

## Use of pesticides in Pernambuco sugarcane fields and damage to workers' health

*Uso de agrotóxicos em canaviais de Pernambuco e danos à saúde do trabalhador*

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**ABSTRACT** This study aims to analyze exposure to pesticides and harm to the health of workers on sugarcane plantations in Pernambuco. This participatory research was conducted in rural territories of five municipalities with a strong presence in sugarcane-planted areas. The primary data were produced in workshops with rural workers to construct a participatory rural diagnosis, analyzed through condensation of meanings, and interpreted in light of the theoretical framework of Latin American critical epidemiology. The results are presented in three sections: i) Flowchart of work on sugarcane plantations; ii) Exposure to pesticides used on crops; iii) Harm to worker's health. We conclude that permanent exposure to pesticides involves working on sugarcane plantations and emerges from a historical and socio-environmental construct in which the ways of life of the territories under the control of sugarcane agribusiness are subsumed. Public policies are recommended to promote family farming with diversification, flow, distribution of agroecological production, and strengthening primary health care and integrated epidemiological, health, environmental, and worker surveillance actions.

**KEYWORDS** Saccharum. Rural workers. Agrochemicals. Rural health.

**RESUMO** O presente estudo teve por objetivo analisar a exposição aos agrotóxicos e os danos à saúde dos trabalhadores das plantações de cana-de-açúcar em Pernambuco. Trata-se de pesquisa participante desenvolvida em territórios rurais de cinco municípios com forte expressão em área plantada de cana-de-açúcar. Os dados primários foram produzidos em oficinas com trabalhadores rurais para construção de diagnóstico rural participativo, analisados mediante condensação de significados e interpretados à luz do referencial teórico da epidemiologia crítico latino-americana. Os resultados estão apresentados em três seções: i) Fluxograma do trabalho nas plantações de cana-de-açúcar; ii) Exposição aos agrotóxicos utilizados nas lavouras; iii) Danos à saúde do trabalhador. Conclui-se que a exposição permanente aos agrotóxicos envolve o trabalho nas plantações de cana-de-açúcar e emerge de um construto histórico e socioambiental, em que se encontram subsumidos os modos de vida dos territórios sob o domínio do agronegócio canavieiro. Recomendam-se políticas públicas de fomento à agricultura familiar com diversificação, escoamento e distribuição da produção agroecológica, além do fortalecimento da Atenção Primária à Saúde e de ações integradas de vigilância epidemiológica, sanitária, ambiental e do trabalhador.

**PALAVRAS-CHAVE** Saccharum. Trabalhadores rurais. Agroquímicos. Saúde da população rural.

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## Introduction

In Brazil, 720.87 thousand tons<sup>1</sup> of pesticides were consumed in 2021 alone, which places the country among the world's largest consumers of these agents. Soy, corn, cotton, and sugar cane monocultures comprise 85% of the total pesticides used<sup>2</sup>. According to Bombardi<sup>3</sup>, Brazil had 715 pesticides with authorized use in 2017, 177 of which had been prohibited for use in the European Union (EU)<sup>3</sup>, which expresses a Brazilian situation permeated by conflicts of interest that directly interfere with the environmental and health regulation of the country. This situation has deteriorated in recent years with the authorization of use and the realization of 2,807 new pesticide registrations between 2017 and the first half of 2022<sup>4</sup>.

Brazil has the most significant sugarcane production in the world. Pernambuco is the second-largest producer in the North and Northeast, with 134 thousand hectares of planted area and production of around 7 thousand tons/year<sup>5</sup>. The state has the third-highest number of agricultural establishments using pesticides and the second-highest record of deaths related to exogenous poisoning<sup>3</sup>.

Recent studies denounce the painfulness of human work, its exploitation by the sugar and alcohol sector, and the deteriorated health of sugarcane workers, who are daily exposed to the substandard, unsafe, and unhealthy conditions of the production process – besides the preserved historical and structural inequalities imposed to rural territories with direct implications for local epidemiological profiles<sup>6,7</sup>.

Conventional epidemiology understands the exposure category based on the assumptions of externality and eventuality, which govern the causal relationship of the organism exposed to the toxic substance. In contrast, the dialectical perspective of critical epidemiology broadens the spectrum of observation by considering the ecosocial history of exposure and distinguishes it as occasional, chronic, or permanent. The permanent exhibition refers to the imposed work and consumption

patterns, invariable and intrinsic to the ways of life subsumed by the hegemonic productive logic<sup>8</sup>.

The contradictions arising from the relationship between health, environment, and work must be clarified in this context. Furthermore, this occurs through the production of data and scientific information with the active participation of affected populations and communities so that it becomes feasible to support strategic planning and political decision-making for reconfiguring health praxis and effective coping with the problems. This article analyzes the exposure to pesticides and harm to the health of sugarcane workers in Pernambuco, Brazil.

## Material and methods

This participatory research<sup>9</sup> with exploratory and qualitative analysis aimed to understand the subjects' meanings, interactions, and behaviors in their experiences and circumstances<sup>10</sup>. It was developed in rural territories located in five municipalities with a strong expression in sugarcane planted areas, which are considered a priority for monitoring pesticide exposure in Pernambuco<sup>11</sup>: Água Preta and Sirinhaém, in Zona da Mata Sul; and Goiana, Itambé, and Aliança, located in Zona da Mata Norte.

Primary data was collected from January to August 2022 through workshops in exposed communities to build a Participatory Rural Diagnosis (PRD) on socioenvironmental vulnerabilities arising from the sugar-energy production process. The PRD promotes the direct acquisition of primary information through pedagogical tools that facilitate dialogue, the systematic assessment of problems, and solution opportunities, encouraging “self-analysis and self-determination of community groups”<sup>12(13)</sup>.

Coordination visits were conducted with community leaders in the territories to mobilize a workshop per municipality to build ‘work flowcharts’<sup>12,13</sup> in the sugarcane fields.

Each workshop lasted two hours and had an average of ten participants, selected over the age of 18, residents or sugarcane workers residing in the territory.

The first part of the workshop shared knowledge, memories, experiences, and practices that weave the historical and socioenvironmental fabric of the communities' ways of life. The narratives of work activities were described and sorted according to the participants' daily workflow. Then, the activities were grouped into sequential steps related to the agricultural cycle and named on paper cards. Subsequently, the tool facilitated the debate on the historical and political context regarding the socio-health and environmental impacts resulting from the use of pesticides in the study territories. It enabled the characterization of exposure and harm to workers' health.

The statements were analyzed from the condensed meanings<sup>14</sup>, which supported the identification and essential description of the central themes related to the study: i) Flowchart of work on sugarcane plantations; ii) Exposure to pesticides used on crops; iii) Harm to the worker's health. Data interpretation was anchored in Latin American critical epidemiology and theoretical and methodological inputs to the social determination of health, whose dialectical observation of the epidemiological reality of health-disease processes involves the context of disputes in society and its inequalities, be they economic, cultural, political, social and health-related<sup>8</sup>.

This study is nested in broader academic research conducted by the Health, Environment, and Work Laboratory of the Oswaldo Cruz Foundation. It was approved by the Research Ethics Committee of the Aggeu Magalhães

Institute and aligns with the Resolution of the National Health Council/CNS N° 466/2012, under CAAE: 73834317.2.0000.5190 and Opinion N° 2.617.522. All participants signed the Informed Consent Form.

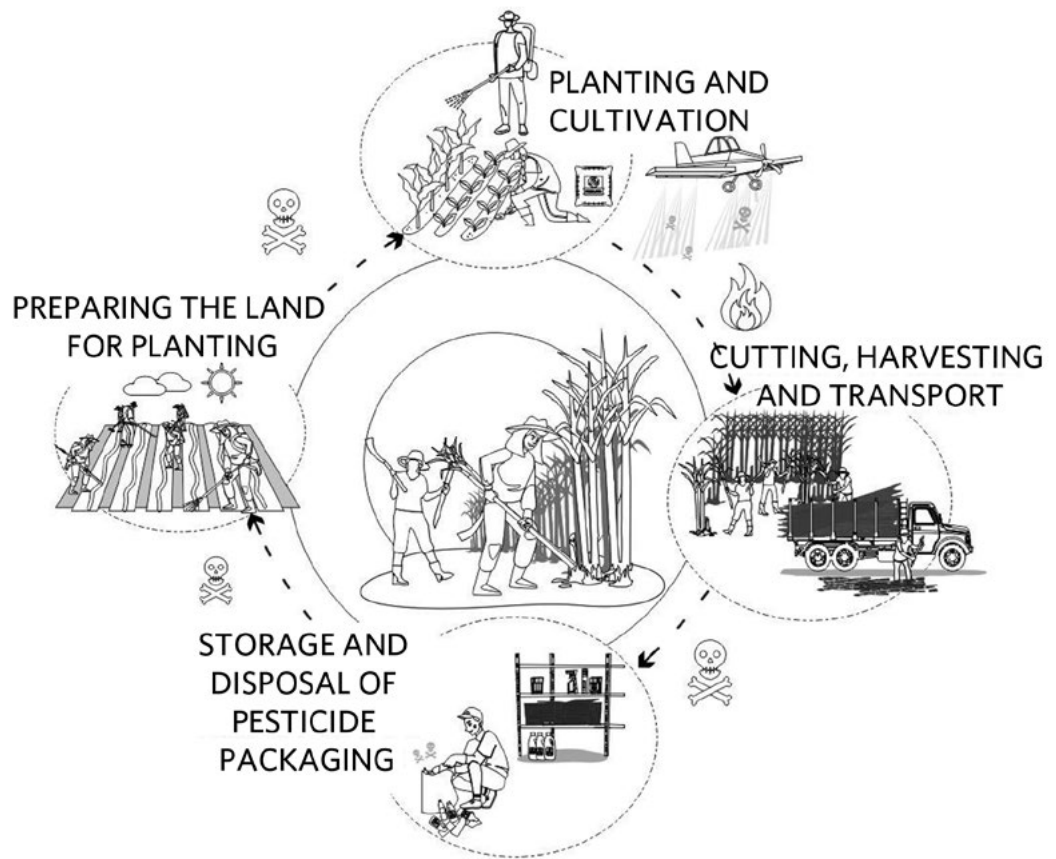
## Results and discussion

### Flowchart of work on sugarcane plantations

The sugar and alcohol production context is marked by the social division of labor, whose exploitation and spoliation affect the farmers of the extensive sugarcane fields. Payment for the production of manual agricultural work, which sustains the income of the plants, fluctuates with the abusive targets imposed on salaried workers, those settled with small plots of land, or migrants<sup>15,16</sup>.

During the PRD workshops, the debate surrounding working conditions underscored the exhausting nature of the working hours and work pace, with an overload of physical and mental effort, repetitive movements and work accidents, under high temperatures and substandard conditions of nutrition and hydration of workers, aligning with results from other studies<sup>17-19</sup>. The work flowcharts were built by the communities emphasizing worker exposure to pesticides used during the sugarcane cultivation cycle stages. The work activities reported by the workers were grouped into work process stages and sorted per the narrative sequence of the community discourses produced (*figure 1 and table 1*).

Figure 1. Graphical representation of work flowcharts on sugarcane plantations in Pernambuco, 2022



Source: Own elaboration.

Observing the work flowchart suggests that the use of pesticides operates as a spinal column for the sugarcane production process and is evident in the main fieldwork stages. It aligns with other convergent studies on the

topic<sup>19,20</sup>, which signal the exploitative and degrading conception of the capitalist production model regarding nature and human work, with its practices violating essential rights to human and ecosystemic life<sup>21</sup>.

Table 1. Description of the activities performed at each stage of the work process in the sugarcane fields in Pernambuco, 2022

Work process stages	Narrative description of the communities
Preparing the land for planting	<p><i>"Right at the beginning we put the poison in the bush. The poison can dry that bush. Instead of paying 60 reais to clean a block [with a hoe], you buy a drum of roundup poison, mix it with 2.4 D. In short, several poisons. They put it in and kill the bush [...] Then they set the fire, so it stays clean. They pass over with the tractor so they can start scratching straight away. Others put the grid. They harrow it and then come with the plow to scratch. Here are several thoughts, each one doing it their way [...]" (Aliança, PE).</i></p> <p><i>"I keep holding back so I don't put the poison in [...] There's a man here who can't stand cleaning and clearing the bushes. There comes a time when we get tired, we can't stand it [...] It has to be with the poison. We depend on it here" (Água Preta, PE).</i></p>
Sugar cane planting and cultivation	<p><i>"Dig the furrow, sow the sugarcane, add chemical fertilizer, and then cover it. Apply the poison to the sugarcane [...] It both destroys the seeds of any other quality of plant and the roots that are born. Only sugarcane is immune to that poison [...] It is a pest. It's called 'buffalograss'. Its seeds fly far. It's called 'plant pest' [...] Cultivation is precisely by applying roundup to the bush so that it doesn't reach the size of the sugarcane, and applying a poison to ripen the sugarcane" (Itambé, PE).</i></p> <p><i>"The planes fly by during the period when they are about to be cut, right" (Goiana, PE).</i></p>
Cutting, harvesting and transporting the crop	<p><i>"We do it like this: when it's mature and needs to harvest, we make the firebreak [...] The firebreak is like a path, right... a division so the fire doesn't catch everything at once [...] then at night, I set it on fire because it will make cutting easier - when raw, it is harder [...] after cutting comes the machinery process. Nothing is manual anymore. It's all machinery. Then a tractor comes and puts it on the truck" (Sirinhaém, PE).</i></p>
Storage and disposal of pesticide packaging	<p><i>"We find the containers [of pesticides]. They often don't collect them and leave them on the roads" (Itambé, PE).</i></p> <p><i>"Some people throw the containers in any corner and children pick them up. One child here caught it and was assisted [...] Some people reuse the cylinders and get water to drink" (Aliança, PE).</i></p> <p><i>"Some store them in a reserved place, but some others keep them at home with children and everything, right" (Água Preta, PE).</i></p>

Source: Own elaboration.

As noted in the reports, pesticides mainly eliminate adjacent plants' growth, which appear spontaneously and compete for nutrients in the soil with the cultivated sugarcane seedlings. The workers explain that the use of poison replaces the practice of manual clearing with a hoe during land preparation, planting, and cultivation, which allows them to concentrate more significant physical effort to meet the goals imposed in the subsequent stage of manual sugarcane cutting, converging with the results highlighted in a recent study carried out in Goiana, Pernambuco, Brazil<sup>22</sup>. Communities also point out the use of biocides during cultivation due to the proliferation of insects and other 'pests' that harm growth and the final concentration of sucrose in the sugarcane to be weighed and sold to the mills, aligned with the study of the same content<sup>23</sup>.

The statements revealed that the pesticides most used by workers are herbicides glyphosate (Roundup®) and 2,4-D, along with termite killer fipronil (Regent®), whose applications occur directly through manual knapsack spraying equipment coupled to the worker's body and by aircraft that fly over the studied communities close to the harvest period, to combat the proliferation of leafhoppers in the sugarcane fields that surround the territories. In general, all communities realize that the incorporation of agribusiness technologies in the sugar and alcohol sector is motivated by increased productivity and the accumulation of wealth by the dominant agribusiness classes, a result also identified in another similar study<sup>15</sup>.

The intensive use of pesticides in Pernambuco is immersed in a broader national situation since a 128.64% increase was

recorded from the 2017-2022 period alone against the sum of the 2001-2016 period<sup>4</sup>. This situation results from the dismantling of environmental and health protection mechanisms, legislative flexibility, scrapping of supervisory bodies<sup>3</sup>, and consequent induction of an 'economy of death'<sup>24</sup>, given that the destruction of biodiversity and traditional ways of life were 'authorized' by public authorities, especially in the last five years. Glyphosate, for example, is the most sold poison throughout the country and is the most commonly used herbicide in sugarcane crops. Currently, the Maximum Residue Limit (MRL) for this product in sugar cane is 20 times higher than those established in the EU<sup>3</sup>.

The manual cutting stage is preceded by the centuries-old practice of regular burning of extensive sugarcane fields, with the explanation of facilitating the cutting of sugarcane bundles by the machete blow performed by workers, whose labor rhythm is dictated by the imposed goals<sup>16</sup>. The gross collection of the harvested material is performed by machinery, and the residual remains are collected manually by workers. Then, the tons of sugarcane are transported by so-called 'treminhões' (large buckets for transporting sugarcane mounted on a traction vehicle) to the plant, where the production is weighed.

The statements also describe the storage and disposal conditions of pesticide packaging, which highlights the opposite provisions of Law N° 7.802 of 1989<sup>25</sup>, which addresses the use of pesticides and establishes conditions for the storage and disposal of contaminated packaging, prohibiting their reuse for other purposes. Family exposure is highlighted by those who perceive the danger of accidents related to the storage of poisons in the domestic environment, aligned with the findings of Bombardi<sup>3</sup>, who points out Pernambuco as the second-highest state in the country in the number of records of pesticide poisoning in children aged 0-14 in the country.

### Exposure to pesticides used on crops

Table 2 clearly shows that the permanent pattern of exposure to pesticides is related to the production system, which seems to be a determinant of the lifestyles of the communities studied and prevents workers' social mobility, which forces them to remain in that social structure that limits the reproduction of living conditions. However, the reality of work is hazardous and associated with insecurity, physical exhaustion, and unhealthy conditions<sup>16</sup>.

Table 2. Permanent patterns of sugarcane production and worker exposure to pesticides used on plantations in Pernambuco, 2022

Production patterns and exposure to pesticides	Narrative description of the communities
Working on sugarcane farming as the only or main form of survival	<p>"It's the only right crop that the guy plants and that has a shirt at the end of the year. Because I planted half a world of cassava trees here and in the end it was water for water" (Aliança, PE).</p> <p>"What moves this here is called sugar cane [...] it's either cutting sugarcane or move to get another job [...] a plant like this employs thousands of people who only know doing that there. If you are going to work in another job, there is no way to stand out because you do not have a qualified study. People's survival here is impossible without it [sugar cane]" (Sirinhaém, PE).</p>



Table 2. Permanent patterns of sugarcane production and worker exposure to pesticides used on plantations in Pernambuco, 2022

Production patterns and exposure to pesticides	Narrative description of the communities
High-risk jobs for worker's health	<p><i>"Workers mix [the poisons], right, in a barrel, in a drum" (Goiana, PE).</i></p> <p><i>"The more this hard-working man works, the poorer he becomes. He works day and night, and even overtime. He puts everyone's poison here [...] He is a poison professional" (Aliança, PE).</i></p> <p><i>"I don't apply mine [poison] myself; only those who can't afford it apply it, because those who have it prefer to pay" (Água Preta, PE).</i></p> <p><i>"When the plane came, we gave it the poison. It went up and, again, spread poison. We were in the sun below. We really felt that poison was coming at us" (Sirinhaém, PE).</i></p>
Unsafe and unhealthy use of pesticides	<p><i>"I put poison. It doesn't matter whether I wear gloves or not [...] I don't put anything on my face because if I put on the mask, I can't stand it [...] Whoever works with the body pump (20 liters), it's too heavy. We go up and down the mountains [...] that plastic clothing is very thick. No one can handle that inside the sugar cane. You could die sweating in it" (Sirinhaém, PE).</i></p> <p><i>"A bomb of poison then wet my back. I realized it was when I went to fill up again. So today I still feel sick. I didn't get any better" (Água Preta, PE).</i></p> <p><i>"It [2.4 D - dichlorophenoxyacetic acid] kills more because it has no smell, so you trust it. The worker thinks: 'This doesn't smell or stink, so there's no need for PPE'" (Itambé, PE).</i></p>

Source: Own elaboration.

In the municipalities surveyed, the economic monopoly of the sugar and alcohol sector was consolidated through the appropriation of territories and subsumption of peasant family work to the dependent chemical production process, and sugar cane cultivation was the only way of survival for most local populations. Recent studies have revealed that generating direct and seasonal jobs in this sector for less educated and people with low-income circulation in trade was perceived by local populations as a positive impact of the sugar-energy production chain<sup>26,27</sup>, which was the leading corporate, media, and even state argument used to justify the poisoning and permanent sacrifice of territories. As a result, the secular domination of territories by the sugarcane production process occurs by subordinating local people and ways of life to the reproduction of its predatory logic<sup>28,29</sup>.

Mixing and spraying pesticides using backpack pumps were highlighted by the five communities in this study as the unhealthiest activities in the work flowchart. We observed the social division of labor in sugarcane already evidenced by the scientific literature<sup>6</sup>, and the

unequal distribution of risks and harm related to the occupation of jobs hazardous to the worker's health, and poison applicators were the professional category most vulnerable to poisoning<sup>30</sup>. The exposure burden increases depending on the types of equipment used during spraying. Lozier et al.<sup>31</sup> found twice the concentration of atrazine in the personal air inhaled by sugarcane workers who use a conical spray nozzle compared to those who use a flat nozzle. Pesticide atrazine's Active Ingredient (AI) was banned in the EU 20 years ago due to the evident harm to human and environmental health. However, local and national initiatives have been prohibiting the manufacture, use, and sale of this pesticide in Brazil<sup>32,33</sup> only recently.

The sociodemographic profile of pesticide applicators registered in Pernambuco shows that 97.4% of registrations correspond to male workers, 71.5% aged between 18 and 49, and 65% self-declared Black and brown people. Furthermore, 63.1% of poison applicators registered in the state are self-employed, casual, and temporary workers<sup>27</sup>. The most dangerous jobs are delegated to poor Black men, a

permanent pattern of reproducing historical class, gender, and race segregation structures preserved in the territories explored by the productive sugarcane agribusiness model.

The patterns of insecurity and unhealthy conditions underlying the use of pesticides were reported by communities as routine conditions intrinsic to the ways of life subsumed by the productive context. The potential harm of pesticides to human health shows the impossibility of safe use and total control of the risks associated with these agents. The bio-cumulative, interactive, additive, and synergistic effects of exposures must be considered while producing epidemiological data and information and analyzed through theoretical and methodological triangulations based on complex systems. Furthermore, it is necessary to consider the entire problem under the socioeconomic, political, and cultural context in which the exposure occurs, reducing biases<sup>34</sup>.

Workers reported the misuse or non-use of Personal Protective Equipment (PPE) during the PRD workshops, and the reasons were anchored in the discomfort during work activities with great physical effort under high temperatures and the false impression of safety regarding pesticides. These results align with

other authors<sup>35,36</sup>. The statement of a resident of Itambé-PE describes a pattern of collective belief, already pointed out by Fonseca et al.<sup>37</sup>, in which there is an association between odor and the substantial danger of the poison, which implies a tendency towards greater exposure of those workers who disbelieve in the toxicological potential of odorless pesticides and abdicate PPE use.

Pesticide use by rural workers was also marked in the study by Pessoa et al.<sup>27</sup>, mainly by the lack of training and non-use of PPE, even with a crucial weekly frequency of pesticide application using a manual knapsack sprayer. Authors highlight that obtaining information about pesticides occurs through social relationships between neighbors or television programs and only a tiny group from technical professionals. In contrast, another portion still needs reliable information about pesticides handled in everyday life<sup>38</sup>.

The workers and residents of the communities analyzed identified the main routes of pesticide exposure, listed in *table 3*, in dialogue with the findings of Mattia and Ródio<sup>39</sup> in Paraná, which express the multiple biological pathways that harm the sugarcane production process imposed on workers.

Table 3. Routes of exposure to pesticides during the work process in sugarcane fields in Pernambuco, 2022

Exposure routes	Narrative description of the communities
Inhalation	<p><i>"When I uncovered the lid, the odor rose. This material is very bad for humans [...] You wake up in the morning and there is the [poison] bomb, with the wind and against the wind and you receive it little by little and have direct contact"</i> (Itambé, PE).</p> <p><i>"He used to apply herbicide and the smell is very uncomfortable. It chokes [...] You can go to the corner today where they applied the herbicide, and you can still feel the vapor, the smell of it"</i> (Goiana, PE).</p> <p><i>"I use the mask when applying it, but when preparing the poison, I don't put it on. Then when I'm preparing it, I smell it and remember"</i> (Água Preta, PE).</p> <p><i>"It comes home too, it's not just those who are planting"</i> (Aliança, PE).</p>
Ingestion	<p><i>"About 3 or 4 times at work. I've felt a different taste that I think was poison [...] I've heard of some cases of people taking poison"</i> [suicide attempt] (Sirinhaém, PE).</p> <p><i>"We ingest and become intoxicated too"</i> (Aliança, PE).</p> <p><i>"The guy is applying poison, the roundup. Then, the nozzle clogs. Do you know what he does? [sucking sounds]. He unclogs the pump nozzle with his mouth"</i> (Itambé, PE).</p>



Table 3. Routes of exposure to pesticides during the work process in sugarcane fields in Pernambuco, 2022

Exposure routes	Narrative description of the communities
Dermal absorption	<p>"Many people applied the poison with bare feet" (Itambé, PE).</p> <p>"I've even seen people put poison in the bomb and do it with their own hands. I know that many people itch after using the poison" (Sirinhaém, PE).</p> <p>"There is water contamination. I scratch myself after taking a shower. My boy feels it [...] My husband says it looks like I have psychosis. I feel so itchy" (Aliança, PE).</p>

Source: Own elaboration

Exposure to pesticides through inhalation was reported in the five territories studied and noted in all stages of the work flowchart in the sugarcane fields. The condensed meanings from the statements revealed reports on sensory perceptions linked to the strong odor emanated by some pesticides in the management and mixing activities of the poison cocktail applied to the crops and aerosols dispersed in the atmosphere during soil spraying.

The volatility of pesticides was verified by Yera and Vasconcelos<sup>40</sup>, in which AI was found in samples of fine particulate matter collected in São Paulo's urban and rural areas, and the atmospheric transport was an element of solid dispersion and ecosystem pollution. Another recent study<sup>41</sup> in South Africa verified concentrations of four pesticides in the personal air inhaled by sugarcane workers during work, identifying agents such as 2,4-D, a poison widely cited by the communities in this research. Inhalation is also a route of exposure to polluting gases, particulate materials<sup>42</sup>, and other toxic elements, such as polycyclic aromatic hydrocarbons produced during biomass combustion<sup>43</sup> with atmospheric dispersion and burning before sugarcane harvesting in the municipalities studied.

Exposure through ingestion was reported by communities and related to daily agricultural work's unhealthy practices, such as workers using their mouths to unclog the sprayer nozzle, mixing poisons with hands, chewing sugarcane lumps during painful working hours, and other practices. The chronic family intake of contaminated food and water is also noteworthy, aligning with

the results by Oliveira et al.<sup>44</sup> in their research on sugarcane agribusiness.

The Brazilian deregulation of the use of pesticides generally exposes the population to food and nutritional insecurity, specifically burdening the most vulnerable populations<sup>45</sup>. Only glyphosate has an authorized MRL in Brazil, five thousand times higher in drinking water than international parameters<sup>3</sup>. The Dossier on water contamination in the Brazilian Cerrado, which denounced the disastrous scenario in all states that make up the biome, identified at least one AI in more than 70% of water collection points in seven communities in the region exploited by agribusiness. Furthermore, nine different AI pesticides were identified in a single water sample collected in Maranhão, indicating multiple exposures to concentrations up to 32 times higher than the parameters authorized in the EU<sup>46</sup>.

We should emphasize the fact that communities identify the ingestion of pesticides as the main route of exposure used in attempted or committed suicide among local populations. Other studies converge on these findings and endorse the discussion of a systematic reality still observed in different territories permanently exposed to pesticides<sup>47-49</sup>.

Exposure by dermal absorption was also reported by the communities analyzed, associated by workers with handling, mixing, and applying poisons to crops and direct contact between the worker's skin and contaminated crops during the sugar cane manual cutting and harvesting. Dermal exposure to pesticides is the most common route associated with

occupational poisoning, with the prevalence of symptoms significantly high (p-value = 0.032) in the group of workers who do not use waterproof clothing<sup>50</sup>.

The exposure routes described in this section are observed in other analyses<sup>41,51,52</sup>

and are related to several clinical outcomes in acute, chronic, and fatal forms described in *table 4*.

## Harm to worker's health

Table 4. Harm to health related to permanent exposure to pesticides used in sugarcane fields in Pernambuco, 2022

Harm to worker's health	Narrative description of the communities
Acute poisoning	<p>"A friend's husband went to work with poison and fell ill within a week. He started applying the poison and ended up in the hospital [...] it was these surgeries that he suddenly had to undergo. The doctor said it was because of the poison that he worked with for a long time" (Itambé, PE).</p> <p>"One guy here who went to apply poison and passed out inside the sugarcane [...] I placed 10 poison bombs myself. I got home when it was midnight. I started blowing like windmill. He helped me. If it weren't for him, I would have died" (Aliança, PE).</p> <p>"Not a headache at the time, but nausea when you breathe [...] However, I already felt dizzy, and my mouth was bitter. I had a headache" (Água Preta, PE).</p> <p>"People who smell this poison have a lot of intestinal infections there at the plant [...] shortness of breath, diarrhea, stomach pain [...] I have heard of people saying that they have passed out after applying that poison" (Goiana, PE).</p> <p>"I know that many people itch after using the poison [...] Once, when I was handling it [the poison], it got hot, and I threw myself into the river" (Sirinhaém, PE).</p>
Chronic poisoning	<p>"Several peers of mine are affected by the poison [...] one went for an ultrasound and found out that his liver was compromised by more than 50% due to the poison, due to the herbicide" (Goiana, PE).</p> <p>"There's one as yellow as a sheet of silk. His belly has grown, he's all sucked up. He now has diabetes" (Aliança, PE).</p> <p>"A colleague of mine lives on the plantation and had bone cancer due to the pesticide [...] He's sitting like that and, when he goes to get up, his bones make a few cracks, just for you to see, and that was due to the poison" (Sirinhaém, PE).</p>
Fatal outcomes	<p>"He constantly worked with poison. He was harmed, became ill and very thin, just flesh and bone [...] He continued putting poison. It didn't last a month. When he collapsed, he went there and died" (Sirinhaém, PE).</p> <p>"A peer of mine died because of the smell. He was working and the smell choked him. When they helped him, he was helpless. He was putting herbicide" (Goiana, PE).</p> <p>"At noon, the plane came by spraying the sugarcane and we were below [...] when the plane passed over, it blew all that breath all over him. When he got home, he fell and was left struggling [...] He arrived dead at the hospital" (Itambé, PE).</p>

Source: Own elaboration.

The statements evidence community perceptions about illness related to permanent exposure to pesticides and describe clinical manifestations with acute, chronic, and fatal progression. A recent study in the Northeast found that 74.6% of the rural population in Juazeiro and Petrolina reported having had

some pesticide poisoning symptoms throughout their lives<sup>35</sup>.

Acute health harm was identified through reports referring to immediate signs and symptoms with localized clinical expression, such as headache, stomach pain, nausea, vomiting, diarrhea, and itching. Some also reported

systemic manifestations, such as dizziness, fainting, convulsions, and severe respiratory failure, and requests for urgent medical intervention were common. Acute and immediate symptoms are often related to respiratory exposure through inhalation of pesticides during work in sugarcane fields<sup>6</sup>.

Regarding chronic harm, the statements described later and typical clinical manifestations of endocrine, metabolic, hepatic, hematological, and oncological diseases. Some chronic harm reported by communities was diagnosed by medical professionals who associated the illness with permanent exposure to pesticides to which workers are subjected in their daily lives. When it occurs during critical periods of development, exposure can cause severe and potentially irreversible harm to future generations. For example, in early childhood behavioral neurodevelopment and fetal maturation, deleterious effects can permanently harm those exposed. Effects are observed in the fetal period, primarily in the first trimester of pregnancy, so that exposure to pesticides can be decisive in developing malformations and prematurity<sup>53,54</sup>, miscarriages, low birth weight, and other adverse outcomes<sup>55</sup>.

Community reports also described fatal cases resulting from workplace accidents due to poisoning. They highlighted the sudden nature of the worker's systemic collapse and the inability to reverse the sudden outcome, as some could not be transferred to an emergency unit in time. Other testimonies narrate the irreversibility of acute or chronic damage, even when there was guaranteed access to adequate services and care, and death was the outcome resulting from the illness process. These results converge with the findings observed by Tavares et al.<sup>48</sup>, in which higher rates of deaths due to pesticide poisoning in 2007-2017 are in Pernambuco and São Paulo.

This myriad of acute, chronic, and fatal outcomes is widely known in the scientific literature<sup>51,56,57</sup>. This health situation emerges from the chemical-dependent capitalist model in which agribusiness represents overload,

demands, and costs for health services, showing the need to reorganize the health system towards precautionary, mitigation, and damage repair strategies, besides strengthening worker and environmental health surveillance actions.

Despite the damages mentioned in this and other studies<sup>51,53-57</sup>, research highlights the troubling underreporting of poisoning cases in Brazil<sup>58,59</sup>. Among the reported cases are different issues with records in health information systems, such as non-identification of chronic cases, incomplete and inadequate data, and information that cannot support planning actions and implementation of specific public policies to address priority problems<sup>59</sup>.

There are significant gaps in the scientific literature on the additive, interactive, synergistic effects of analyzing chronic and permanent exposure since the challenge of toxicological studies already produced is the difficulty of analyzing multiple simultaneous exposures to the combination of toxic substances<sup>52</sup>, recommending the use of critical and contextualized toxicology for a broader understanding of the problem that considers the subjects based on their life experiences, problems, and health needs<sup>34</sup>. Strategies of this nature prevent these territories made vulnerable by agribusiness from becoming sacrificial zones imposed by this model of Brazilian development, in which nature and people are plundered to guarantee the accumulation of a few in an Ecocide process that is the racist, modern-colonialist product in the biome<sup>60</sup>.

The limitations of this study are related to the nature of the methodology chosen for the production of primary research data, whose results represent, exclusively, the perception of the participating subjects involved during the PRD workshops held in the selected territories, and their representation cannot be extrapolated to the municipal level and others. Furthermore, the PRD provides a general analysis of priority problems and complementary data collection and analysis techniques and tools for a more in-depth understanding of the problems listed in this diagnosis.

## Final considerations

We can see that sugarcane work patterns and characteristics have critical elements of the health-disease process that emerge from a historical and socio-environmental construct in which the epidemiological profile of the territories under the control of sugar and alcohol agribusiness is subsumed. Such results are relevant for the construction of Primary Health Care territorialization strategies, which include area diagnosis and mapping of areas most vulnerable to pesticide poisoning, supporting the planning of promotion, prevention, and monitoring actions for exposed populations, establishing referral and counter-referral flows for acute and chronic cases, besides strengthening local health, environmental, and occupational health surveillance strategies.

It is urgent and necessary to build public policies and socio-environmental legislation based on the involvement of exposed populations with active participation in all stages, from planning, implementation, and inspection of coping strategies to periodic monitoring

and evaluation in epidemiological, health, environmental, and occupational surveillance. We recommend promoting family farming with diversification, flow, and distribution of agroecological production by strengthening community organization resources and forms, expanding access to rural credit, and continuous technical assistance based on worker safety.

## Collaborators

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