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IMPACT OF PESTICIDE EXPOSURE: AN EPIDEMIOLOGICAL PROFILE OF RURAL POPULATIONS IN THE CENTRAL-WEST REGION OF BRAZIL

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ABSTRACT

Brazilian agriculture is the greatest pesticide consumer in the world. The pesticides used to control pests are employed to increase crop productivity and profit. However, pesticide exposure may lead to acute and chronic complications. The objective of this study was to identify the epidemiological profile of pesticide-exposed rural populations in Jataí, Goiás, Brazil. This cross-sectional, descriptive, retrospective epidemiological study was conducted in the countryside near the city of Jataí between 2018 and 2020. The research population comprised 99 farmworkers potentially exposed to pesticides, whose children attended three rural schools in the municipality. The data were collected by trained researchers in individual interviews, using a standardized questionnaire. Of the interviewed farmworkers, only 16.2% of the participants reported no pesticide exposure whatsoever. The presence of neuropsychiatric disorders was reported by 47.5% of the participants. The vulnerability of the pesticide-exposed rural population is closely related to the following factors: high toxicity of agricultural inputs; inadequate and/or absent use of personal protective equipment; low educational attainment; lack of specialized pesticide use instructions. This research is expected to contribute to the analysis and reflection of the topic approached and the promotion of effective strategies aiming at the comprehensive health of the Brazilian rural populations.

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INTRODUCTION

Agricultural lands have been modernized, greatly impacting the expressive use of pesticides in the countryside. The green revolution, which took place between the 1960s and 1980s, brought to Brazil a variety of government incentives and measures and encouraged innovations toward large-scale cultivation. The appearance of these technological solutions for agriculture reflected significantly on people's health – a scenario with profound incongruences in the relationship between productivity, financial gain, and health deterioration (Morin; Stumm, 2018). Brazilian agriculture has been growing exponentially and, although it is not the greatest agricultural producer in the world, it is the greatest consumer of pesticides (ANVISA, 2019), having surpassed the United States, which was in first place until 2008. Since that year, Brazil became the world leader in pesticide use. According to the 2012 dossier by ABRASCO, approximately 28% of the agrochemicals used in Brazil contain substances unauthorized for sale or consumption. Part of the Brazilian agricultural inputs has been banished in Europe and North America (Morin; Stumm, 2018). Brazil is the country of Mercosur with the strictest norms for pesticide use – which is an advancement in the country's laws considering the harms to the environment and human health. However, its inspection is deficient, from commercialization to use and proper disposal of the containers (Morin; Stumm, 2018). Pesticides are used to control pests in agriculture and livestock. Even though their effectiveness increases productivity and profit from the land (Dellamatrice *et al*., 2014), exposure to these chemical products poses a risk to human and environmental health (Queiroz *et al*., 2019).

Intense exposure to such chemicals can be considered a public health issue in Brazil (Rigotto *et al*., 2014). Various studies have demonstrated that excessive pesticide use impairs physical and psychic health. The most frequent symptoms of poisoning are "nausea, headache, irritability, disorientation, chest pain, vertigo, tachycardia, fatigue, dizziness, skin, eye, and mucosa irritation, and respiratory difficulties" (Morin; Stumm, 2018). The exposure can happen by means of ingestion, breathing, and/or skin contact. Consuming contaminated water and food is an important source of human exposure to pesticide residues in the general population (Sharma *et al*., 2010). Moreover, occupational and para-occupational exposure has been a cause of great health concern (Deziel *et al*., 2015). Continuous pesticide exposure can cause people to develop chronic complications with irreversible impairments. Studies carried out between 2008 and 2016 have reported: "cardiovascular disease, respiratory morbidity, Parkinson's disease, vision disorders, anxiety, depression, mental confusion, arterial hypertension, and a variety of neurological effects, including suicide" (Morin; Stumm, 2018). Given the abovementioned aspects, it is important to establish the epidemiological profile of rural populations affected by pesticide exposure. Such an epidemiological assessment makes it possible to describe characteristics, find overall disease behavior patterns, identify more vulnerable populational groups, estimate the incidence and prevalence of certain health problems, and indicate the environmental risk factors or human behaviors that may suggest associations with such health problems. In other words, epidemiology provides the understanding of disease etiology, as it examines cultural, behavioral, and lifestyle characteristics. These change from one country or community to another and can be associated with health events, which makes it a valuable tool to countless studies, paving the way for positive interventions (Lima-Costa, 2003). Hence, this study aimed to identify the epidemiological profile of rural populations exposed to pesticides and describe possible risk factors associated with the prevalence of diseases and conditions, formulating hypotheses on the relationship between pesticide exposure and health impact.

MATERIALS AND METHODS

This is a cross-sectional, descriptive, retrospective epidemiological study conducted in the countryside near the city of Jataí, Goiás, Brazil, between 2018 and 2020. The research population comprised 99 pesticide-exposed farmworkers, whose children attend three rural schools in the municipality of Jataí. These schools were selected through the partnership with the Municipal Department of Education of Jataí. The target population encompassed those who sprayed pesticides, weeded the fields, harvested, lived near the crops, and belonged to the population in the area affected by pesticides, either having direct or indirect contact with them or not. The fieldwork was carried out through health promotion activities at the schools, followed by data collection questionnaires (annex) administered by trained researchers in individual interviews. This questionnaire provided information on the following variables: age, sex, educational attainment, race, exposure type, exposure time, personal protective equipment use, poisoning history, smoking, alcoholism, previous pathological history, cancer history, and neuropsychiatric symptoms. They were used to construct and cross the data, obtaining essential prevalence information to analyze the hypotheses of this study. The analyses were made with the Statistical Package for the Social Sciences (SPSS), version 21.0, with descriptive statistics and comparison tests (bivariate analysis). The statistical significance was set at $p < 0.05$.The study was approved by the Ethics Committee of the Federal University of Goiás, under evaluation report no. 78045417.6.0000.5083. The participants were informed of the ethical commitments and voluntarily signed the informed consent form.

RESULTS

The main economic activity of the Central-West region of Brazil is agriculture, particularly large-scale soybean, corn, sunflower, and sorghum monocultures. Jataí is a city in the state of Goiás that ranks high in grain production. The municipality has approximately 102 thousand inhabitants in an area of 7,174 km².

Table 1. Sociodemographic characteristics of pesticide-exposed farmworkers in southwestern Goiás between 2018 and 2020

		Frequency (n)	*Percentage (%)*
Sex	Males	38	38.4
	Females	61	61.6
Age range	0-20 years	45	45.5
	21-40 years	34	34.3
	>41 years	20	20.2
Race	White	23	23.2
	Multiracial	49	49.5
	Indigenous	1	1.0
	Black	26	26.3
Educational Attainment	Illiterate	3	3.0
	Middle school not completed	13	13.1
	Middle school completed	8	8.1
	High school not completed	46	46.5
	High school graduate	15	15.2
	Higher education not completed	5	5.1
	Bachelor's degree	8	8.1
	Not sufficient	1	1.0

According to the data surveyed with the questionnaire, pesticide use in the region began in the early 1980s with the transformations in the cultivation process, particularly in large-scale grain production. This study collected 99 questionnaires in the health promotion activities at the rural schools in the municipality. The participants' mean age was 28.46 years (± standard deviation 14.07), ranging from 14 to 71 years. The workers' sociodemographic characteristics indicated a majority of women (61.6%), in the age range from 0 to 20 years (45.5%), multiracial (49.5%), not graduated from high school (46.5%) (see Table 1). Most interviewees had low educational attainment, as 59.6% reported not having completed middle or high school, whereas only 13.2% had a bachelor's degree. In this sample, 49% claimed to be multiracial; 26.3%, black; 23.2%, white; and 1%, indigenous (Table 1). Regarding pesticide exposure, the study participants were subdivided into three groups, defined as directly exposed (DE), indirectly exposed (IE), and nonexposed subjects (NE). The DE subjects were those who had direct contact with pesticides at some stage of their use – i.e., product preparation, dilution, harvest, spraying supervision, product storage, and others. The IE subjects were those who had some contact, particularly because they lived near cultivated areas where pesticides are used, even with the aerial application. Lastly, the NE were those who had no contact whatsoever with pesticides and lived in areas free from such substances (Figure 1).

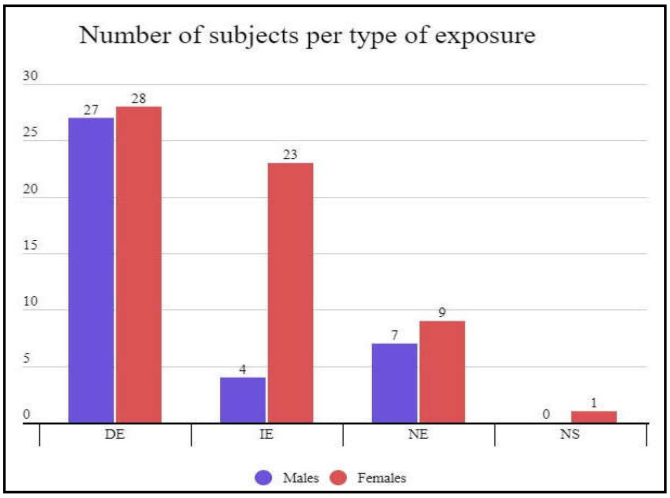

Figure 1.

It was found that 55 participants were directly exposed to pesticides, of whom 49.09% were males and 50.91% females; 27 participants were indirectly exposed, of whom 85.18% were females and 14.82%, males; and 16 participants did not report any type of exposure (Figure 1). Concerning the frequency distribution of farmworkers in relation to smoking and alcoholism, no significant difference was found between the sexes – i.e., most men and women neither smoked nor consumed alcohol (p=0.25; p=0.71, respectively) (Table 3). Ten participants had been smoking for a mean of 10.90 ± 7.54 years, ranging from 1 to 20 years. The males had been smoking (mean=14.50 ± SD=6.2) for longer than females (mean=5.50 ± SD=6.45), though without a significant difference between the sexes (p=0.26) – which can be explained by the sample size (n=10). Seventeen participants had been drinking for a mean of 9.82 ± 7.29 years, ranging from 1 to 30 years. The males had been consuming alcohol (mean=12.00 ± SD=9.23) for longer than females (mean=8.30 ± SD=5.59), though without a significant difference between the sexes (p=0.13) – which can be explained by the sample size (n=17). Regarding the presence of comorbidities, most participants did not have previous diseases (27.3%). However, the presence of neuropsychiatric disorders occurred in 47.5% of the participants in this research.

DISCUSSION

The incentive to use pesticides is known to derive from the potentialized and modernized agriculture development aiming at great productivity and movement of the economy. The impact of such pesticide exposure is a variable that directly interferes with people's health. Farmworkers make up a vulnerable group to contamination, poisoning, and a variety of health comorbidities (Jacobson *et al*., 2009). This study participants' profile indicated low educational attainment, revealing that approximately 24% had attended school only up to middle school, followed by 46.5% who did not complete high school. According to Silva *et al*. (2013), Rebelo *et al*. (2011), and Faria *et al*. (2009), low educational attainment contributes to the incidence of pesticide poisoning, with severe impacts on the farmworkers' health. According to Peres and Moreira (2007), the technical terminology and formal language used in the pesticide containers make them difficult to understand and increase the risk of pesticide exposure. Siqueira *et al*. (2013), point out that the high illiteracy rates (20.5% of a sample with 342 farmworkers) and the low educational attainment significantly compromise the safety and effectiveness of their work.

Table 2. Distribution of the frequency of pesticide exposure in farmworkers and their use of personal protective equipment in southwestern Goiás between 2018 and 2020

		Males		Females		p-value	Total	
		n	%	n	%		n	%
Type of exposure	Nonexposed	7	18.4	9	14.8	0.02*	16	16.2
	Indirectly exposed	4	10.5	23	37.7		27	27.3
	Directly exposed	27	71.1	28	45.9		55	55.6
	Not sufficient	0	0	1	1.6		1	1.0
PPE use*	Never	14	36.8	34	55.7	0.14	48	48.5
	Always	11	28.9	8	13.1		19	19.2
	Sometimes	6	15.8	9	14.8		15	15.2
	Not sufficient	0	0	1	1.6		1	1.0

PPE: Personal protective equipment; *16 missing responses; chi-squared test; * significant difference; n: frequency of cases; %: percentage. Source: Data from the research.

Table 3. Frequency distribution of farmworkers in relation to smoking and alcoholism in southwestern Goiás between 2018 and 2020

		Males		Females		p-value	Total	
		n	%	n	%		n	%
Smoking	Yes	6	15.8	4	6.6	0.25	10	10.1
	No	32	84.2	56	91.8		88	88.9
	Not sufficient	0	0	1	1.6		1	1.0
Alcoholism	Yes	7	18.4	10	16.4	0.71	17	17.2
	No	31	81.6	50	82.0		81	81.8
	Not sufficient	0	0	1	1.6		1	1.0

Chi-squared test; * significant difference; n: frequency of cases; %: percentage. Source: Data from the research.

Table 4. Frequency distribution of farmworkers in relation to comorbidities in southwestern Goiás between 2018 and 2020

		Males		*Females*		*p-value*	*Total*	
		n	%	n	%		n	%
Previous diseases	Yes	7	18.4	20	32.8	0.19	27	27.3
	No	31	81.6	40	65.6		71	71.7
	Not sufficient	0	0	1	1.6		1	1.0
Cancer	Yes	1	2.6	1	1.6	0.69	2	2.0
	No	37	97.4	59	96.7		96	97.0
	Not sufficient	0	0	1	1.6		1	1.0
Neuropsychiatric disorders	Yes	16	42.1	31	50.8	0.47	47	47.5
	No	22	57.9	29	47.5		51	51.5
	Not sufficient	0	0	1	1.6		1	1.0

Chi-squared test; * significant difference; n: frequency of cases; %: percentage. Source: Data from the research.

Only 2% of the participants reported having had cancer – one case of mouth and one of skin cancer. The main previous diseases reported were gastroesophageal reflux disease (3 cases), systemic arterial hypertension (9 cases), diabetes mellitus (7 cases), asthma (2 cases), sinusitis (3 cases), depressive disorder (3 cases) (Table 4).

Faria *et al*. (2009), highlight that health protection is a complex challenge in agriculture, particularly in the farmworkers' everyday life, who usually begin working and being exposed to pesticides in childhood or adolescence, often extending it until they are old. Hoshino *et al*. (2008) and Rebelo *et al*. (2011), point out that most poisonings occur among young people, usually occupationally active, having begun working in farms when they were children, following family patterns. In this perspective, this study also demonstrated that young people up to 20 years old was the most predominant age range, corresponding to approximately 45.5% of the sample. Faria *et al*. (2009), highlight that, although part of the farmworkers claimed they used PPE (personal protective equipment), much of the poisoning still occur for the lack of such equipment. On the other hand, this study showed a high rate of participants who reported they had never used PPE (48.5%, not counting the missing responses), which was expressively evident among females (Table 2). Moreover, Peres and Moreira (2007) researched the hill range of Rio de Janeiro and reported low adherence to PPE use in pesticide-exposed farmworkers. Hoshino *et al*. (2008) stated that not using PPE increases the incidence of pesticide poisoning and hearing health problems. Hence, the question arises concerning the true effectiveness of the ideal protective measures for workers. Is there equipment available? If so, did the workers receive it, and were they instructed on how to use it? Is the inspection effective?

A factor that strongly influences pesticide contamination is PPE nonuse and inadequate use. In the research, only 19.2% claimed they used PPE. Research conducted in Central Brazil, involving the municipalities of Silvânia, Montividiu, and Jataí, all of them in Goiás, showed that PPE use is still very deficient. Of the farmworkers interviewed, 41.7% reported not using it (Ramos *et al*. 2021). In Brazil, some pieces of research provide data with more diverging numbers: while in Piauí 56.8% of the surveyed subjects did not use PEE (Santana *et al*., 2016), this number in Rio Grande do Sul decreases to 35% (Faria *et al*., 2004). Corcino *et al*. (2019), reported that the reason given by most participants in their research for not using PPE is the discomfort due to the high local temperatures. Carelessness after handling the material also interferes with the degree of exposure. The habit of not washing the hands after spraying the pesticide, for instance, potentializes health damage (Damalas; Eleftherohorinos, 2011; Khanal; Singh, 2016; Godoy *et al*. 2019). Concerning this topic and directly analyzing Table 2, an indirect exposure is noticeably reported by women, corroborating the lack of PPE use and suggesting a need for in-depth research on this topic. Does this exposure occur when they wash their partners' clothes? Could it be avoided if they are instructed to use PPE (such as gloves, masks, goggles, etc.) even in less stereotypical poisoning circumstances? What other indirect situations stand out and how can contact be prevented? Rebelo *et al*. (2011) and Silva *et al*. (2013), conclude that there is an unawareness of the importance of PPE use, which can increase by approximately 535% the odds of poisoning.

Campos *et al*. (2016), Silva *et al*. (2013), Souza *et al*. (2011), and Faria *et al*. (2009) suggest a relationship between alcoholism and poisoning. Souza *et al*. (2011) and Faria *et al*. (2009), point out that pesticide exposure increases the likelihood of alcohol consumption. It must be taken into account that "these results indicate the importance of considering alcohol consumption when assessing pesticide poisoning, due to liver overload and the resulting neurotoxicity of the combined activity of both substances" (Faria *et al*. 2009). The association between the farmworkers' tobacco, alcohol, and pesticide use can greatly expose them to mutagenic and/o carcinogenic agents. Cigarettes contain more than 7,000 chemical substances, many of which are mutagenic and/or carcinogenic agents, such as reactive oxygen species (ROS) generators, heavy metals, and polycyclic aromatic hydrocarbon (PAH). Furthermore, the aldehydes from alcohol metabolization can enhance the effects of tobacco (Singh *et al*. 2011). Even though some pesticide components may be categorized as moderately or little toxic, their chronic effects, which may appear months or years after the contact, should not be overlooked. These chronic effects manifest as neoplasias, congenital malformations, endocrine, neurological, and mental disorders, and so forth (Carneiro, 2015). Moreover, other evident pesticide effects on human health include psychiatric and neurological disorders, peripheral neuritis, deafness, Parkinson's disease, etc. (CONSEA, 2013). Hence, the data analysis in this study does not reveal a significant relevance between pesticide exposure and frequency of alcoholism and smoking – partly because of the sample size. However, in clinical terms, these patients are known to have worse outcomes regarding complications and quality of life when pesticides are associated with alcohol and cigarettes – as in the present study. The debate around this topic turns our eyes toward future approaches to educate these populations concerning their constant exposure and its effects on human health, which negatively interfere with their quality of life. Thus, planning, informing, teaching, and disseminating preventive and educative measures regarding such exposure may ensure an increase in these people's life expectancy, directly impacting their quality of life. Concerning the long-term effects, which may involve mutations and consequent neoplasias, 2% of the participants said they had cancer. The International Agency for Research on Cancer categorizes the pesticides used in highly productive agricultural regions as potentially carcinogenic. Exposure to such chemical substances has been pointed out as a possible causal factor of cancer (Pignati *et al*. 2017). Molecular biology and toxicology epidemiological studies have demonstrated that contact with environmental pollutants, including pesticides, is directly related to the sharp increase in cases of neoplasia (Tebourbi *et al*. 2011). Hence, the greater incidence of cancer in the last 50 years may be explained not only by the increased life expectancy but also by the greater use and dissemination of carcinogenic agents, either in occupational contact or in the environment.

According to Neves *et al*. 2020, the cause-and-effect relationships are much more difficult to establish in cases of chronic poisoning (which are mild and continuous, unlike chronic poisoning) because the manifestations may occur months or years after the exposure. This may be one of the factors that make case reports difficult. A large number of substances and their mixtures are also risk factors in the reports, as the physicians are unaware of the substances used in the processes. In the sample, 27% had previous diseases (most of them women), and 2% of the sample had cancer. Psychiatric disorders are the diseases that stand out the most, as 47% of the sample had corresponding symptoms. According to Nascimento *et al*. (2021), some studies point out the presence of persistent neuropsychological sequelae in people who had moderate or severe acute poisoning by organophosphorus compounds – which are chemical compounds present in most currently used herbicides and insecticides. Faria *et al*. (2000) developed a study in the south of Brazil showing that 75% of the interviewed farmworkers used various types of pesticides in their work, indicating a high predominance of mental disease related to pesticide exposure. The various pieces of research that produce knowledge about pesticides and related them to their consequences to human health demonstrate that farmworkers are the most affected groups (Freire; Koifman, 2013). Despite the laws and regulations, in Brazil, the Ministry of Health, the National Health Surveillance Agency (ANVISA), and other agencies, there has been a sharp increase in pesticide use in Brazil in recent years (Ribeiro *et al*. 2014). Freire; Koifman (2013), suggest that acute pesticide exposure increases the farmworkers' risk of developing neuropsychiatric sequelae and the suicide and mortality rates. Peres; Moreira (2007), Cezar-Vaz *et al.* (2016), Neves; Bellini (2013), Malaspina *et al*. (2011), Meyer *et al*. (2010), and Hoshino *et al*. (2008), point out that health problems caused by pesticide exposure pose a great challenge to public health.

CONCLUSION

The vulnerability of the pesticide-exposed rural population is closely related to the following risk factors: high toxicity of agricultural inputs; inadequate and/or absent PPE use; low educational attainment; lack of specialized pesticide use instructions; lack of public policies to promote, prevent, and treat the health of the populations at risk.Concerning the pesticide exposure of the population in this study, the inadequate or absent PPE use highlights that the farmworkers are not prepared to handle pesticides. It is important to point out that, in the last 5 years, few studies and pieces of research have approached the topic. The epidemiological studies on the consequences of pesticides on human health in Brazil need to be further explored to encourage greater solvability of the pesticide-related health issues.

People are unaware of the growing incidence of health problems involving pesticide exposure. In this regard, it is important to highlight that the information systems for these diseases and health problems need to be more effective and ensure more comprehensive and reliable information in data collection. The need for an action plan for the health of pesticide-exposed rural populations is evident and urgent. The development of Brazilian agriculture portrays the retaliation and neglect of human health subordinated to the variations of the financial market in relation to the means of agricultural production and biome survival. Environmental degradation and the increased incidence of health problems are subject to the qualitative and quantitative incentives of the economy. The results of this research are expected to contribute to the analysis and reflection of the topic approached and the promotion of effective strategies for the comprehensive health of rural populations.

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