,27-29,35-38}. The respondents living within the perimeter of the irrigation project were considered to be environmentally exposed to pesticides, regardless of whether they worked directly in the preparation or application of these products. The proximity to agricultural fields and the exposure to pesticides were examined by a study in the Netherlands with participants of the Dutch PIAMA birth cohort study that investigated the influence of environmental factors on the development of respiratory diseases. The study observed that proximity of homes to fields treated with pesticides was a proxy for environmental exposure to pesticides²⁸.

An ecological study in Brazil showed that increased pesticide use was positively correlated with the following health indicators: acute pesticide poisoning, incidence of fetal malformation, and childhood cancer³⁵. A study in the State of Ceará found that cancer death rates were higher in municipalities with the predominance of irrigated industrial agriculture than in those with the predominance of family farming²⁹.

Previous episodes of pesticide poisoning, which is an indicator of exposure to high doses of pesticides, was reported by a significant proportion of the group exposed to pesticides and frequency of pesticide poisoning was significantly higher in this group than in the group adopting agroecological practices. The likelihood of previous episodes of pesticide poisoning was eight times greater among the group exposed to pesticides.

Although the literature shows that there is an association between suicide ideation and acute pesticide poisoning, there is no robust epidemiological evidence supporting an association between depression/suicide and long-term cumulative exposure to pesticides²⁶. To answer the question "Is chronic pesticide exposure associated with suicide ideation?", we adjusted the model with other variables that may have influenced the results. The results show that suicide ideation during the last 30 days maintained its association with long-term cumulative exposure to pesticides, regardless of the occurrence of previous episodes of acute pesticide poison-

Table 3. Characteristics associated with agricultural practices (agroecological practices versus pesticide exposure) in the semi-arid region of the north of Minas Gerais, 2019 (n=547) (Logistic regression analysis).

Variables	Peasant farmers exposed to pesticides/peasant farmers adopting agroecological practices		
	Adjusted Odds Ratio	CI95%	p
Sex			
Male	1	-	-
Female	0.95	0.62-1.32	0.61
Age group			
18 to 39 years	1	-	-
≥40 years	1.01	0.69-1.48	0.95
Marital status			
With partner	1	-	-
Without partner	0.65	0.44-0.95	0.03
Level of education*			
Literate		-	-
Illiterate	0.43	0.23-0.81	0.01
Harmful alcohol consumption			
No		-	-
Yes	2.30	1.18-4.48	0.01
Acute pesticide poisoning			
No		-	-
Yes	8.58	2.98-24.72	0.00
Suicide ideation during the last 30 days*			
No		-	-
Yes	2.30	1.16-4.56	0.02

*Variation in n=547 due to missing information.

Source: Elaborated by the authors.

ing and other aspects, such as harmful alcohol consumption, level of education, and marital status, which also maintained their association with agricultural practices. These findings are consistent with those of a cross-sectional study nested within the Agricultural Health Study in the United States, which found an association between psychiatric disorders and chronic pesticide exposure³³.

The biological plausibility of the association between chronic pesticide exposure and neuropsychiatric disorders has been discussed by literature reviews^{13,18,26}. A literature review of mortality

and morbidity studies related to suicide among pesticide-exposed populations suggested that organophosphate insecticides and other highly toxic pesticides are part of the causal pathway of depression and psycho-emotional disorders due to biological plausibility¹⁸. Acute pesticide poisoning causes cholinergic hyperstimulation due to the inhibition of the enzyme acetylcholinesterase in the nerve synapses. With chronic poisoning, where doses are not high enough to cause cholinesterase inhibition, experimental studies have observed alterations in other neurotransmitter systems, such as the serotonergic, glutamatergic, noradrenergic, and dopaminergic systems²⁶. The effects of chronic poisoning include neurodevelopmental changes¹³, depression, increased impulsivity, and other mood and behavior changes, which may contribute to suicide ideation and suicide¹⁸.

The data presented also show that the likelihood of harmful alcohol consumption is greater in the group exposed to pesticides (OR=2.30; 95%CI 1.18-4.48).

Other studies have highlighted that modern industrial agriculture, based on monocultures and intensive pesticide use, has a negative impact on the mental health of peasant farmers^{14,19,32,37-39}, especially in peripheral countries where pesticide use is widespread and encouraged, but poorly controlled and regulated^{1,3,18,36}.

This study has some limitations. First, we did not use probability sampling because official population registers were not available for the traditional communities. Second, we did not address other well-known risk factors for suicide ideation/suicide, such as personal and family history of psychiatric disorders and suicidal

behavior, as well as health characteristics and stressors not related to agriculture. Furthermore, a direct assessment of pesticide poisoning in the communities was not conducted. Despite these limitations, this study provides some important findings, which should inform the debate on this issue and stimulate further research in the region on this problem.

Conclusion

Peasant farmers living within the perimeter of the irrigation project and therefore subject to long-term cumulative pesticide exposure were more likely to report suicide ideation during the last 30 days than those living in traditional communities adopting agroecological practices, regardless of the occurrence of previous episodes of acute pesticide poisoning.

The findings of this study investigating two different groups of peasant farmers both living in the semi-arid region of the north of Minas Gerais, but immersed in distinct agricultural models, reinforce the need for further research to gain a better understanding of the association between intensive pesticide use in industrial agriculture and psychiatric disorders in peasant farmers and agricultural workers.

Multiple connections between the field of health and agroecology need to be better explored, by not only building and recognizing the importance of sustainable food systems and the preservation of ecosystems, but also demonstrating the potential of sustainable practices for shaping new directions at the individual and collective levels and providing hope for the future.

Collaborations

All authors participated equally in the design of the study, analysis of results and writing of the final text. CWP Gonzaga was responsible for data collection.

Acknowledgements

We are grateful to the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for awarding a master's scholarship to Carla Wernecke Padovani Gonzaga.

References

- Carneiro FF, Rigotto RM, Augusto LGS, Búrigo AC. *Dossiê ABRASCO: um alerta sobre os impactos dos agrotóxicos na saúde*. Rio de Janeiro/São Paulo: Expressão Popular; 2015.
- Porto MF, Soares WL. Modelo de desenvolvimento, agrotóxicos e saúde: um panorama da realidade agrícola brasileira e propostas para uma agenda de pesquisa inovadora. *Rev Bras Saude Ocup* 2012; 37(125):17-50.
- Bombardi LM. *Geografia do uso de agrotóxicos no Brasil e conexões com a União Europeia*. São Paulo: USP; 2017.
- Bassil KL, Vakil C, Sanborn M, Cole DC, Kaur JS, Kerr KJ. Cancer health effects of pesticides: Systematic review. *Can Fam Physician* 2007; 53:1704-1711.
- Curvo HRM, Pignati WA, Pignatti MG. Morbimortalidade por câncer infanto-juvenil associada ao uso agrícola de agrotóxicos no Estado de Mato Grosso, Brasil. *Cad Saude Colet* 2013; 21(1):10-17.
- Diamanti-Kandarakis E, Bourguignon JP, Giudice LC, Hauser R, Prins GS, Soto A, Zoeller RT, Gore AC. Endocrine-disrupting chemicals: an Endocrine Society scientific statement. *Endocr Rev* 2009; 30(4):293-342.
- Bergman Å, Heindel JJ, Jobling S, Kidd K, Zoeller TR. *State of the science of endocrine disrupting chemicals 2012*. Geneva: WHO; 2013.
- Ascherio A, Chen H, Weisskopf MG, O'Reilly E, McCullough ML, Calle EE, Schwarzschild MA, Thun MJ. Pesticide exposure and risk for Parkinson's disease. *Ann Neurol* 2006; 60(2):197-203.
- Parrón T, Requena M, Hernández AF, Alarcón R. Association between environmental exposure to pesticides and neurodegenerative diseases. *Toxicol App Pharm* 2011; 256(3):379-385.
- London L, Beseler C, Bouchard MF, Bellinger DC, Colosio C, Grandjean P, Raul Harari, T Kootbodien, Kromhout H, Little F, Meijster T, Moretto A, Rohlman DS, Stallones L. Neurobehavioral and neurodevelopmental effects of pesticide exposures. *Neurotoxicology* 2012; 33(4):887-896.
- Bouchard MF, Bellinger DC, Wright RO, Weisskopf MG. Attention-deficit/hyperactivity disorder and urinary metabolites of organophosphate pesticides. *Pediatrics* 2010; 125(6):e1270-e1277.
- Grandjean P, Harari R, Barr DB, Debes F. Pesticide exposure and stunting as independent predictors of neurobehavioral deficits in Ecuadorian school children. *Pediatrics* 2006; 117(3):e546-e556.
- Björling-Poulsen M, Andersen HR, Grandjean P. Potential developmental neurotoxicity of pesticides used in Europe. *Environ Health* 2008; 7(1):50.
- Horrigan L, Lawrence RS, Walker P. How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environ Health Perspect* 2002; 110(5):445-456.
- Burigo AC, Vaz BA, Londres F, Franco Netto G, Menezes MAC, Pacheco MEL, Souza NA, Petersen P, organizadores. *Caderno de estudos: saúde e agroecologia*. Rio de Janeiro: Fiocruz, ANA, ABA-Agroecologia; 2019.
- Altiere MA. Agroecology: the science of natural resource management for poor farmers in marginal environments. *Agric Ecosyst Environ* 2002; 93(1-3):1-24.
- Faria NM, Fassa ACG, Meucci RD. Association between pesticide exposure and suicide rates in Brazil. *Neurotoxicology* 2014; 45:355-362.
- London L, Flisher AJ, Wesseling C, Mergler D, Kromhout H. Suicide and exposure to organophosphate insecticides: cause or effect? *Am J Ind Med* 2005; 47(4):308-321.
- Meyer A, Koifman S, Koifman RJ, Moreira JC, De Rezende Chrisman J, Abreu-Villaca Y. Mood disorders hospitalizations, suicide attempts, and suicide mortality among agricultural workers and residents in an area with intensive use of pesticides in Brazil. *J Toxicol Environ Health A* 2010; 73(13-14):866-877.
- Kim J, Shin DH, Lee WJ. Suicidal ideation and occupational pesticide exposure among male farmers. *Environ Res* 2014; 128:52-56.
- Zhang J, Stewart R, Phillips M, Shi Q, Prince M. Pesticide exposure and suicidal ideation in rural communities in Zhejiang province, China. *Bull WHO* 2009; 87:745-753.
- Olfson M, Weissman MM, Leon AC, Sheehan DV, Farrow L. Suicidal ideation in primary care. *J Gen Intern Med* 1996; 11(8):447-453.
- Koh SB, Kim TH, Min S, Lee K, Kang DR, Choi JR. Exposure to pesticide as a risk factor for depression: A population-based longitudinal study in Korea. *Neurotoxicology* 2017; 62:181-185.
- Kim J, Ko Y, Lee WJ. Depressive symptoms and severity of acute occupational pesticide poisoning among male farmers. *Occup Environ Med* 2013; 70(5):303-309.
- Wesseling C, De Joode BVW, Keifer M, London L, Mergler D, Stallones L. Symptoms of psychological distress and suicidal ideation among banana workers with a history of poisoning by organophosphate or n-methyl carbamate pesticides. *Occup Environ Med* 2010; 67(11):778-784.
- Freire C, Koifman S. Pesticides, depression and suicide: a systematic review of the epidemiological evidence. *Int J Hyg Environ Health* 2013; 216(4):445-460.
- Ferreira MLPC. A pulverização aérea de agrotóxicos no Brasil: cenário atual e desafios. *R Dir Sanit* 2014; 15(3):18-45.
- Bukalasa JS, Brunekreef B, Brouwer M, Vermeulen R, Jongste JC, van Rossem L, et al. Proximity to agricultural fields as proxy for environmental exposure to pesticides among children: The PIAMA birth cohort. *Sci Total Environ* 2017; 595:515-520.
- Rigotto RM, Silva AMC, Ferreira MJM, Rosa IF, Aguiar ACP. Tendências de agravos crônicos à saúde associados a agrotóxicos em região de fruticultura no Ceará, Brasil. *Rev Bras Epidemiol* 2013; 16(3):763-773.
- Paraná. Secretaria de Estado da Saúde (SES). *Protocolo de avaliação das intoxicações crônicas por agrotóxicos* [Internet]. 2013 [acessado 2019 mar 23]. Disponível em: http://www.saude.pr.gov.br/arquivos/File/CEST/Protocolo_AvaliacaoIntoxicacaoAgrotoxicos.pdf.
- Conigrave KM, Hall WD, Saunders JB. The AUDIT questionnaire: choosing a cut-off score. *Addiction* 1995; 90(10):1349-1356.
- Pires DX, Caldas ED, Recena MCP. Uso de agrotóxicos e suicídios no Estado do Mato Grosso do Sul, Brasil. *Cad Saude Publica* 2005; 21:598-604.

33. Beseler CL, Stallones L, Hoppin JA, Alavanja MC, Blair A, Keefe T, Kamel F. Depression and pesticide exposures among private pesticide applicators enrolled in the Agricultural Health Study. *Environ Health Perspect* 2008; 116(12):1713-1719.
34. Pickett W, King WD, Lees RE, Bienefeld M, Morrison HI, Brison RJ. Suicide mortality and pesticide use among Canadian farmers. *Am J Ind Med* 1998; 34(4):364-372.
35. Pignati WA, Lima FANDS, Lara SSD, Correa MLM, Barbosa JR, Leão LHDC, Pignatti MG. Distribuição espacial do uso de agrotóxicos no Brasil: uma ferramenta para a Vigilância em Saúde. *Cien Saude Colet* 2017; 22(10):3281-3293.
36. Bull D. *A growing problem: pesticides and the Third World poor*. Oxford: Oxfam; 1982.
37. Campos Y, Silva VSP, Mello Sarpa MC, Barros UO. Exposure to pesticides and mental disorders in a rural population of Southern Brazil. *Neurotoxicology* 2016; 56:7-16.
38. Moreira JC, Peres F, Simões AC, Pignati WA, Dores EDC, Vieira SN, Strüssmann C, Mott T. Contaminação de águas superficiais e de chuva por agrotóxicos em uma região do estado do Mato Grosso. *Cien Saude Colet* 2012; 17(6):1557-1568.
39. Carneiro FF, Pessoa VM, Teixeira ACA. *Campo, floresta e águas: práticas e saberes em saúde*. Brasília: Ed UnB; 2017.

Article submitted 07/04/2020

Approved 14/07/2020

Final version submitted 16/07/2020

Chief editors: Romeu Gomes, Antônio Augusto Moura da Silva