https://doi.org/10.1590/1980-549720220018.supl.1

ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Environmental and occupational exposure among cancer patients in Mato Grosso, Brazil

Exposição ambiental e ocupacional entre pacientes com câncer em Mato Grosso

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ABSTRACT: ***Objective:*** To estimate the prevalence of occupational and environmental exposure according to sociodemographic factors in cancer patients treated at reference hospitals in the state of Mato Grosso, Brazil. ***Methods:*** This is a cross-sectional study on cancer patients aged 18 years or older. The prevalence of exposure to pesticides, asbestos, lead, heavy metals, formaldehyde, benzene, exposure to industrial dust, and handling of other chemical substances were calculated according to sex, age group, and level of education. ***Results:*** A total of 1,012 patients were interviewed (55.0% women, 45.6% aged 60 years or older, and 56.8% had less than five years of formal education). Pesticides (22.8%), industrial dust (10.7%), and benzene (10.1%) were the most frequent exposures. Occupational and environmental exposure was higher in men for all evaluated exposures, except for formaldehyde, which was higher in women. Exposure to pesticides, industrial dust, benzene, asbestos, and heavy metals increased with age and were more frequent among those with lower level of education. ***Conclusion:*** Approximately one in five cancer patients treated at reference hospitals in Mato Grosso reported having been exposed to pesticides, and one in ten were exposed to industrial dust and benzene, with greater exposure among men, older individuals, and those with lower level of education.

Keywords: Cancer. Occupational exposure. Agrochemicals. Environmental pollution.

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Conflict of interests: nothing to declare – **Financial support:** This study is part of the university extension project *Vigilância de Câncer e seus fatores associados: atualização dos registros de base populacional e hospitalar* [Surveillance of cancer and its associated factors: update of population-based and hospital-based registry], with funding from the State Department of Health of Mato Grosso, in force from April 2016 to March 2021, and the research project *Câncer e seus fatores associados: análise de registro de base populacional e hospitalar* [Cancer and its associated factors: analysis of population-based and hospital-based registry], with funding from the Ministry of Public Labor Prosecution of the 23rd Region, in force from July 2019 to July 2023.

Associated editors: Elisete Duarte, Gulnar Azevedo e Silva

Scientific editor: Cassia Maria Buchalla

This document has an erratum: https://doi.org/10.1590/1980-549720220018.supl.1erratum

RESUMO: ***Objetivo:*** Estimar a prevalência da exposição ocupacional e ambiental segundo fatores sociodemográficos nos pacientes com câncer atendidos nos hospitais de referência do estado de Mato Grosso. ***Métodos:*** Estudo transversal com pacientes com câncer de 18 anos ou mais. Foram calculadas as prevalências de exposição a agrotóxicos, amianto, chumbo, metais pesados, formol, benzeno e poeira industrial e de manuseio de outras substâncias químicas conforme sexo, faixa etária e escolaridade. ***Resultados:*** Foram entrevistados 1.012 pacientes (55,0% do sexo feminino, 45,6% com 60 anos ou mais, 56,9% com menos de cinco anos de escolaridade). Agrotóxicos (22,8%), poeira industrial (10,7%) e benzeno (10,1%) foram as exposições de maior frequência. A exposição ocupacional e ambiental foi maior no sexo masculino para todas as exposições avaliadas, exceto para o formol, que foi maior no sexo feminino. A exposição a agrotóxico, poeira industrial, benzeno, amianto e metais pesados aumentou com a idade e foi mais frequente entre aqueles de menor escolaridade. ***Conclusão:*** Aproximadamente um em cada cinco pacientes com câncer atendidos em hospitais de referência de Mato Grosso relatou ter sido exposto aos agrotóxicos, e um a cada dez foi exposto a poeira industrial e benzeno, sendo maior a exposição entre os indivíduos do sexo masculino, mais velhos e de menor escolaridade.

Palavras-chave: Câncer. Exposição ocupacional. Agroquímicos. Poluição ambiental.

INTRODUCTION

Cancer is a chronic, multifactorial disease, related to genetic and hereditary alterations (about 20%) or caused by environmental factors, lifestyle and behavioral habits, sociodemographic conditions, exposure to chemicals, among others (80%)[1,2].

The International Agency for Research on Cancer (IARC) classifies chemicals, such as pesticides, benzene, ionizing radiation, asbestos, silica, chemical dust, among others, as potentially carcinogenic products[3]. According to an update of the IARC monographs performed by Loomis et al.[4], the authors evaluated that, of the 120 types of potentially carcinogenic chemical agents, 40 result from occupational exposure.

The relationship between exposure to physical and chemical agents and the occurrence of an occupational disease is difficult to investigate from the causal link point of view. Based on this assumption, it is of paramount importance for the Brazilian Ministry of Health, as well as the Ministry of Labor, to prioritize surveillance and prevention actions of occupational diseases, such as cancers, seeking to minimize the impacts caused by the productive activities of the country[5].

The literature has advanced in the evaluation of the relationship between the occurrence of certain cancers and exposure to chemicals. However, more studies are needed to strengthen health surveillance of exposed populations and the occurrence of chronic diseases such as cancer. Therefore, the objective of this study is to estimate the prevalence of occupational and environmental exposure according to sociodemographic factors in cancer patients treated at reference hospitals in the state of Mato Grosso (MT), Brazil.

METHODS

This is a cross-sectional study that is part of the research project *Câncer e seus fatores associados: análise de registro de base populacional e hospitalar de Cuiabá-MT* [Cancer and its associated factors: analysis of population-based and hospital-based registry in Cuiabá-MT, Brazil] , developed by the Public Health Institute (Universidade Federal de Mato Grosso) in partnership with the State Department of Health and funding from the Ministry of Public Labor Prosecution of the 23rd Region. The study included the Hospital Universitário Júlio Muller (HUJM), which is the teaching hospital of Universidade Federal de Mato Grosso, and the Hospital de Câncer de Mato Grosso (HCan), a High-complexity Oncology Care Unit responsible for about 70% of all cancer care in the state[6].

The estimated population for Mato Grosso in 2021 was 3,567,234 inhabitants. The state is the third most extensive in the country, with a territorial area of 903,207,047 km^2, a population density of 3.95 inhabitants per km^2, and a Human Development Index of 0.725. Its economy comprises agribusiness in most of its 141 municipalities. Of these, the highest population concentration is in the capital, Cuiabá, with an estimated population in 2021 of 623,614 inhabitants[7]. The economy of the state of MT is based on agribusiness due to the large extent of land destined for the cultivation of monocultures and the intensive use of pesticides, making the state the largest consumer in Brazil in recent years[8].

For the sample calculation, the following aspects were considered: number of hospitalizations of the Hospital-based Cancer Registry (2015) of patients aged 20 years or older due to the lack of information on the number of patients seen in the outpatient clinics, maximum proportion of p=0.50, tolerable error of 2.5%, and confidence level of 95%. The estimated sample was 1,050 patients treated in both hospitals, considering 10% of losses. A total of 1,122 patients over 18 years of age were interviewed. Of these, six refused to participate, 21 did not have their medical records found, and in 83 the diagnosis of cancer was unconfirmed; thus, the final sample was 1,012 patients. The inclusion criteria for the selection of participants were: people of both sexes aged 18 years or older treated at the HCan and HUJM outpatient clinics with cytopathological or histopathological diagnosis of cancer during the data collection period.

Data collection took place between November 2019 and March 2020 and was carried out by a questionnaire structured in 12 blocks through face-to-face interviews at the very outpatient clinics, in a place reserved for this, using an electronic data collection platform (Open Data Kit – ODK) installed on a tablet with Android system[9]. Data were collected from medical records from December 2019 to March 2020 and from April to June 2021, due to the COVID-19 pandemic.

For this study, occupational and environmental exposure was considered as dependent variable, measured by the question "Have you ever worked or currently works with any of these factors?" (yes; no): a) Pesticides (insecticides, fungicides, herbicides, acaricide); (b) Asbestos (corrugated tiles, asphalt, water boxes); c) Lead (pipes, welds, blades, manufacture of PVC, paints, dyes, enamel, and makeup); (d) Heavy metals (chemical fertilizers, mercury);

e) Formaldehyde (hair straightening, dye, textile industry); (f) Benzene (fuel, petrol, diesel); (g) Exposure to industrial dust (examples: marble powder, wood dust, leather powder); and (h) Handling of other chemical substances (which are not included in the previous examples). The independent variables were: sex (men and women), age group (18 to 39; 40 to 59; 60 years or older), and level of education (0 to 4; 5 to 11; 12 years or more of formal education). Moreover, the patients' municipality of residence was analyzed and also for how long they worked or have been working with any of the aforementioned occupational and environmental exposure factors (<5; 5 to 10; 10 to 20; 20 years or more), in addition to the type of cancer, classified according to the International Classification of Diseases (C00-C97; D46) and obtained from data on medical records.

Descriptive analysis was performed using absolute and relative frequencies. The prevalence of occupational and environmental exposure and their respective 95% confidence intervals (95%CI), according to sex, age group, and level of education, were estimated. The analyses were performed in the STATA software version 16.0.

The project and this study were approved by the Ethics Committee of Hospital Universitário Júlio Muller, upon Certificate of Presentation for Ethical Consideration (CAAE): 98150718.1.0000.8124, Opinion no. 3.048.183 on Nov. 20, 2018, and by the Research Ethics Committee of the Department of Health of Mato Grosso State, upon CAAE: 98150718.1.3003.5164, Opinion no. 3.263.744 on April 12, 2019. All participants signed an Informed Consent Form.

RESULTS

Of the 1,012 patients, 557 were women (55.0%), 462 aged 60 years or older (45.6%), and 574 had less than five years of formal education (56.8%). The mean age was 56.8 years (standard deviation – SD=14.3), with minimum of 18 and maximum of 100 years. Regarding the municipality of residence, 387 patients lived in the two most populous cities of Mato Grosso (40.1%), namely 267 in Cuiabá (26.8%) and 120 in Várzea Grande (12.0%), 610 in small cities within the state (59.7%), and 15 in other states (1.5%). The most frequent types of cancer were breast (28.3%; 286), prostate (19.3%; 195), colorectal (9.2%; 93), cervical (4.2%; 43), myeloid leukemia (3.1%; 31), lung (2.7%; 27), stomach (2.4%; 24), larynx (2.0%; 20), and skin (1.9%; 19).

The most frequent exposure was pesticides (22.8%; 95%CI 20.2–25.5), followed by industrial dust (10.7%; 95%CI 8.9–12.8) and benzene (10.1%; 95%CI 8.3–12.1) (Figure 1A). Regarding exposure time, most patients worked more than 10 years exposed to benzene (53.3%; 16), lead (50.8%; 32), and handling of other chemical substances (56.8%; 21). As for the exposure to asbestos (53.7%; 36), heavy metals (49.2%; 30), and formaldehyde (47.5%; 19), the analyzed exposure time was less than five years. For pesticides (52.3%; 113) and industrial dust (53.6%; 52), most patients reported less than ten years of exposure time (Figure 1B).

Occupational and environmental exposure was higher in men for all evaluated exposures, except for formaldehyde, which was higher in women. Regarding age group, the prevalence of exposure to pesticides and industrial dust was higher among those aged 40 years or older (Table 1). Regarding benzene exposure, the highest proportion was found in the age group between 50 and 59 years, and for asbestos and heavy metals, the predominant age group was 50 years or older (Tables 2 and 3).

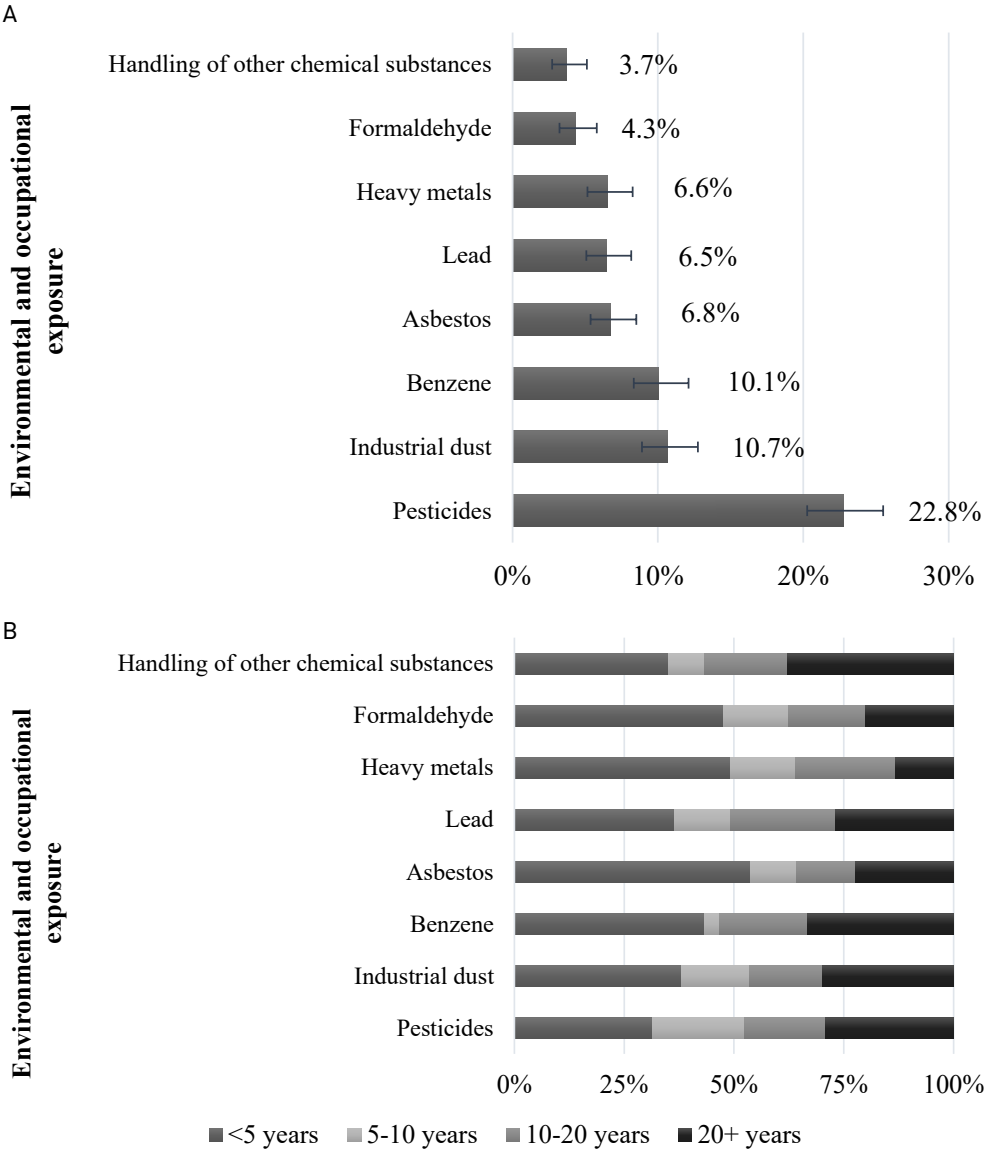

Figure 1. Prevalence (A) and time (B) of occupational and environmental exposure in cancer patients treated at reference hospitals in the state of Mato Grosso, Brazil.

Exposure to pesticides, industrial dust, benzene, asbestos, and heavy metals was more frequent among individuals with lower level of education (0 to 4 years of formal education) (Tables 1 and 3). Formaldehyde exposure was more frequent among those aged 18 to

Table 1. Prevalence of exposure to pesticides and industrial dust according to sociodemographic factors in cancer patients treated at reference hospitals in the state of Mato Grosso, Brazil.

Variable	n	%	95%CI
Exposure to pesticides			
Sex			
Men	177	38.99	34.59–43.57
Women	49	9.11	6.95–11.86
Age group (years)			
18 to 39	12	9.23	5.31–15.56
40 to 49	30	18.29	13.09–24.97
50 to 59	58	23.97	19.00–29.76
60 or older	126	27.63	23.72–31.92
Level of education (years)			
0 to 4	174	31.18	27.47–35.15
5 to 11	37	13.12	9.65–17.59
12 or more	15	10.00	6.12–15.93
Exposure to industrial dust			
Sex			
Men	84	18.50	15.19–22.35
Women	22	4.08	2.70–6.12
Age group (years)			
18 to 39	4	3.08	1.16–7.92
40 to 49	18	10.98	7.02–16.76
50 to 59	33	13.58	9.81–18.50
60 or older	51	11.18	8.60–14.42
Level of education (years)			
0 to 4	79	14.13	11.48–17.28
5 to 11	17	6.03	3.78–9.49
12 or more	9	6.00	3.15–11.14

95%CI: 95% confidence interval.

59 years and with five years or more of formal education (Table 4). The prevalence of lead exposure and handling of other chemical substances was similar between age groups and level of education groups (Tables 3 and 4).

Table 2. Prevalence of exposure to benzene and asbestos according to sociodemographic factors in cancer patients treated at reference hospitals in the state of Mato Grosso, Brazil.

Variable	n	%	95%CI
Exposure to benzene			
Sex			
Men	89	19.60	16.20–23.52
Women	11	2.04	1.14–3.66
Age group (years)			
18 to 39	9	6.92	3.64–12.78
40 to 49	11	6.75	3.77–11.78
50 to 59	36	14.81	10.88–19.86
60 or older	44	9.65	7.26–12.72
Level of education (years)			
0 to 4	67	11.99	9.54–14.95
5 to 11	26	9.25	6.37–13.25
12 or more	7	4.67	2.24–9.47
Exposure to asbestos			
Sex			
Men	60	13.27	10.44–2.71
Women	7	1.30	0.62–2.71
Age group (years)			
18 to 39	3	2.31	0.75–6.92
40 to 49	2	1.22	0.30–4.75
50 to 59	24	9.88	6.70–14.32
60 or older	38	8.39	6.16–11.32
Level of education (years)			
0 to 4	53	9.52	7.34–12.25
5 to 11	10	3.56	1.92–6.49
12 or more	4	2.67	1.00–6.90

95%CI: 95% confidence interval.

Table 3. Prevalence of exposure to lead and heavy metals according to sociodemographic factors in cancer patients treated at reference hospitals in the state of Mato Grosso, Brazil.

Variable	n	%	95%CI
Exposure to lead			
Sex			
Men	38	8.39	6.16–11.32
Women	26	4.82	3.30–6.99
Age group (years)			
18 to 39	14	10.77	6.48–17.37
40 to 49	7	4.27	2.05–8.69
50 to 59	15	6.15	3.75–9.99
60 or older	28	6.45	4.28–8.77
Level of education (years)			
0 to 4	33	5.91	4.23–8.21
5 to 11	21	7.45	4.90–11.16
12 or more	10	6.67	3.62–11.95
Exposure to heavy metals			
Sex			
Men	52	11.45	8.83–14.73
Women	13	2.41	1.40–4.11
Age group (years)			
18 to 49	9	3.06	1.60–5.78
50 to 59	18	7.41	4.71–11.46
60 or older	38	8.33	6.12–11.25
Level of education (years)			
0 to 4	50	8.94	6.84–11.61
5 to 11	12	4.26	2.43–7.35
12 or more	3	2.00	0.65–6.02

95%CI: 95% confidence interval.

Table 4. Prevalence of exposure to formaldehyde and handling of chemical substances according to sociodemographic factors in cancer patients treated at reference hospitals in the state of Mato Grosso, Brazil.

Variable	n	%	95%CI
Exposure to formaldehyde			
Sex			
Men	8	1.76	0.88–3.49
Women	35	6.49	4.70–8.91
Age group (years)			
18 to 39	10	7.69	4.19–13.72
40 to 49	12	7.32	4.20–12.45
50 to 59	13	5.35	3.13–9.00
60 or older	8	1.75	0.88–3.47
Level of education (years)			
0 to 4	6	1.07	0.48–2.37
5 to 11	26	9.22	6.35–13.20
12 or more	11	7.33	4.10–12.76
Exposure to handling of chemical substances			
Sex			
Men	26	5.76	3.95–8.34
Women	11	2.04	1.13–3.65
Age group (years)			
18 to 39	6	4.62	2.09–9.90
40 to 49	5	3.05	1.27–7.12
50 to 59	13	5.35	3.13–9.00
60 or older	13	2.87	1.67–4.88
Level of education (years)			
0 to 4	17	3.06	1.91–4.87
5 to 11	16	5.67	3.50–9.06
12 or more	4	2.67	1.00–6.90

95%CI: 95% confidence interval.

DISCUSSION

Among the environmental and occupational exposures of cancer patients participating in this research, the most common were pesticides, followed by industrial dust, marble powder, wood dust, or leather powder as well as benzene, lead, and heavy metals.

Pesticides was the most mentioned type of exposure. The state of Mato Grosso is the largest consumer of pesticides in Brazil[8], and these are among the most toxic, many of which are prohibited in other countries and with trading regulations, unlike what currently occurs in Brazil[9]. Even considering that this pollutant also affects the general population, including healthy people, it is worth mentioning the possibility of this exposure influencing the predisposition of the population to an increase in the occurrence of cancer in this region. Taking this into consideration, a systematic review study that evaluated occupational exposure to organophosphate pesticides and hematologic neoplasms identified that individuals with longer periods of exposure were also the ones with the highest occurrences of this type of cancer, and among the different types of pesticides, organophosphates were the most prevalent[10]. Another integrative literature review on published studies in relation to exposure to pesticides and cancer focused on farmers, rural population, pesticide applicators, and rural workers, found higher occurrences of cancer among farmers; prostate, non-Hodgkin lymphoma, leukemia, multiple myeloma, bladder, and cervical cancer were among the types of cancer. The same study reports that organophosphorus compounds, pyrethroid, organic chlorine compounds, and thiocarbamates were among the most frequent chemical groups mentioned in cancer patients in Brazil[11].

Other analyzed pollutants were dusts originating from particulate matter, in addition to those originating from soils and industrial dusts. Exposure to silica dust is also significant in Mato Grosso due to the extraction of limestone, gravel, and cement in cities with intense mineral exploration activity[6]. In addition to increasing the prevalence of respiratory diseases, these dusts are also causing lung and skin cancer, among others. Poinen-Rughooputh et al.[12] reviewed several studies in populations exposed to dust, finding higher prevalence of lung cancer in groups directly exposed to these pollutants such as workers in the mining industry and the population adjacent to these workplaces. In the state of Mato Grosso, the presence of the wood industry stands out. The dust originating from its milling is a complex mixture due to its processing. Exposure to this substance occurs both at work, during the use of machines or tools to cut or shape wood, as well as in the environment, from the furniture industry, joinery, among others[13].

The present study also evaluated exposure to benzene among cancer patients. According to IARC, this substance is classified as Group 1 carcinogenic agent and has no safe limit of exposure for the human species[1]. Regarding its carcinogenicity, specifically in relation to its chronic exposure, quantitative changes in blood cells are reported, such as leukopenia, thrombocytopenia, and erythropenia, and, among the most serious effects, acute and chronic leukemias[14]. A systematic review with meta-analysis conducted by Jephcote et al.[15] evaluated residents who lived near petrochemical centers and recorded a higher incidence of

hematologic neoplasia in relation to the general population. In Brazil, the Brazilian National Cancer Institute (INCA), together with the Ministry of Health, developed a manual on cancer surveillance related to work and the environment, relating, among other chemical substances, benzene as the main cause of leukemia among workers in the petrochemical sector, including those who distributed and traded fossil fuels, especially petrol[16].

This research also analyzed the exposure of cancer patients to heavy metals, also considered harmful to health due to their high level of reactivity and their bioaccumulation capacity in animals and humans. Its exacerbated exposure leads to an accumulation of free radicals with consequent oxidative stress and, subsequently, to tumor development in the carcinogenesis process[17]. Several pesticides, chemical fertilizers, and heavy metals, common in mining activities, are frequently used in the state of Mato Grosso, allowing the authors to assume that these environmental contaminants may have partly contributed to the occurrence of some cancers in the studied population. Cruz et al.[18], in a review study on the influence of heavy metals on cancer clinical involvement, mention lung, skin, ovary, breast, stomach, brain, and larynx as related to the exposure to heavy metals. In addition, mercury, particularly and regularly used in the extraction of gold in Mato Grosso, by its absorption, mainly in the form of vapor via the inhalation route, is widely cited as causing several organic effects, including chromosomal anomalies and cancer[19].

As for sex, for all pollutants, exposure to environmental factors was higher among men, who mostly have outdoor jobs or those in industries and factories, compared with women, both concerning formal and informal jobs, except for formaldehyde, whose exposure was higher in women. There are several studies that refer to men as the most vulnerable, even in the general population. For instance, in a quantitative study that analyzed work-related cancer notification forms at an oncology reference hospital in the state of Mato Grosso do Sul (Brazil), almost 100% of the notifications were men. Accordingly, the International Labor Organization reports that men have activities in productive sectors at risk, and are therefore more exposed to carcinogens[20]. However, among environmental pollutants, formaldehyde is one of the main toxicants present in compounds used in hair straightening, having mostly women among customers and workers[21]. Furthermore, the majority of participants (cancer patients in waiting rooms) were women, although men accounted for excess exposure. This possibly occurred due to the higher prevalence of cancers in women, such as breast and cervical cancer, the second and third most common in the environments where patients were interviewed.

Regarding the age group, as expected, older individuals also presented higher occurrences of exposure, demonstrating that the progressive increase in the prevalence of exposure was concomitant with increased age[22]. The effect of the birth cohort is significantly important for the accumulation of exposure to several environmental risk factors, possibly reflecting the higher risk of development of most cancers, which, mostly, depend on a large temporal gradient of exposure.

The present study found individuals with lower level of education with higher prevalence of exposure to the analyzed pollutants. This pattern is also expected in the population of

healthy individuals. In this sense, the literature is quite rich and concordant. For example, in relation to heavy metals[23], a study analyzing cases of heavy metal poisoning in the state of Paraná (Brazil) found a predominance of individuals with low level of education intoxicated by mercury and lead. Lara et al.[24] identified a positive correlation between environmental exposure and pesticide consumption in the municipalities of Mato Grosso, identifying that the agribusiness regions that most produce agricultural commodities (soybean cotton, corn, and sugarcane) also have a higher number of poisonings by agricultural pesticides. Furthermore, considering level of education as a proxy variable for income, it is expected and likely that the exposure of people with lower level of education does not differ from the general population, as these individuals deal more directly with these products in the various jobs of lower professional qualification, both in agribusiness activities and in prospecting and other mineral extraction activities.

It is worth mentioning some possible limitations of the present study. This is a descriptive research without a comparison group, that is, participants without cancer, in such a way that these results should be interpreted with some parsimony, and these findings may not be statistically different from the population without the studied effect, that is, being a noncancer patient.

It is worth highlighting that the study population, diagnosed with cancer, due to greater access to health services, was exposed to risks for different types of cancer, several of which not necessarily associated with occupational exposures. There was also a higher representation of women in the study population, while men had higher prevalence of exposure, and in this case, the occurrence of selection bias, in which men may be underrepresented, must be considered. Another limitation is the effect of age and the birth cohort, as older populations tend to have higher accumulated exposures to risk factors analyzed for the time being.

Finally, it is important to emphasize that exposure measurements were indirectly obtained from a structured questionnaire. In this regard, the difficulty and even the lack of direct methods for collecting biological material and other diagnostic methods should be considered, which were also unfeasible due to ethical issues when it comes to convalescent individuals, in which no invasive intervention to obtain this type of information would be justified[25].

Concerning the strengths, the present study is a pioneer in the measurement of exposures to various environmental and occupational factors to the several types of cancers in reference hospitals in Cuiabá. It should also be considered that its results contribute to the discussions on evaluation of environmental and occupational contaminations, in such a way that other epidemiological studies using comparison groups and new designs are carried out to better understand the influence of these contaminants on the occurrence of cancer.

This study allowed identifying the main environmental and occupational exposures of cancer patients undergoing treatment in the state of Mato Grosso and the most vulnerable groups. Pesticides were the most frequent exposure, approximately one in five cancer patients, and one in ten was exposed to industrial dust and benzene, with higher exposure among men, older individuals, and those with lower level of education.

ACKNOWLEDGMENTS

The authors would like to thank the Public Health Institute of Universidade Federal de Mato Grosso, the State Department of Health of Mato Grosso, and the Ministry of Public Labor Prosecution of the 23rd Region for funding the project, and the Brazilian National Cancer Institute for contributing to the training of cancer registrars.

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Received on: 08/24/2021
Reviewed on: 03/27/2022
Accepted on: 03/29/2022
Preprint: 04/27/2022
https://preprints.scielo.org/index.php/scielo/preprint/view/3983
Corrected on: 09/13/2024

Authors' contributions: Silva, A.M.C.: Writing – original draft, Writing – review & editing, Methodology, Validation, Visualization. Soares, M.R.: Project administration, Investigation. Silva, N.A.: Conceptualization, Writing – original draft, Investigation. Correa, M.L.M.: Writing – original draft, Visualization. Machado, J.M.H.: Writing – original draft, Visualization. Pignati, W.A.: Writing – original draft, Visualization. Andrade, A.C.S.: Formal analysis, Conceptualization, Data curation. Galvão, N.D.: Project administration, Funding acquisition, Resources, Supervision, Validation.