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# Bibliometric analysis of scientific productions related to the use of the word pesticide and associated terms

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## ABSTRACT

The use of pesticides grew significantly with the introduction of synthetic chemicals in the 1940s. Pesticides are used in many areas, such as agriculture, commerce, households and industries, but they can negatively impact biodiversity and human health. Brazil is the second largest consumer of pesticides in the world and Mato Grosso do Sul is in seventh position among the states with the highest use of these chemical products. This study presents a bibliometric analysis of the quantified scientific production of publications expressed to every 100,000 inhabitants related to pesticides. The study was based on databases, *Scopus* and *Web of Science*, considering different geographical levels, including worldwide, Brazil and Mato Grosso do Sul. The terms "*Disease*" and "*Death*" are the terms that present the highest number of studies in all databases and with the words selected at the individual search level. The study shows that the combination "*Pesticide AND Exposure*" has many studies in all databases. The analysis results show that indigenous are frequently associated with publications on pesticides, especially in Mato Grosso do Sul.
**Keywords:** Indigenous. Exposure. Disease.

# Análise bibliométrica das produções científicas relacionadas ao uso da palavra pesticida e termos associados

## RESUMO

O uso de pesticidas cresceu significativamente com a introdução de produtos químicos sintéticos na década de 1940. Os pesticidas são utilizados em diversas áreas, como agricultura, comércio, residências e indústrias, mas podem causar impactos negativos na biodiversidade e na saúde humana. O Brasil é o segundo maior consumidor de pesticidas do mundo e Mato Grosso do Sul está na sétima posição entre os estados com maior uso desses produtos químicos. Este estudo apresenta uma análise bibliométrica relativa a produção científica quantificada de publicações expressa em relação a cada 100 mil habitantes, relacionada aos pesticidas. O estudo se baseou nas bases de dados, *Scopus* e *Web of Science*, considerando diferentes níveis geográficos, incluindo mundial, Brasil e Mato Grosso do Sul. Os termos "*Disease*" e "*Death*" são os termos que apresentam os maiores números de estudos em todas as bases de dados e com as palavras selecionadas em nível de busca individual. O estudo mostra que a combinação "*Pesticide AND Exposure*" apresentam um número elevado de estudos em todas as bases de dados. Os resultados das análises mostram que os povos indígenas são frequentemente associados às publicações sobre pesticidas, especialmente em Mato Grosso do Sul.
**Palavras-chave:** Povos indígenas. Exposição. Doença.

## INTRODUCTION

According to FAO (2021), pesticides are composed of insecticides, fungicides, herbicides, disinfectants, and other mixtures of substances used to prevent, destroy or control pests that may interfere with the production, processing, storage, transport, or marketing of food, agricultural products, wood, wood products and animal feed. While generally associated with chemicals manufactured in facilities, "*pesticide*" can also include living organisms and management practices that seek to restore balance to an unhealthy system (DONLEY et al., 2022).

The use of pesticides grew significantly in the 1940s with the introduction of synthetic chemicals for crop protection (CARVALHO, 2017). Pesticides are applied in diverse areas, such as agriculture, commerce, homes and industries, but they can negatively impact biodiversity and human health (DONLEY et al., 2022; FAO, 2021; LI; JENNINGS, 2017). Although Brazil is the second largest consumer of pesticides in the world, with 377 tons consumed in 2020, the country ranks 27th in terms of pesticide use per cultivated area (FAO, 2021). Pesticides are regulated in Brazil by Decree 4074-2002 and are considered pesticides (BRASIL, 2002).

Using pesticides in the environment can result in negative impacts, such as the collapse of bee colonies, contamination of rivers and intoxication of humans and animals (BETTS et al., 2020; EEA, 2013). Based on scientific evidence, it is increasingly likely that the exposure of freshwater fish species to contaminants in the surface water is causing problems such as immunosuppression and intersexuality (LI et al., 2020). Pesticide poisonings kill about 355,000 people a year, two-thirds in developing countries (LI; JENNINGS, 2017; WHO, 2010). Human exposure to pesticides can occur through ingestion of contaminated food or water, inhalation of contaminated air and dermal contact with contaminated water, air, food, or soil (FAO, 2021; LI; JENNINGS, 2017).

Occupational pesticide exposure is estimated at 25 million cases yearly (JEYARATNAM, 1990). Pesticides can cause several neurological and general effects in humans, such as the link between Diabetes and DNA methylation in indigenous populations of Mexico (LEE et al., 2011; PAREDES-CÉSPEDES et al., 2021). Pesticide poisoning among indigenous is an alarming reality that continues today. Reports such as the chemical attack on the *Guyra Kambi'y* resumption in 2015, the report of intoxication in the Guyraroká village in 2019 and the finding of violence in villages and indigenous

areas in six municipalities in the Cone Sul of Mato Grosso do Sul in 2016, demonstrate the urgency to face the problems (BARBOSA, 2019; CONSEA, 2017; GRIGORI, 2019).

Several studies address the relationship between pesticide use and human mortality (ABU BAKAR et al., 2023; BAI et al., 2023) and the connection between pesticides and diseases (JOKANOVIĆ, 2018; YAN et al., 2018). In addition, some studies investigate the relationship between pesticides and aggression and pesticides and exposure (LERRO et al., 2021; MILONE et al., 2021; YUAN et al., 2022). Researchers also address the issue of the relationship between pesticides and hospitalization (CHEFIRAT et al., 2023; TAO et al., 2022).

Pesticides have been widely used in Brazil's Southeast, South and Midwest regions. Mato Grosso do Sul is the seventh state with the highest use of these chemical products (EMBRAPA, 2021). This state is the first concerning indigenous in the Center-West region and the second in the self-declared indigenous population throughout the country (IBGE, 2012). Some studies address the relationship between pesticides and indigenous (LI et al., 2023; SHANKER et al., 2023; ZHU et al., 2023).

Considering the scenario of pesticide-related studies, it is essential to highlight the importance of carefully choosing the keywords used in this study, both worldwide and in Brazil, mainly in Mato Grosso do Sul. This state has a significant population of indigenous and is a predominantly agricultural region, which underscores the need to deepen knowledge about pesticides and their impacts in this region. By selecting relevant pesticide terms, it will be possible to support in-depth research and gain a broad understanding of the subject.

The objective of this study is to conduct research using a quantitative approach, to analyze published articles on pesticides and other related terms. Specifically, we seek to establish an index of the number of publications per population, considering global, national (Brazil), and regional (Mato Grosso do Sul) scopes. With this, it is intended to verify which terms are most frequently associated and what is the extent of publications in the different areas analyzed. The final objective is to contribute to the advancement of knowledge on the subject and provide relevant information regarding the number of publications and information that contribute to the development of strategies aimed at population health, food safety and the environment.

## MATERIALS AND METHODS

The present study is bibliographic research with a quantitative approach, which used data collected from the Scopus and Web of Science databases. According to (SOARES et al., 2018), bibliometric studies in Brazil are often based on these large databases.

Two searches were carried out in the databases. In the first (on November 7, 2022), keywords were used alone, including "Pesticide", "Exposition", "Intoxication", "Accident", "Indigenous", "Death", "Disease", "Aggression", "Neurological", "Psychiatric", "Hospitalization" and "Exposure". These searches were carried out in worldwide areas, then restricted to Brazil and later to Mato Grosso do Sul (MS), using "Brazil" and "MS" as filters separately. The second search (on November 18, 2022) used the term "Pesticide" together with the keywords of the first search, using the AND operator, also with the same filters.

*Excel 365*® and *R* software, with the *biblioshiny* library, were used to analyze the results. The indices of articles published in relation to the world, Brazil and Mato Grosso do Sul populations of the base year of 2022 were calculated and described as the world, Brazil and Mato Grosso do Sul scopes, using equations (Eq. 1, 2, and 3), as follows:

For world population:

$$IndM = \frac{ArtM}{PopM} * 100{,}000 \quad \text{(Eq. 1)}$$

Where:

***ArtM:*** total articles published worldwide.

***PopM*****:** total world population in the base year of 2022.

***IndM*****:** number of articles per 100,000 inhabitants of the world population (art/100,000 inhab). Result of the total number of articles published worldwide, divided by the total world population and multiplied by 100,000 inhabitants.

For the population of Brazil:

$$IndB = \frac{ArtB}{PopB} * 100{,}000 \quad \text{(Eq. 2)}$$

Where:

***ArtB:*** total articles published in Brazil.

***PopB:*** total population of Brazil in the base year of 2022.

***IndB:*** number of articles per 100,000 inhabitants of the Brazilian population (art/100,000 inhab). Result of the total number of articles published in Brazil, divided by the total population of Brazil and multiplied by 100,000 inhabitants.

For the population of Mato Grosso do Sul:

$$IndMS = \frac{ArtMS}{PopMS} * 100{,}000 \quad \text{(Eq. 3)}$$

Where:

***ArtMS:*** total number of articles published in Mato Grosso do Sul.

***PopMS:*** total population of Mato Grosso do Sul in the base year of 2022.

***IndMS:*** number of articles per 100,000 inhabitants of the population of Mato Grosso do Sul (art/100,000 inhab). Result of the total number of articles published in the scope of Mato Grosso do Sul, divided by the total population of Mato Grosso do Sul and multiplied by 100 thousand inhabitants.

Table **1** was prepared to present the values of the articles and calculated indexes, separated by columns in each database (*Scopus* and *Web of Science*), with two grouping categories: individual grouping for the search for keywords in isolation and the grouping associated with the use of the term "*Pesticide*" associated with the other keywords. The values are separated into three geographical areas: worldwide (ArtM and IndM columns), Brazil (ArtB and IndB columns) and Mato Grosso do Sul (ArtMS and IndMS columns) for each database.

## RESULTS AND DISCUSSION

Table 1 presents the number of articles per 100,000 inhabitants (art/100,000 inhab) in the world, Brazil and MS areas. The three highest index values in each category were highlighted in green to highlight the most relevant terms in this study.

The term "*Disease*" obtained the highest values in both databases (*Scopus* and *Web of Science*), as well as in all areas (worldwide, Brazil and MS). When using the term "*Pesticide AND*" in conjunction with other keywords, it is noteworthy that the term "*Pesticide AND Exposure*" reached the maximum values in the results in all bases and fields (Table 1).

### *Contribution of databases in relation to keywords*

Regarding the number of published articles, the bases have similar percentages. However, the *Scopus* database slightly differs in the number of publications. The

publications in absolute numbers, the values at the world level surpass the other levels. However, Mato Grosso do Sul stands out regarding publications with pesticides in relation to Brazil when the raw number is relativized by its population, especially in the *Web of Science* database (Table 1).

**Table 1 -** Absolute numbers and relative indexes of published articles according to the population concerning the terms used in the survey.

| | **Scopus** | | | | | | **Web Of Science** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Worldwide** | | **Brazil** | | **MS** | | **Worldwide** | | **Brazil** | | **MS** | |
| **Individual** | | | | | | | | | | | | |
| **Keywords** | **ArtM** | **IndM** (***art/100,000 inhab***) | **ArtB** | **IndB** (***art/100,000 inhab***) | **ArtMS** | **IndMS** (***art/100,000 inhab***) | **ArtM** | **IndM** (***art/100,000 inhab***) | **ArtB** | **IndB** (***art/100,000 inhab)*** | **ArtMS** | **IndMS** (***art/100,000 inhab)*** |
| Pesticide | 167395 | 2.09 | 2180 | 1.01 | 24 | 0.85 | 159421 | 1.99 | 3055 | 1.42 | 50 | 1.76 |
| Exposition | 35024 | 0.44 | 326 | 0.15 | 1 | 0.04 | 170529 | 2.13 | 3545 | 1.65 | 12 | 0.42 |
| Intoxication | 260793 | 3.26 | 834 | 0.39 | 11 | 0.39 | 46810 | 0.59 | 1444 | 0.67 | 24 | 0.85 |
| Accident | 641466 | 8.02 | 3931 | 1.82 | 18 | 0.63 | 179465 | 2.24 | 1932 | 0.90 | 3 | 0.11 |
| Indigenous | 158041 | 1.98 | 3688 | 1.71 | 108 | 3.80 | 125320 | 1.57 | 4994 | 2.32 | 156 | 5.49 |
| Death | 1538947 | 19.24 | 11392 | 5.29 | 74 | 2.61 | 1151253 | 14.39 | 24793 | 11.51 | 220 | 7.75 |
| Disease | 10704265 | 133.80 | 65574 | 30.43 | 506 | 17.82 | 6409025 | 80.11 | 114619 | 53.19 | 824 | 29.02 |
| Aggression | 104008 | 1.30 | 718 | 0.33 | 6 | 0.21 | 77318 | 0.97 | 1302 | 0.60 | 9 | 0.32 |
| Neurological | 388716 | 4.86 | 1658 | 0.77 | 15 | 0.53 | 566853 | 7.09 | 9533 | 4.42 | 50 | 1.76 |
| Psychiatric | 383840 | 4.80 | 2667 | 1.24 | 5 | 0.18 | 1044823 | 13.06 | 5910 | 2.74 | 8 | 0.28 |
| Hospitalization | 479377 | 5.99 | 5065 | 2.35 | 19 | 0.67 | 196281 | 2.45 | 4739 | 2.20 | 31 | 1.09 |
| Exposure | 1792019 | 22.40 | 10295 | 4.78 | 44 | 1.55 | 1368834 | 17.11 | 34097 | 15.82 | 273 | 9.62 |
| **Pesticide AND** | | | | | | | | | | | | |
| Exposition | 293 | < **0.006** | 8 | < **0.006** | 0 | - | 669 | 0.01 | 4 | < **0.006** | 5 | 1.76 |
| Intoxication | 6785 | 0.08 | 101 | 0.05 | 3 | 1.06 | 75 | < **0.006** | 0 | - | 0 | - |
| Accident | 1183 | 0.01 | 37 | 0.02 | 1 | 0.35 | 131 | < **0.006** | 0 | - | 0 | - |
| Indigenous | 862 | 0.01 | 17 | 0.01 | 0 | - | 1532 | 0.02 | 14 | 0.01 | 2 | 0.70 |
| Death | 3890 | 0.05 | 79 | 0.04 | 3 | 1.06 | 5446 | 0.07 | 10 | < **0.006** | 3 | 1.06 |
| Disease | 22043 | 0.28 | 380 | 0.18 | 5 | 1.76 | 33 | - | 0 | - | 0 | - |
| Aggression | 94 | < **0.006** | 1 | - | 0 | - | 667 | 0.01 | 2 | < **0.006** | 0 | - |
| Neurological | 792 | 0.01 | 5 | < **0.006** | 0 | - | 87 | < **0.006** | 0 | - | 0 | - |
| Psychiatric | 200 | < **0.006** | 10 | < **0.006** | 0 | - | 71 | < **0.006** | 0 | - | 0 | - |
| Hospitalization | 385 | < **0.006** | 12 | 0.01 | 0 | - | 158 | < **0.006** | 3 | < **0.006** | 0 | - |
| Exposure | 34339 | 0.43 | 550 | 0.26 | 6 | 2.11 | 1368834 | 17.11 | 34097 | 15.82 | 273 | 96.15 |

**ArtM** = total articles published worldwide

**IndM** = Index of articles published worldwide per 100,000 inhabitants

**ArtB** = total articles published in Brazil

**IndB** = Index of articles published worldwide per 100,000 inhabitants

**ArtMS** = total articles published in Mato Grosso do Sul

**IndMS** = Index of articles published in Mato Grosso do Sul per 100,000 inhabitants

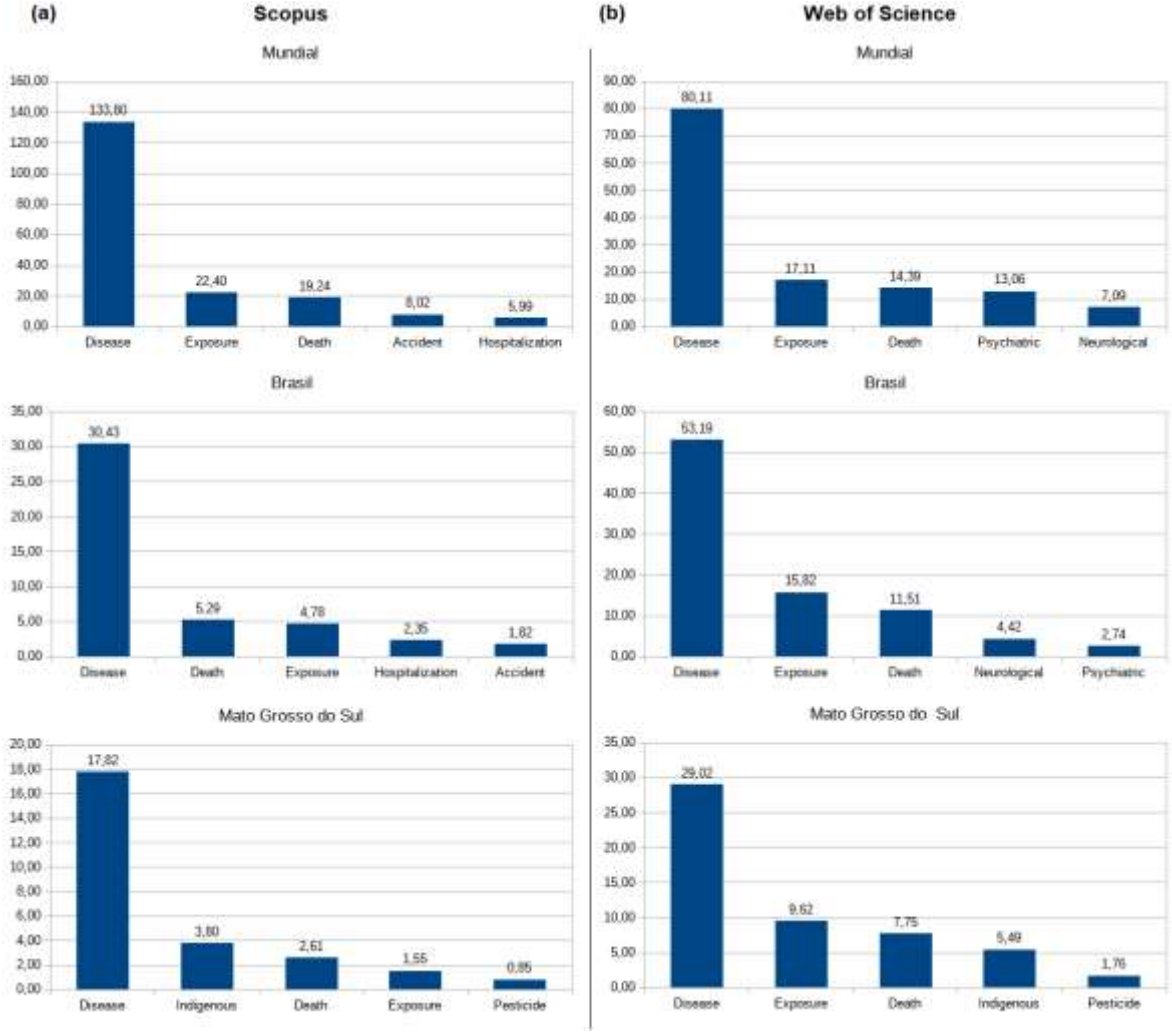
**< 0.006** = Index of articles with a total less than 0.006

**-** = Index of articles that presented a value of 0.000

**(*art/100,000 inhab*)** = number of articles per 100,000 inhabitants.

When analyzing the indexes by keyword, it is observed that the term "*Disease*" reached the highest indexes worldwide, Brazil and Mato Grosso do Sul. The term "*Death*" was in second or third place in the indexes in all scopes (Figure **1**).

**Figure 1 -** The five most extensive indexes of articles published on a scale of 100,000 inhabitants worldwide, Brazil and Mato Grosso do Sul spheres for searching for terms individually. Column (a) contains data from the *Scopus* database and column (b) from the *Web of Science* databases.




The term "*Exposure*" appears in second or third place in all areas surveyed and, in both databases, except in the Mato Grosso do Sul sphere of the *Scopus* base (Figure **1**), where the term appears in fourth place. Other terms that stood out among the top five in

both databases were: "*Indigenous*", "*Psychiatric*", "*Neurological*", "*Pesticide*", "*Neurological*" and "*Hospitalization*".

An interesting fact is the representatives of the term "*Indigenous*" (Table **1**). In the Brazilian context, the same term goes to the sixth position in the *Scopus* and *Web of Science* databases. When referring specifically to Mato Grosso do Sul, the term appears in second and third place (Figure **1**).

The substantial number of publications may be related to the fact that Mato Grosso do Sul has the most prominent indigenous in the Midwest region and the second Brazilian state in the number of indigenous peoples (CHAMORRO; COMBÈS, 2019). In addition, as highlighted by Chamorro and Combes (2019), the state has been the target of complaints of violations of the human rights of indigenous, which may have contributed to the increase in publications on the subject.

There are reports of pesticide poisoning suffered by indigenous in Brazil and Oregon, in the United States (FARQUHAR et al., 2008). In both cases, there is information about lack of training and exposure to worrying levels of pesticides, which has led to health problems in adults and children, including skin and eye irritation, diarrhea, fever and headaches and sore throats. (FARQUHAR et al., 2008). In addition, research on violence and human rights violations in indigenous areas in the Cone Sul of Mato Grosso do Sul has been affected by the expansion of agribusiness and the intensive use of pesticides (CONSEA, 2017). Land demarcation and titling, access to public policies, and guaranteeing the human right to food are possible solutions to these problems (CONSEA, 2017).

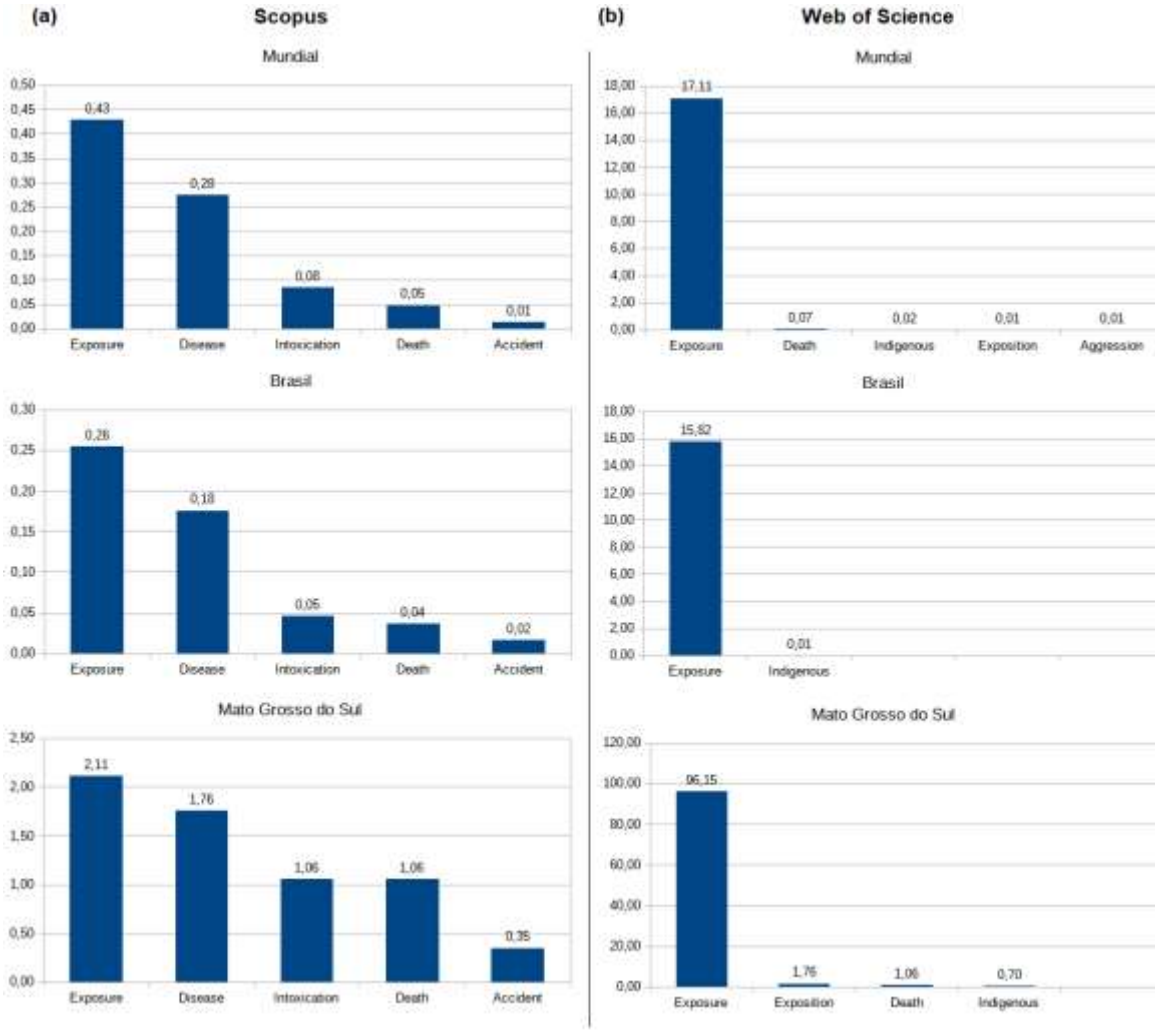
***Searches for pesticides associated with terms***

In the second part of Table **1**, we present the association of "*Pesticide*" with other terms in descending order. The combination "*Pesticide AND Exposure*" obtained the highest rates in all areas surveyed and in both databases (*Scopus* and *Web of Science*). In the *Scopus* database, "*Pesticide AND Disease*" occupied the second position among most publications (Figure **2**). At the same time, "*Pesticide AND Intoxication*" appeared in the third position (Table **1**) and also in the *Scopus* database (Figure **2**). In the *Web of Science* database, other combinations of terms that stand out are "*Pesticide AND Indigenous*" and "*Pesticide AND Death*" (Figure **2**).

There is a difference in the results obtained in the combination of the terms "*Pesticide AND Exposure*" in the *Scopus* and *Web of Science* databases, with the *Web of Science* presenting much higher indexes in relation to the *Scopus* base in this specific combination of terms (Figure 2). The association in the search between "*Pesticide AND Exposure*" has been explored in several studies, such as the incidence of cancer among workers in rural areas (LERRO et al., 2021; YUAN et al., 2022), the production of royal jelly by bees (MILONE et al., 2021), Parkinson's disease (PALANISAMY et al., 2022), contamination of river water (MAHLER et al., 2021; QAZI et al., 2023), among others.

The use of pesticides in agriculture has been associated with several adverse effects on human health. Among these effects, contamination by organochlorine pesticides (OCP) in breast milk has been a concern, especially for women living in rural areas of Latin American countries. Exposure to these pesticides may increase the risk of breast cancer in women and neurodevelopmental disorders in children (POLANCO RODRÍGUEZ et al., 2017). Furthermore, studies show that exposure to organophosphate pesticides may contribute to the burden of Attention Deficit Hyperactivity Disorder (ADHD) in childhood. Higher levels of exposure to these pesticides have been associated with adverse outcomes in mental development (BOUCHARD et al., 2010).

**Figure 2:** The five highest indexes of articles published on a scale of 100,000 inhabitants worldwide, Brazil and Mato Grosso do Sul spheres for the "Pesticide AND" survey. Column (a) contains data from the *Scopus* database and column (b) from the *Web of Science* database.




The combination of "*Pesticide AND Indigenous*" has also been the subject of several studies in different regions of the world, including Asia (BANO et al., 2021; RAMANAGOUDA; NAIK, 2021), America (LOPEZ-CARMEN et al., 2022; PAREDES -CÉSPEDES et al., 2021), Europe (BIONDI, A et al., 2013), Oceania (GAW et al., 2019) and Africa (GERBER et al., 2016; THEODORY, 2021). The term "*Pesticide AND Disease*" ranked second on the world scale in Brazil and third in MS (Table 1). There are research reports that associate the use of pesticides with degenerative diseases (JOKANOVIĆ, 2018; MOSTAFALOU; ABDOLLAHI, 2018), Parkinson's (YAN et al., 2018), Alzheimer's (YAN et al., 2016), cardiovascular diseases (WAHAB et al., 2018) and others.

Different studies also suggest that agricultural work involving pesticides may be associated with respiratory symptoms, such as asthma. Exposure to these pesticides can increase the prevalence of these symptoms, especially when exposure exceeds two days a month (FARIA et al., 2005; FIETEN et al., 2009). In addition to the effects already mentioned, there are concerns about the role of pesticides in developing other diseases, such as myasthenia gravis. Studies suggest that the different chemical substances in pesticides can act as antigenic stimulators for developing this disease (CAMARGO, 2015).

## FINAL CONSIDERATIONS

This study presented a bibliometric analysis of the quantity and types of publications related to the use of pesticides at three levels: worldwide, Brazil, and Mato Grosso do Sul. The *Scopus* database has more publications than other databases in absolute numbers. The analysis of the most used keywords in the publications revealed that "*Disease*" was the most frequent in the world, Brazil and Mato Grosso do Sul. The term "*Death*" ranked second or third in the number of publications in searches carried out in all spheres.

The term "*Indigenous*" was also widely used in publications and appeared in relevant positions in the searches. Some publications are related to human rights issues of indigenous and problems caused by pesticides. In addition, it was observed that the combination of the terms "*Pesticide AND Exposure*" and "*Pesticide AND Disease*" were the most frequent in the analyzed publications, which highlights the importance of research in this specific area.

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