

# Agribusiness and pandemic in Brazil

Is a syndemic worsening the Covid-19 pandemic?





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2021



for a toxics-free future



IPEN is a global network forging a healthier world where people and the environment are no longer harmed by the production, use, and disposal of toxic chemicals.

Over 600 public interest NGOs in more than 124 countries, largely low- and middle-income nations, comprise IPEN and work to strengthen global and national chemicals and waste policies, contribute to ground-breaking research, and build a global movement for a toxics-free future.

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Abrasco aims to support and articulate Collective Health entities to strengthen associates and expand the dialogue with the technical-scientific community and with health services, governmental and non-governmental organizations and civil society. At the international level, Abrasco maintains a close dialogue with entities such as the World Federation of Public Health Associations (WFPHA), of which it has been associated since 2002, with the Latin American Association of Social Medicine and Collective Health (Alames) and others, such as the International Pollutants Elimination Network (IPEN).

# Acknowledgments

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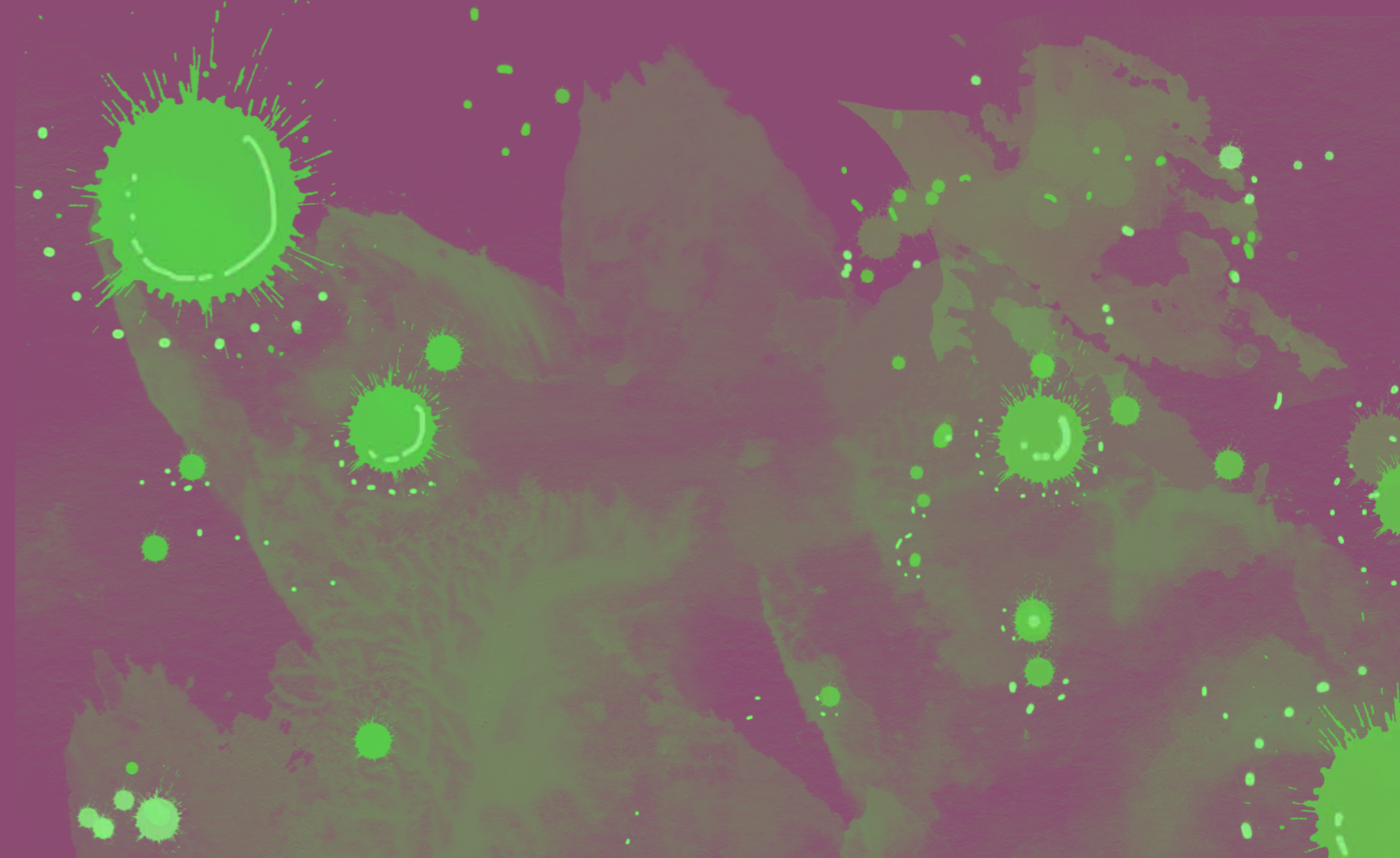
We would like to thank Prof. Dr. Fernando Carneiro (Fiocruz / Abrasco) for suggestions to improve this document.

### We dedicated this report to:

- Brazilian workers that suffered from direct or indirect impacts of pesticide use and agribusiness;
- The people that were beaten when they denounced the damages of agribusiness;
- Millions of Brazilian families that suffered direct or indirect impacts of the COVID-19 pandemic.

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Logging. Aerial drone view of deforestation environmental problem. Photo: Richard Carey - stock.adobe.com



Spraying herbicide on plantations where there was the native cerrado. Photo: GuiaBruno - stock.adobe.com



Aerial view Agricultural field in the cerrado. Maranhao. Photo: Manuel - stock.adobe.com

# Introduction

Covid-19 is a disease caused by an infectious process by the SarsCov-2 virus.

Many processes are simultaneously driving the emergence of new zoonoses, including increased demand for animal protein, agricultural intensification, increased exploitation of wildlife and natural resources, accelerated urbanization and extractive industries, increased travel and lengthening food supply chains (United Nations Environment Programme 2020). In Brazil and other low- and middle- income countries, the health effects of the pandemic are exacerbated by deep social inequalities, high and unequal burden of comorbidities, democratic fragility and setbacks in social and environmental policies, along with exposure to contaminants such as pesticides (Ortega, Orsini 2020).

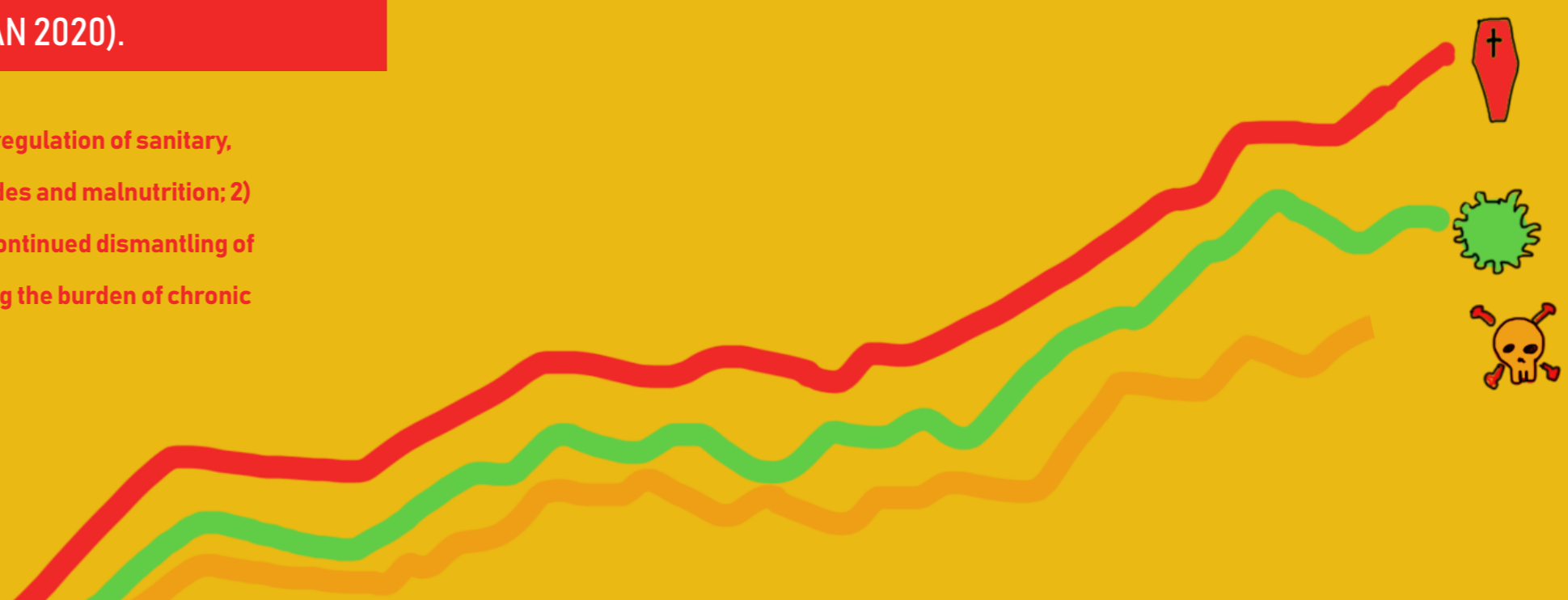
**BLACK AND INDIGENOUS PEOPLE AS WELL AS POOR AND PRECARIOUS WORKERS ARE MORE VULNERABLE TO THE VIRUS AND TO THE SOCIAL CONSEQUENCES OF MEASURES TO CONTAIN THE VIRUS (WANG, TANG 2020; WENHAM, SMITH, MORGAN 2020).**

In Brazil the effect of these factors is accentuated by the: **1) deregulation of sanitary, labor and environmental systems that increase exposure to pesticides and malnutrition; 2) dismantling of health and environmental inspection structures; 3) continued dismantling of health services for both prevention and assistance; and 4) increasing the burden of chronic disorders generating a syndemic interaction with COVID-19.**

The food industry is shaping the diet of the population with increasing consumption of calories, fat, salt and sugar, driving the rising incidence of many non-communicable disorders including cardiovascular disorders, diabetes and cancer. Exposure to pesticides is contributing to several pathophysiological mechanisms that affect organic systems, such as the central nervous, endocrine and immune systems. The incidence and case fatality of COVID-19 is known to be higher among people with many different chronic disorders, including obesity, diabetes, cancer, lung disorders and dementia.

Thus, in a synergistic way, the “agribusiness production model” not only increases the risk of emerging zoonotic viruses, but also drives increased exposure to pesticides that, together with malnutrition, increases people’s vulnerability to negative health effects.

This report will analyze the COVID-19 pandemic in Brazil in the context of the 1) ongoing dismantling of institutions and legislation, 2) influence of agribusiness on policy and 3) dependence on the use of pesticides. A chronology and a brief analysis of the facts that preceded the COVID-19 pandemic and some of the implications for health, such as the use of pesticides and malnutrition (food security) in the context of the COVID-19 pandemic, will be presented.



## 2. The Brazilian context – the pervasive role of agribusiness

Brazil has been seriously hit by the COVID-19 pandemic. The cumulative mortality rate from COVID-19 was, in mid-January, around 100 per 100.000 people. It is slightly lower than the worst hit high-income countries such as USA, UK and Spain; however, Brazil has a much younger population. Moreover, the lower rate is due to lower test capacity and is presumably underestimated.

Excess death in all-cause mortality is a less biased measure and for the period where estimates for Brazil have been done (March-May 2020) mortality was approximately 10% higher (=39,146 deaths) than the same period the previous year (Silva et al. 2020). Similar but not entirely comparable estimates have been done for European countries that show excess all-cause mortality of -2% to +7% found in West European countries (Office for National Statistics 2020a). As we shall discuss in more detail below, mortality in COVID-19 is influenced not only by exposure to the virus but also by several comorbidities including obesity and immunological dysfunctions.

Agriculture is a major component of the Brazilian economy, and in 2019, the sector contributed 4.4% of GDP (119 bn USD) and nearly 30% of the exports. A huge and increasingly industrialized agricultural sector is followed by use of pesticides, factory farming and influence on industrial food production.

Pesticides are toxic by design and many of them are known – even in long-term low dose exposure – to influence several organ systems. They are not only used in agribusiness but also in dwellings to protect against mosquitoes, which are vectors for other viruses. Pesticides have a broad range of health effects (Rigotto et al. 2014, Carneiro et al. 2015, Curl

et al. 2020). The question about the impact of pesticides on immunity as protection against the pandemic has already been raised (Muhammad et al. 2020, Kostoff et al. 2020). With our fast growing – but still limited – knowledge about the pathogenesis of COVID-19, it is of interest to investigate the possible connections are between the impact of agribusiness on population health and the COVID-19 pandemic in Brazil. The question has become even more urgent in the period of environmental deregulation in Brazil (Andreazzi et al. 2020) and a longstanding culture of political obstacles to learning from science (Donadelli et al 2020).

**INEQUALITY OF LAND DISTRIBUTION (1% OF THE POPULATION IN BRAZIL OWNS 45% OF THE LAND), INADEQUATE ACCESS TO LAND BY THE POOR, INSECURE TENURE, EXTRACTIVE AGRARIAN PRODUCTION, AND CHEMICAL DEPENDENCY ARE ALL FACTORS CONTRIBUTING TO DEGRADATION OF LAND, AND DESTRUCTION OF FOREST AND BIODIVERSITY, AS WELL AS RURAL POVERTY, VIOLENCE, AND EXODUS. THIS SITUATION IN THE LAST 60 YEARS HAS FORCED MILLIONS TO MOVE TO BIG CITIES FORMING SLUM AREAS (FAVELAS) WHERE HOUSING CONDITIONS MAKE IT IMPOSSIBLE TO PROTECT AGAINST SEVERAL INFECTIOUS DISEASES INCLUDING COVID-19.**

In Brazil the production of commodities has increased dramatically in the last 60 years. The production of cereals (incl. corn, rice, soybean and wheat) has, for example, increased seven-fold since 1961, due to a doubling of the cultivated area exploited, and intensification of production from 1.3 t/ha to 4.8 t/ha (Food and Agriculture Organization 2021).

In 1997, 20% of the Brazilian population was employed in agriculture. By 2017, that had declined to below 10%, nevertheless, the value of the food production has in the same period more than doubled. The dominant agricultural model adopted is the so-called “Green Revolution”, with intensive exploitation, large farms (latifundio), and chemical dependent technology. Since 2000, the use of both pesticides and fertilizers has increased



approximately 4% annually (Carneiro et al. 2015). The introduction of transgenic seeds in 2005 has contributed to the growth of pesticide consumption.

The political context in Brazil has been favorable for the expanding agribusiness. In the 1960s, during the Military Dictatorship, a set of measures were implemented to support the “Green Revolution”, including the expansion of the production of pesticides and other chemical inputs. However, with the end of the Military Dictatorship in the 1980s, the process of re-democratization brought about an opening for more progressive legislation (Brasil 1988). Among the main legal frameworks, health was established as a fundamental right and a duty of the State, with the Unified Health System (SUS) carrying out that responsibility.

The important Pesticides Law (Brasil 1989) was also established in this period, in which pesticides were defined as:

“The products and agents of physical, chemical or biological processes, intended for use in the sectors of production, storage, and processing of agricultural products, in pastures, in the protection of forests, native or implanted, and of other ecosystems as well as urban environments, hydrological and industrial, whose purpose is to change the composition of flora or fauna, to preserve them from the harmful action of living beings considered deleterious; and substances and products, used as defoliantes, desiccants, stimulators and growth inhibitors”. (Brasil 1989).

This law is detailed in Decreto 4,074 (Brasil 2002a), which regulates the registration of pesticides in accordance with the guidelines and requirements of the bodies responsible for the agriculture, health and environment sectors. The use of mutagenic, carcinogenic, and teratogenic pesticides was prohibited, as well as those that disrupt the reproductive and endocrine systems.

However, several issues have hindered the practical implementation of this legal framework. The first example is the administrative efforts to promote the registration of pesticides. **The health agency uses mostly studies presented by industries whose methodologies are far from the reality of those using these products, such as toxicological studies with laboratory animals or in vitro, and extrapolate the results to human health and/or separately evaluate the active substance, without considering the**

### **health effects of multiple exposure.**

Another form of incentive to use pesticides are created by credit policies, where farmers must present a plan for the acquisition and use of pesticides (Carneiro et al. 2015), even without identifying the real need. Tax exemption for pesticides has also been an important driver for the rapid and intensive technological conversion to agriculture dependent on chemicals. The resources for control, inspection and monitoring the use and health effects of pesticides, are also far below what is necessary.

The growing pressure from producers of agrochemicals has suppressed government regulations. The result is a tension between the Brazilian economic development model and the right to health, because the expansion of agribusiness is based on the intensive use of pesticides (Gurgel et al., 2017a).

This development model is not only based on ever expanding agribusiness, but also on new extraction industries and mines. Both demand continuous expropriation of land in areas of environmental protection and indigenous reserves. The land becomes degraded and unsuitable for life, threatening the survival of traditional peoples and communities.

More recently, the advance of neoliberal policies has created the ideal scenario to deepen the agribusiness agenda. After 2016, several reforms reduced workers' rights and the security of the Brazilian population. **A labor reform (law n° 13.467 / 2017)(Brasil 2017) made employment conditions much more precarious and “slave-like” During the COVID-19 pandemic, the consequences became very clear when employers demanded flexible working hours with reduced remuneration.**

The Law Project (No. 6,299) (Brasil, 2002b) allows the use of agents associated with the emergence of cancers, DNA mutations, fetal malformations, endocrine disruption and reproductive system damage. The federal government permits spraying of pesticides by aircraft in inhabited and urban areas to control mosquitoes that transmit arboviruses such as Dengue, Zika and Chikungunya (Brasil, 2016).

RECENTLY THE CORONAVIRUS PANDEMIC WAS SEEN AS AN “OPPORTUNITY” TO FURTHER DEREGULATE. AN ILLUSTRATIVE EVENT IS THE INFAMOUS MINISTERIAL MEETING, HELD ON APRIL 22, 2020, WHERE THE MINISTER OF THE ENVIRONMENT RECOMMENDED TAKING ADVANTAGE OF THE COVID-19 PANDEMIC, WHEN THE POPULATION AND MEDIA HAVE ANOTHER FOCUS, TO MAKE CHANGES TO ENVIRONMENTAL PROTECTION THAT FAVOR THE INTEREST OF AGRIBUSINESS WITHOUT CONGRESSIONAL APPROVAL (SPRING, 2020).



### 3. Rolling back social security and public participation

The unprecedented alliance between extreme populists and the religious right and economic liberalism took over the government in 2019 (Lobato, Costa, Rizzotto 2019). In 2019, the government's first step was to modify and remove ministries, notably those that had a supervisory or social function. The Ministry of Labor (MTE) was removed and a policy to weaken the influence of unions and civil society was implemented under the heading to deconstruct the 'paternalistic excesses' supposedly present in Brazilian labor legislation (Dutra, Jesus 2020). The ministerial office was incorporated into other Ministries, such as Economy, Citizenship and Justice and Public Security, removing the labor agenda from the core of the executive branch, which was followed by a process of emptying and limiting the performance of labor inspectors. The Law No. 13,874 / 2019 (Brasil 2019a) further dismantled labor rights followed by the Provisional Measure (MP) No. 905, known as the Green and Yellow Contract MP, which reduced labor rights under the premise that fewer rights will ensure more jobs (Dutra; Jesus, 2020). Rights to holidays and the Christmas bonus (known as "thirteenth salary") were removed.

The loosening of protection resulting from the new labor policy increased the population's vulnerability, which was decisive for the massive job loss that happened with the pandemic, which threw millions of Brazilians into informal employment, depriving them of various social rights.

A comprehensive Social Welfare Reform was submitted to the Brazilian Congress (Lobato; Costa; Rizzotto, 2019). The Social Welfare Reform increases the minimum retirements age and the period of contribution to social security, and reduces social

benefits, which severely affects the poorest, Black, female, and rural populations (Nulle & Moreira 2019). The Reform ignores the large social inequalities in years worked, health, and working conditions. With the Reform, social security loses part of its function, which is being a protection system that supports millions of Brazilians and whose main objective is to guarantee a minimum standard of living (Nulle; Moreira, 2019).

Social participation plays a critical role in Brazilian health policy, institutionalized by the Law 8,142 / 90 (Brasil 1990) and the Councils and Health Conferences. However, since the beginning of the current (2019) Brazilian government, the country has experienced a dismantling of public participation, especially in public health. In 2019, the President ordered the elimination of several councils, committees and working groups in the federal administration with Decree 9,759 (Brasil 2019b). Among these councils are the CONSEA (National Council for Sustainable Food and Nutritional Security).

Several other bodies were also dismantled, including the National Council for the Rights of Persons with Disabilities (Conade); the National Council for Combating Discrimination and Promoting the Rights of LGBT; the National Council for the Eradication of Child Labor (CONAETI); the Rights of the Elderly (CNDI); the Public Transparency and the Fight against Corruption (CTPCC); the National Public Security Council (Conasp); the Labor Relations Council; the National Commission for Agroecology and Organic Production (CNAPO), the National Commission for Indigenous Policy (CNPI), and the National Commission on Biodiversity (CONABIO).

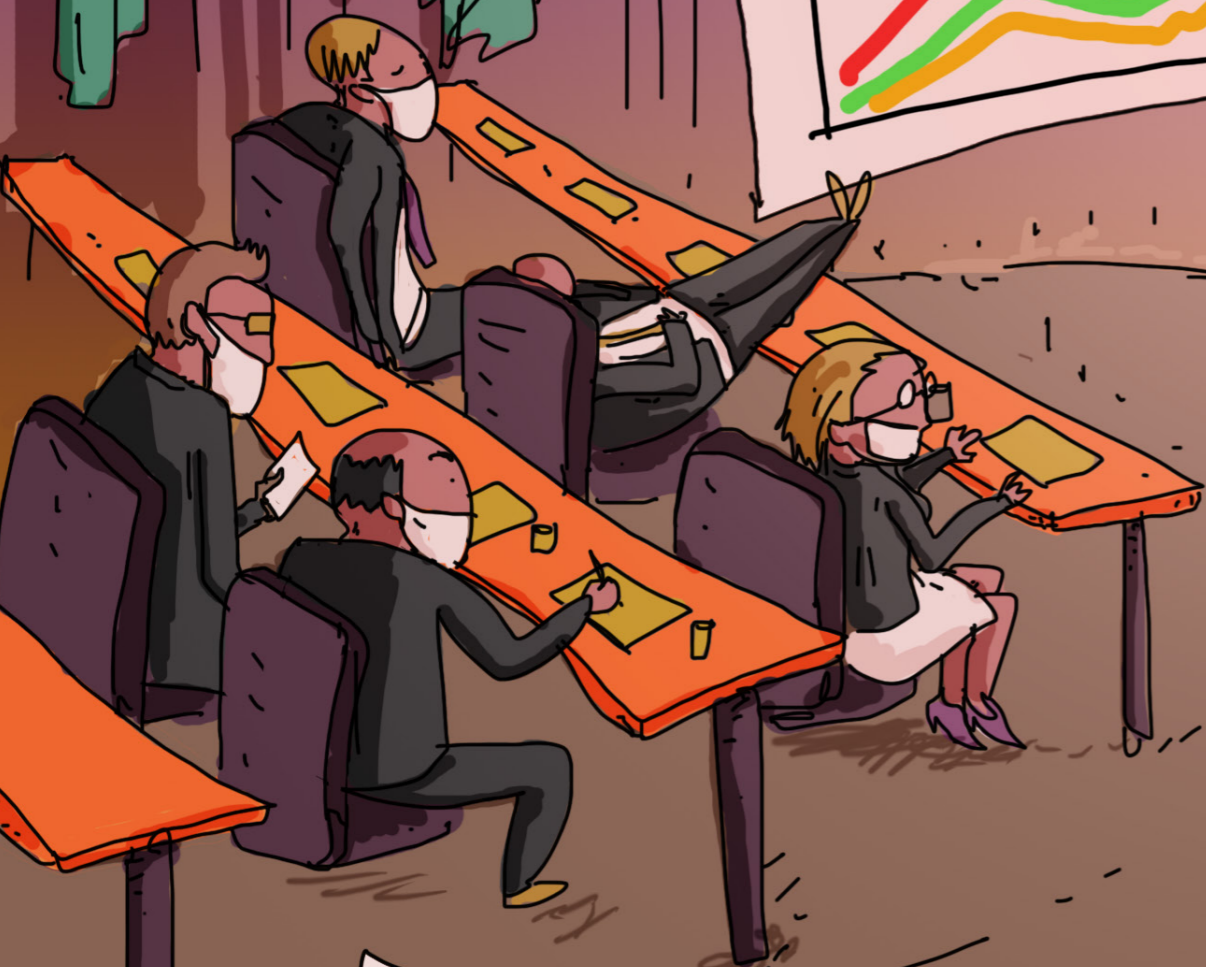
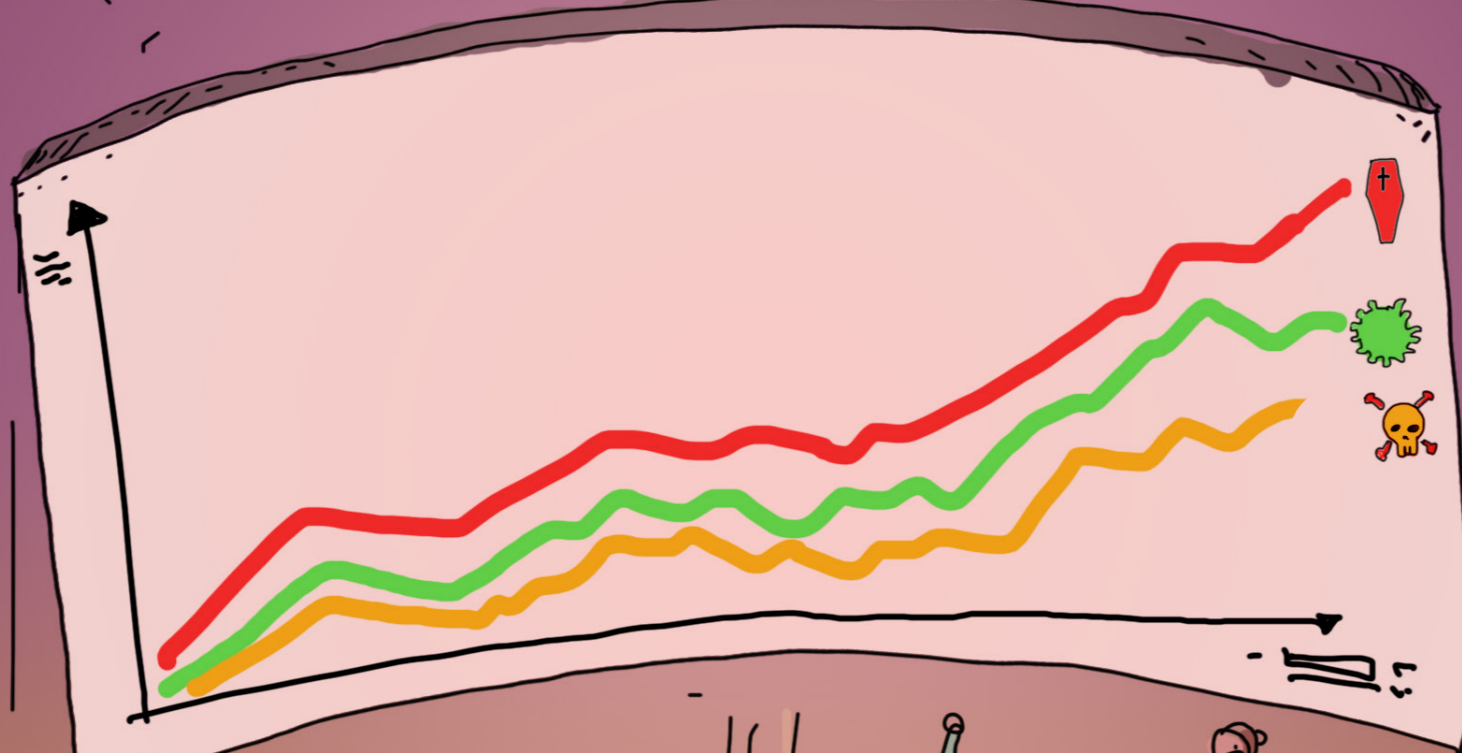
Although the Brazilian State has incorporated democratic tendencies within it, it has not yet effectively overcome its patrimonial, patriarchal, slave and bureaucratic character. A State, which is often inclined to the interests of capital, must be guided by the logic of emancipatory health promotion, referencing the social determination of health for a collective construction of an ethical way of establishing priorities, where practices are developed through participatory processes of production, circulation and appropriation of knowledge and information from /within the territory (Porto et al. 2016).

In decision-making bodies dealing with pesticides, the tradition of rural agribusiness,

and the pandemic in Brazil, conservatism is strong and tends to segregate the most affected people from the interests of agribusiness and their lobbying and supposedly neutral scientists. The weakening of social participation can be seen in public consultations within the processes related to the regulation of pesticides within the Brazilian Health Regulatory Agency (Anvisa). For example, in public consultations carried out by Anvisa, society's participation is now restricted to filling out online forms, with no room for debate. The relationship between the regulator and the regulated sector has in contrast been very close, with frequent meetings to discuss registrants' products. **In the toxicological reassessment processes, the regulated sector has actively participated through the Task Force, as observed in the cases of Glyphosate, 2,4-D, Paraquat, and thiram; producing and presenting evidence and even influencing / guiding the agency's decision-making regulator.** The opinions produced by the Task Force often neglect independent studies and decisions by other regulatory bodies, such as the WHO's International Agency for Research on Cancer (IARC).

This extensive undermining of protective public policies has become very visible during the COVID-19 pandemic (Souza et al. 2020). Government agencies have prioritized actions related to the recovery of the economy and left the protection of the population and health care in the background instead of strengthening the fight against the pandemic. The rise of the teleworking, the suspension of employment contracts, and the reduction of working hours and wages are seen as characteristics of the new morphology of work. The Brazilian population has been left to decide how to protect themselves since the government has no strategic way of coping with the pandemic.

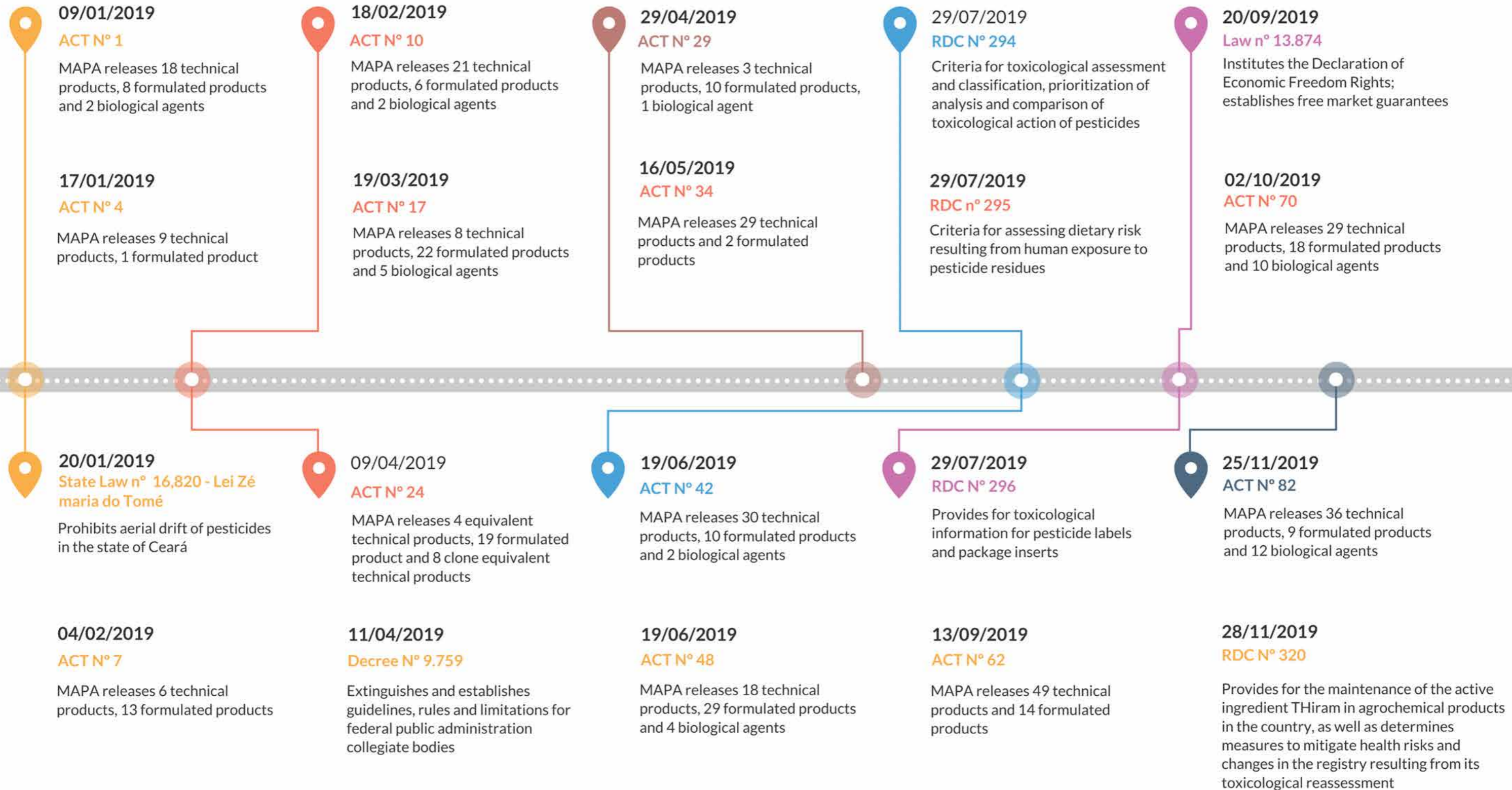




# Timeline of pesticide (de)regulation in Brazil



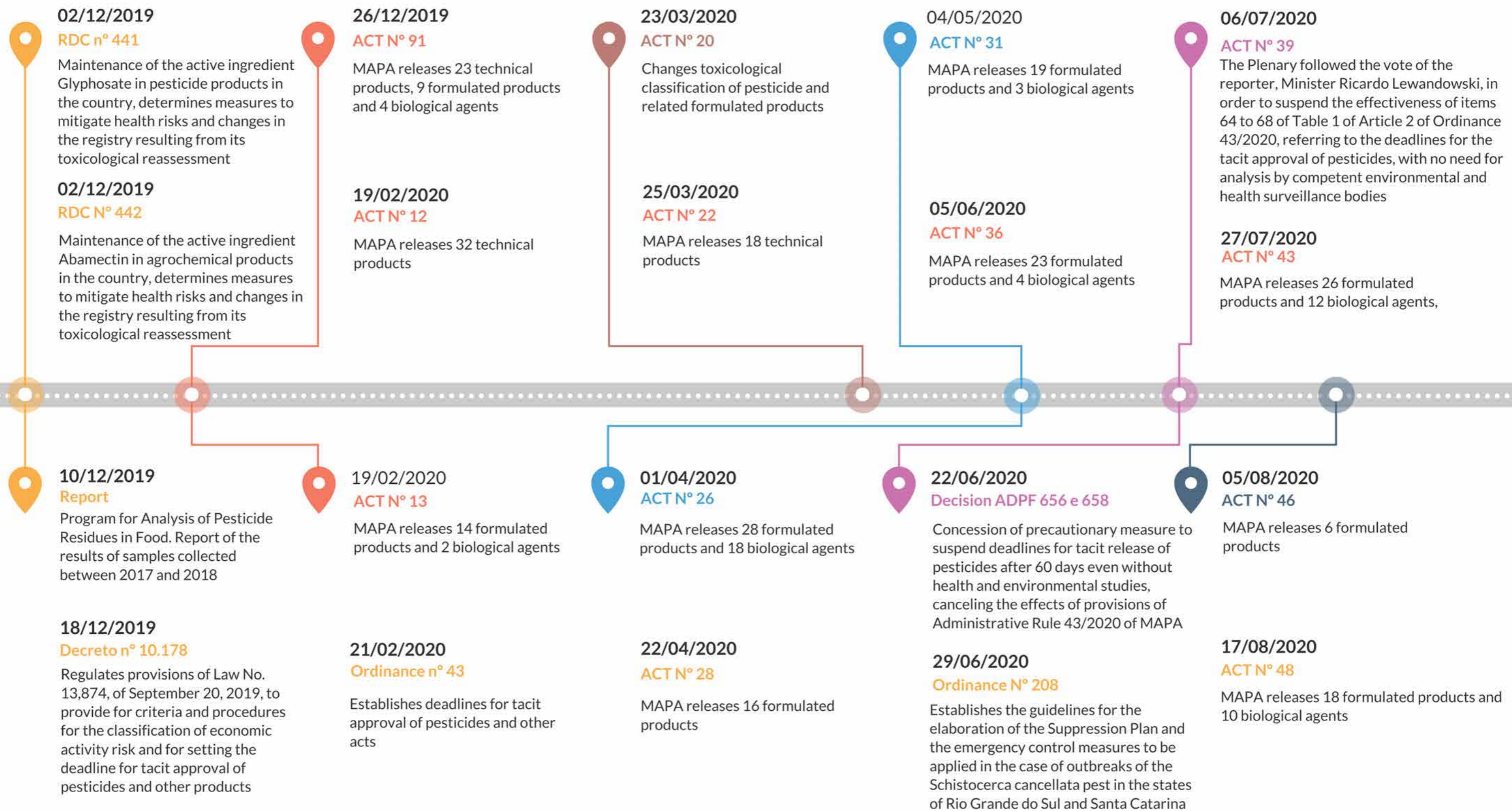
# 2019-2020



# Timeline of pesticide (de)regulation in Brazil



# 2019-2020





03/09/2020

**ACT N° 51**

MAPA releases 14 formulated products

19/10/2020

**ACT N° 59**

MAPA releases 12 formulated products

23/12/2020

**ACT N° 70**

MAPA releases 37 technical products and 19 biological agents

21/09/2020

**ACT N° 55**

MAPA releases 27 formulated products and 4 biological agents

26/10/2020

**ACT N° 60**

MAPA releases 13 formulated products and 3 biological agents

28/12/2020

**ACT N° 71**

MAPA releases 32 technical products

06/10/2020

**Resolution CONAMA/MMA N° 499**

Provides for the licensing of the waste co-processing activity, including pesticides, in rotary kilns for the production of clinker (cement)

18/11/2020

**ACT N° 64**

MAPA releases 21 formulated products

08/10/2020

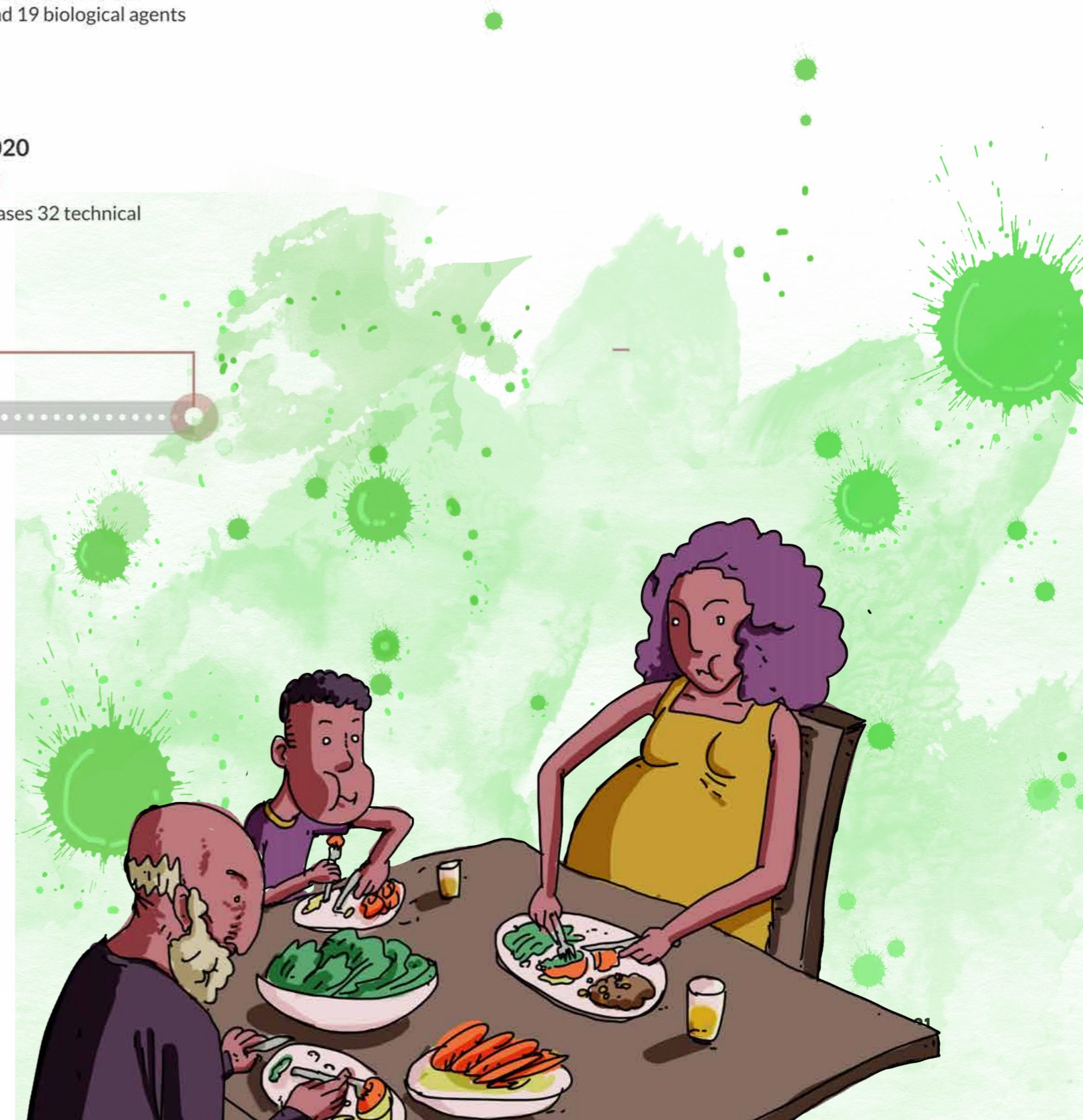
**RDC n 428**

Amends Collegiate Board Resolution - RDC No. 177, of September 21, 2017, which provides for the prohibition of the active ingredient Paraquat in agrochemical products in the country and for transitional risk mitigation measures, to deal with the use of stocks held by Brazilian farmers of products based on the active ingredient Paraquat for crop management in the 2020/2021 agricultural harvest

23/11/2020

**ACT N° 65**

MAPA releases 31 formulated products and 11 biological agents





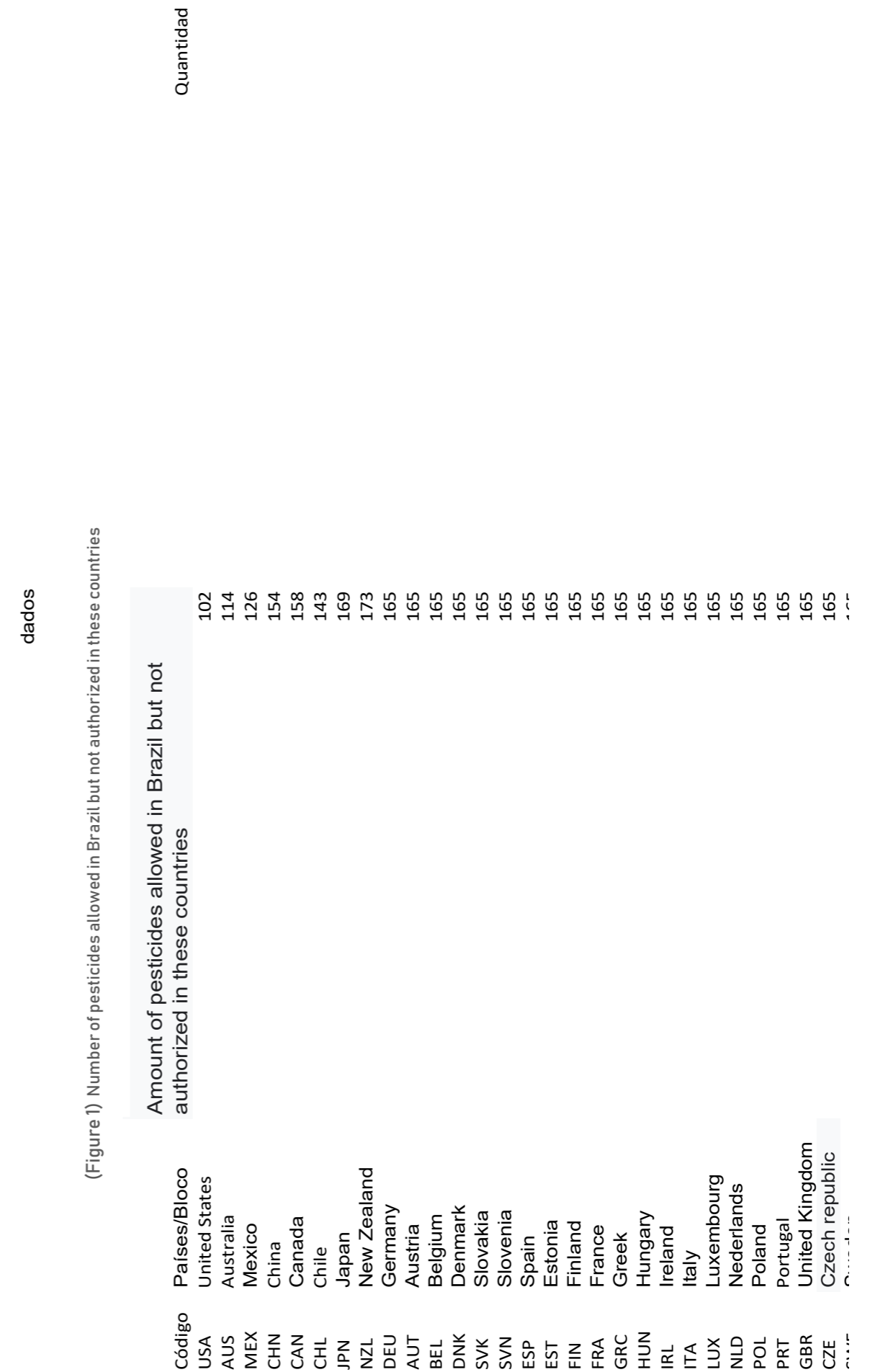
# 4. (De)regulation of pesticides in Brazil – current situation

## 4.1 Pesticides used in the country and banned internationally

**Current Brazilian legislation does not provide for a minimum period for the renewal of licensing. Pesticides that have been in the Brazilian market for more than 4 decades are still used today, without ever undergoing an assessment of environmental and health issues (BRASIL, 1989).**

As shown in a recent study, several of these products have already been banned in other countries (Friedrich et al, 2021b). International registration information was collected for OECD and BRICS member countries. Among the 400 active substances classified as chemical and semiochemical that are authorized for agricultural use, 85.7% are not authorized for use in Iceland; 84.7% in Norway; 54.49% in Switzerland; 52.6% in India; 45,6% in Turkey; 44.4% in Israel; 43.4% in New Zealand; 42.4% in Japan; 41.48% in the European Community; 39.6% in Canada; 38.6% in China; 35.842% in Chile; 31.6% in Mexico; 28.6% in Australia and 25.6% in the United States (Figure 1).

Results showed that of the total of 399 active substances considered in the study mentioned above, 120 active substances can damage health and the environment. Considering the active substances for which marketing data are available in the country, 67.2% of this volume is associated with at least one serious chronic damage, according to the USEPA, IARC and European endocrine disruption list. In the study of Friedrich et al (2021b) three central issues stand out:

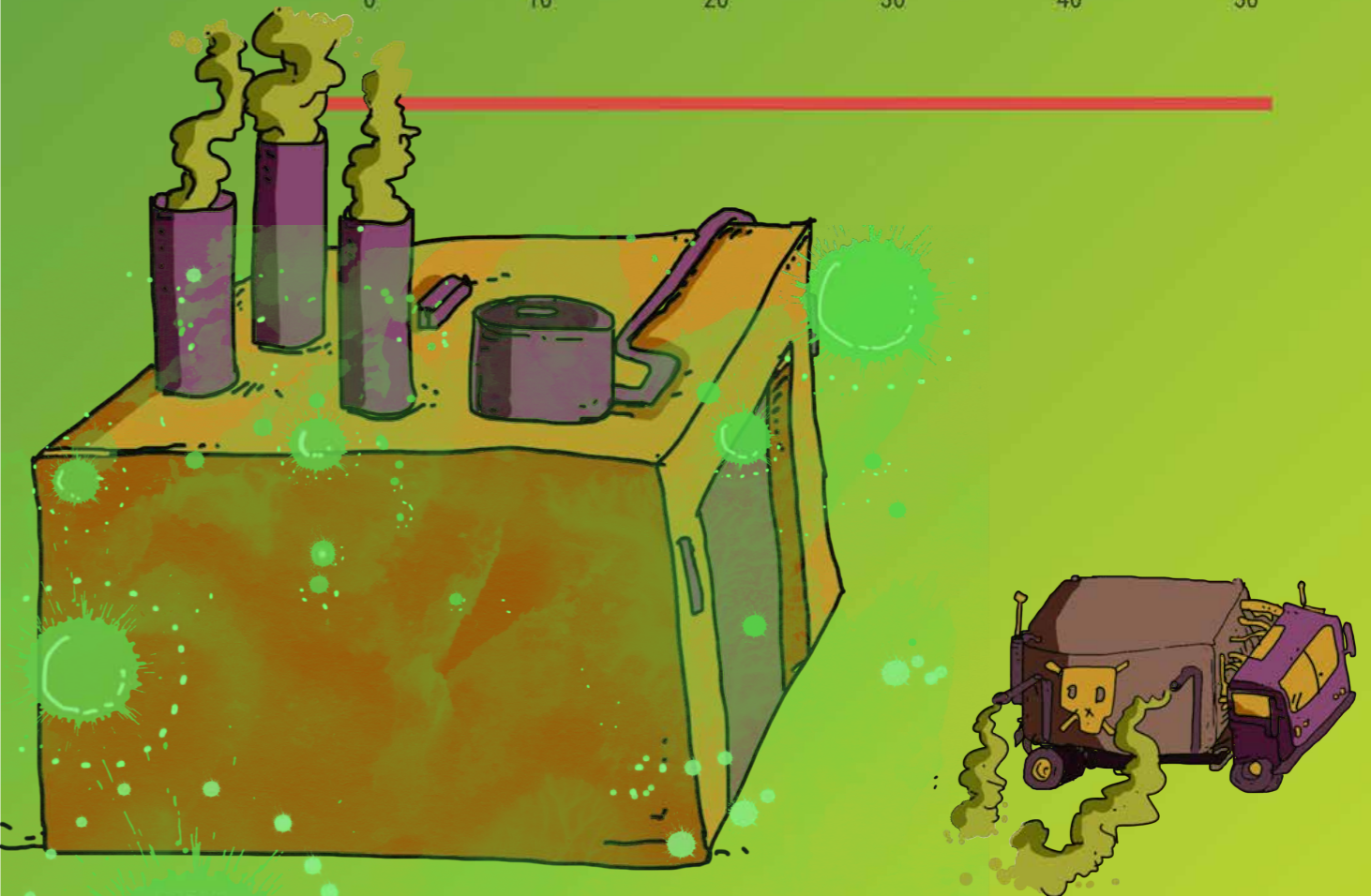
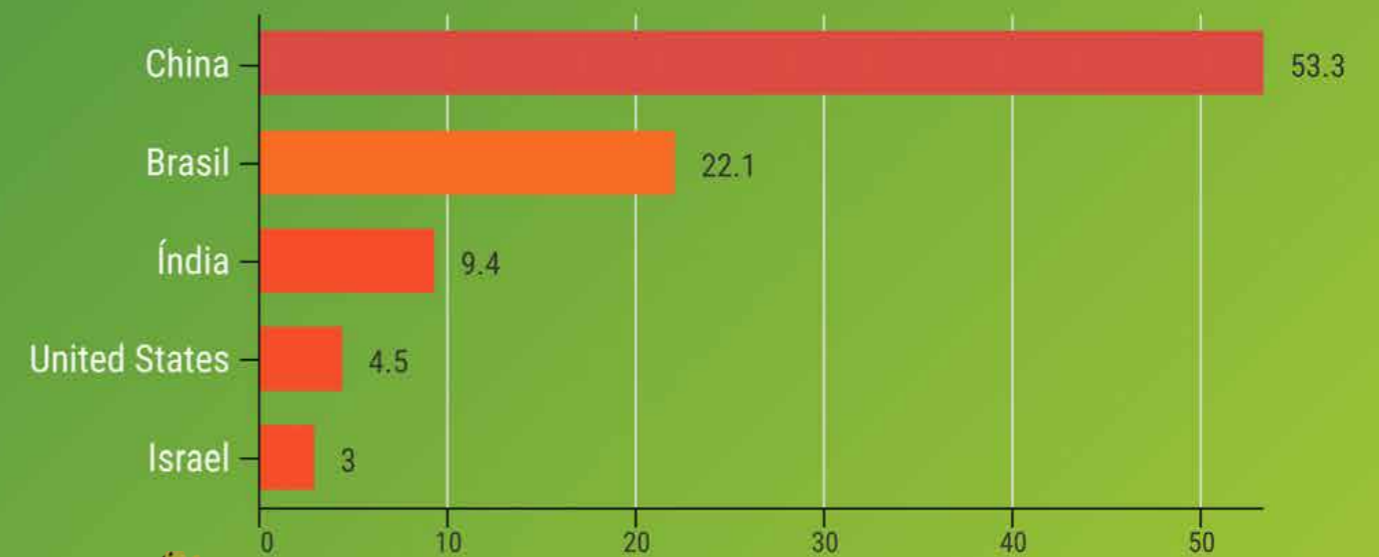


(Figure 1) Number of pesticides allowed in Brazil but not authorized in these countries

(Figure 2)

# Manufacturing country

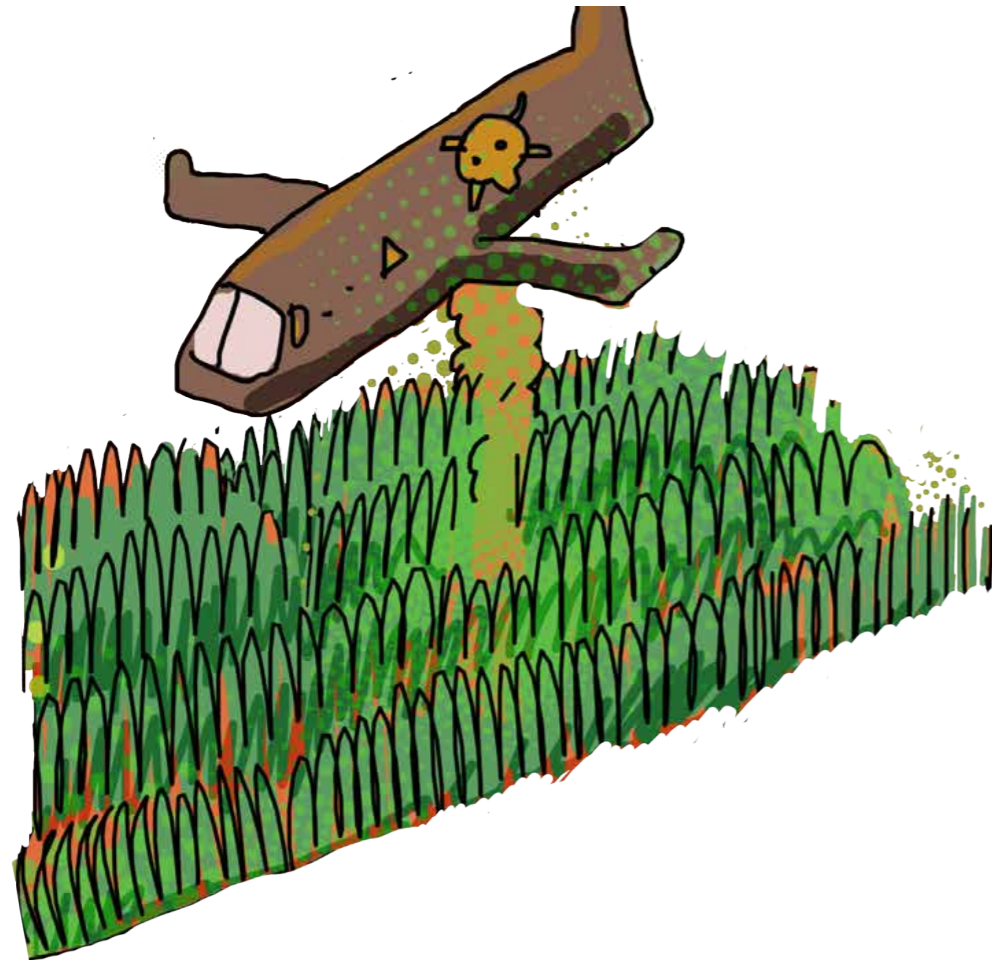
Origin of products licensed in Brazil in 2019 and 2020 (%)



(1) Brazil, a large global consumer market for pesticides, uses products that are not allowed in other countries, almost all of which have been available on the national market for more than four decades. This may lead companies to launch more modern products in countries that review environmental, sanitary, and agronomic legislations more frequently.

(2) More protective criteria must be adopted for licensing of pesticides in the country. Therefore, the study is relevant in highlighting the importance of reviewing the registration of products unauthorized in at least three OECD member countries or in the European Union;

(3) The study points to the need for greater transparency by international regulatory agencies about the reasons for authorizing or not the active substances. This would promote protection actions and stimulate the global market to develop less harmful and more sustainable technologies.



## 4.2 Pesticides in Brazilian food - latest data

In Brazil, Anvisa coordinates the Pesticide Residues Analysis Program in Food (PARA). This program consists of collecting fresh food in commercial establishments in Brazilian capitals, followed by sending it to laboratories for research and identification of pesticide residues. In recent years, the time between the collection of samples and the dissemination of results has been excessively long. Another limitation of PARA is that few laboratories are qualified to carry out the analyzes, an impasse that is also reflected in the analysis of other matrices such as water, processed and ultra-processed foods and clinical samples (Fundação Oswaldo Cruz, 2019). The latest results were published in December 2019 and refer to samples collected between 2017 and 2018.

In the 12-month period between the second semester of 2017 and the first semester of 2018, only 4,616 samples were analyzed, distributed unevenly, in 14 foods that correspond to 31% of the consumption of vegetables in the country. From 60 to 243 pesticide residues

were researched, depending on the food. The percentage of food samples without pesticide residues was 49%. Samples containing pesticides within the permitted limits were 28%. Non-compliant samples accounted for a total of 23% (17.3% of which were not authorized for the crop; 2.3% above the Maximum Residue Limit (MRL); 0.5% banned; and 2.9% with more than one non-conformity). Among these are:

a) Pesticides found. The most frequently identified active substances were: imidacloprid (713), tebuconazole (570) and carbendazim (526). Acephate, chlorpyrifos, and methamidophos were the most frequent substances identified in non-compliant samples. Among the pesticides most used in the country, the herbicides Glyphosate and 2,4-D were researched for the first time in this edition of PARA, but only in a few samples.

b) Mixtures of pesticides. A high diversity of pesticides was found per food sample, setting a scenario of exposure to mixtures of substances. Despite being authorized by regulatory agencies, risks to human populations due to this kind of exposure are not properly investigated prior to licensing. **The report showed a high percentage of food samples containing more than one pesticide. This scenario implies a potential risk not only for the health of food consumers, but especially for workers, and the ecosystems where these products are used.** The results found that 34.5% of the analyzed samples contained two or more pesticide residues, reaching 21 samples. Figure 2 illustrates the foods with the highest percentage of samples containing mixtures of pesticides.

c) Acute risk, chronic risk and mixtures. In the report, Anvisa presented the methodology for assessing acute dietary risk following international standards. Anvisa concluded that the data would not represent acute risk. However, the risk communication strategy to the general population did not consider three important limitations:

1. The Acute Reference Dose (ARfD) calculation process takes into account experimental studies, with laboratory animals, acutely exposed (only once) to the test pesticide, disregarding that, as a rule, the exposure occurs to more than one active substance at the same time.

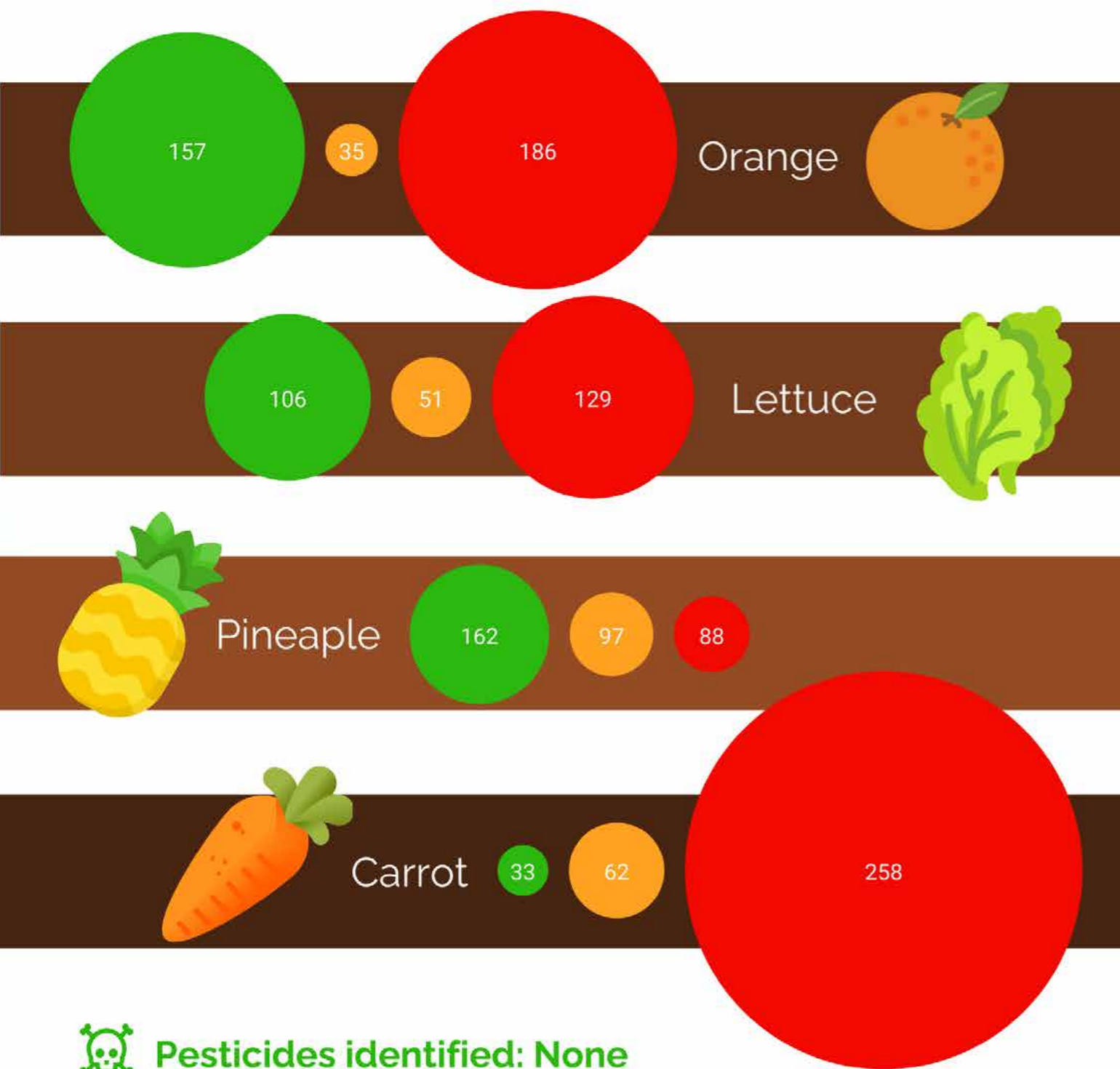
2. Results evidence a frequent presence of pesticides mixtures in food samples.

(Figure 3)



### Mixtures of pesticides residues identified in food collected 2017-2018 (PARA/Anvisa)

Numbers: quantity of samples



- Pesticides identified: None
- Pesticides identified: One
- Pesticides identified: Two or more

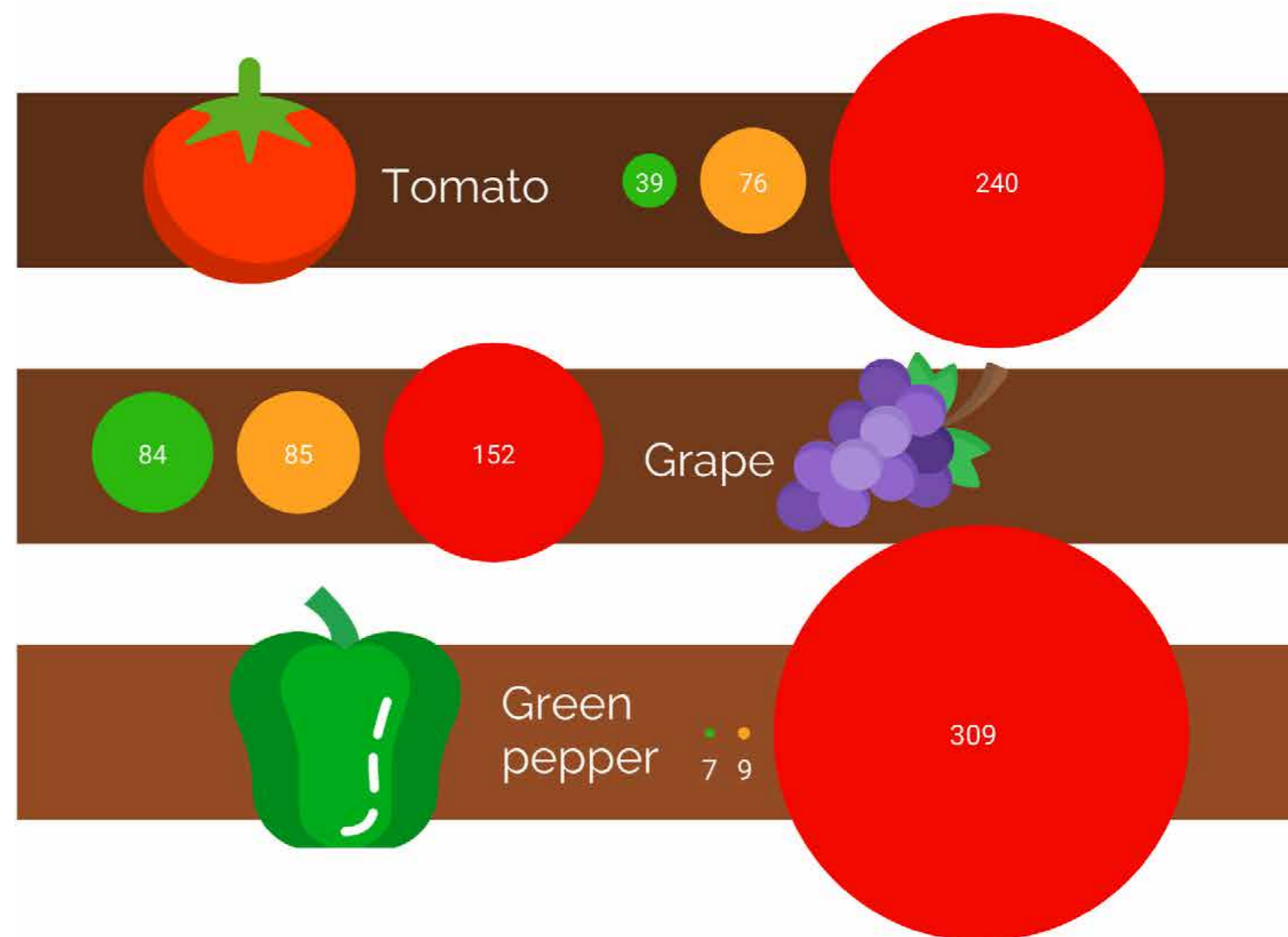
Interactions between pesticides can generate additive, synergistic effects that necessarily impact the calculation of ARfD. Therefore, stating that the quantities found are safe without considering the limitation of these calculations, does not match the updated scientific knowledge, and are basic and consolidated principles in the field of pharmacology / toxicology.

3. According to the report, of the 4,616 samples, 0.89% of the samples would represent an acute risk. However, for some foods this percentage is quite worrying: orange (7.07%), guava (2.83%), grape (1.25%), sweet potato (0.32%), pineapple (0, 29%).

The mixtures of pesticides (2 to 21 residues present) was detected in 34.6% of the samples, and 17.0% of the analyzed samples presented one pesticide residue.

The results refer only to the researched residues that varied from 60 to 243.

The highest percentage of pesticide mixtures were observed on pepper (95%); carrot (73%); tomato (68%); orange (49%); grape (47%); lettuce (45%).



### 4.3 Flexibility of environmental and pesticides legislation: a chronological order.

In the environmental area, important setbacks have been imposed in Brazil. Specifically with regard to pesticides, measures to relax legislation involving the registration and use of pesticides were intensified, meeting the agenda for strengthening agribusiness, based on the weakening of State control in the regulation of pesticides (Gurgel et al. 2018). Many measures have been implemented directly by the Executive, to speed up the process by circumventing the required steps. The main measures adopted in the period were:

#### a) Acts of the Ministry of Agriculture, Livestock and Food Supply (MAPA)

In January 2019, one of the first government measures was the publication of Administrative Acts authorizing the registration of pesticides in Brazil, despite the existence of alternatives that are less harmful to health and the environment. In total, 503 products were released in 2019 (See Timeline). The majority of products are imported, in which 57.4% of the products are manufactured in China and 24.2% in Brazil (Figure 3). **Several products banned in the manufacturing country were released, which include: 2 products manufactured in France (both from BASF and indicated for cotton and corn crops) and classified as toxic to bees; 14 manufactured in China and 1 in India (authorization data in China and India are from 2015 and may be out of date). Of the 161 formulated products, 36 corresponded to mixtures of pesticides (22 indicated for soy, 20 for corn, etc.), whose synergisms and additive effects have not been evaluated by the registration bodies (Fundação Oswaldo Cruz, 2020).**

In 2020, continuing the accelerated release of products, 494 products were authorized, totaling 997 new products in just two years. In comparison, between 2010 and 2015, 815 pesticides were registered, lower than the number approved in the current federal administration. The governmental justification is that the pesticide release process in Brazil has been made “de-bureaucratic”. **However, accelerating the granting of registration was not reflected in the registration of more modern or less toxic products,**

**but in the introduction or maintenance or registration of obsolete, outdated products, most of which have already lost their patent and are therefore cheaper.**

#### b) Maintenance of the Glyphosate Registration

On March 8, 2019, the National Health Surveillance Agency (Anvisa) opened the deadline for contributions to the “Proposed Resolution of Collegiate Board of Directors, which provides for the maintenance of the active substance Glyphosate in pesticides in the country and the measures resulting from its toxicological reassessment”.

According to Abrasco’s (Brazilian Association of Collective Health) Technical Opinion (Associação Brasileira de saúde Coletiva, 2019), recent studies and court decisions verify the relationship between exposure to this pesticide and damage to health and the environment. Glyphosate was classified as a probable human carcinogen (group 2A) by IARC (International Agency for Research on Cancer 2018). North American judges recognized the association of this pesticide with cancer, which was based on a body of evidence from extensive scientific, clinical, epidemiological and experimental studies, resulting in Monsanto’s loss of billion-dollar lawsuits. The transnational corporation has also interfered in the results of studies, seeking to maintain the product registration (McHenry 2018; Krimsky; Gilliam, 2018).

Despite this evidence, Anvisa decided to maintain the registration of Glyphosate (Agência Nacional de Vigilância Sanitária, 2019a) concluding that Glyphosate does not present mutagenic, teratogenic and carcinogenic characteristics, is not an endocrine disruptor and is not toxic for reproduction. This decision was supported by the conclusions presented by a group of registering companies (Task Force) to defend their products in regulatory processes (Friedrich et al., 2021).

Finally, on December 2, 2020, Anvisa published RDC No. 441/2020, providing for the maintenance of the active substance Glyphosate on the Brazilian market (Agência Nacional de Vigilância Sanitária, 2020a). **Despite the risk pointed out by Anvisa for children, home cleaning and amateur gardening is still allowed.** Aerial spraying with Glyphosate is also

also permitted. The use of polyoxyethyleneamine surfactant (POEA), prohibited in other countries, is also authorized in formulations in concentrations up to 20%.

The process of re-evaluating Glyphosate, 2,4-D, Thiram, abamectin and Paraquat (which will be addressed below) is an example of how, in practice, the prohibition criteria provided for in the legislation can be disregarded, depending on which studies about toxicological factors are considered for decision making.

### c) Maintenance of the 2,4-D registration

On May 14, 2019, Anvisa, after a re-evaluation process, decided to maintain the registration of the herbicide 2,4-D, with small restrictions. Anvisa concluded that there are no prohibitive registration effects associated with 2,4-D under Brazilian law, according to the prohibitive criteria for toxic substances. Anvisa ignored that IARC classifies 2,4-D as a possible human carcinogen (2B) (International Agency for Research on Cancer, 2017), as well as the evidence presented by the Oswaldo Cruz Foundation on the potential for this herbicide to induce oxidative stress, which is associated with the emergence of cancer cases (Friedrich, 2014). In addition to cancer, hormonal and reproductive problems were observed in more than one animal species after exposure to 2,4-D (Environmental Protection Agency, 2005), providing robust evidence to cancel the registration of this product in the country. Another problem associated with 2,4-D is the possibility of unintentionally producing dioxin, a substance classified as a persistent organic pollutant recognized for causing cancer, among other effects (Sears et al., 2006).

As with Glyphosate, Anvisa based its conclusions on an opinion prepared by the 2,4-D Task Force, made up of a group of companies that manufacture the pesticide (Agência Nacional de Vigilância Sanitária, 2015).

### d) Publication of Resolutions of the Collegiate Directorate (RCD) of the National Health Surveillance Agency nº 294, 295 and 296/2019

In July 2019, three RCDs were published, which changed several regulations for pesticides in Brazil. The justification was to “de-bureaucratize” the process related to the registration and use of pesticides.

RCD No. 294 changes the toxicological assessment required for the registration or review of the registration of pesticides in the country (Agência Nacional de Vigilância Sanitária, 2019b). The Resolution replaced Ordinance No. 3 of 1992, which defined the mandatory studies to be submitted at the time of registration, including studies of fetal malformation, carcinogenicity and mutagenicity (BRASIL, 1992). The new standard does not mention which studies should be submitted at the time of registration of a pesticide or its review (Agência Nacional de Vigilância Sanitária, 2019a), exempting the manufacturer from presenting essential studies to assess the potential damage related to the evaluated pesticide (Souza et al., 2020).

RDC No. 294 (Agência Nacional de Vigilância Sanitária, 2019b) also excluded dermal and eye irritation studies from those used for toxicological classification and begins to follow GHS recommendations.

The new classification considers only the risk of immediate death to determine the acute toxicity of a pesticide. Thus, even if a pesticide causes serious eye and skin damage, this effect will not be considered indicative of its potential for acute damage. Considering the precariousness of the conditions of use and the health monitoring and surveillance actions of the exposed, this measure can represent an important public health problem (Gurgel; Friedrich, 2020). With the Resolution, more than 90% of the pesticides previously considered extremely toxic (class 1) were reclassified with less toxic potential, or even as unlikely to cause acute damage. **Considering the conditions of use of pesticides in the country, where a significant number of workers who use these products have a low level of education – changing the toxicological classification may**

**present the wrong idea that the products have become less toxic.**

RDC nº 295 provides for the criteria to assess dietary risk resulting from human exposure to pesticide residues (Agência Nacional de Vigilância Sanitária, 2019c). The resolution is silent on the specification of the studies necessary for calculating the doses that theoretically a person could expose themselves to without manifesting acute and chronic effects. With the non-specification of the studies, the calculations of the Acute Reference Dose (DRfA) and the Acceptable Daily Intake (IDA) may be impaired or the values obtained may not reflect the potential for damage related to the evaluated active substances (Gurgel; Friedrich, 2020). Additionally the resolution does not mention the toxicological impact of mixtures present on food.

RDC nº 296 (Agência Nacional de Vigilância Sanitária, 2019d) changes risk communication considering the toxicological information provided on labels and package inserts for pesticides, similar products and wood preservatives in Brazil. The Resolution eliminates the mandatory skull and crossbones pictogram, traditionally used to identify “poison” on the labels of products classified as low toxic or unlikely to cause acute damage (classes 4 and 5), according to the new toxicological classification of RDC No. 294 (Agência Nacional de Vigilância Sanitária, 2019b).

Considering the conditions of pesticide use in the country, where a significant number of workers who use these products have a low level of education – and, consequently, difficulty in reading and interpreting simple texts properly, the removal of the pictogram hides essential information for understanding the level of health threat (Gurgel; Friedrich, 2020).

### **e) Discussion of the toxicological reevaluation prioritization criteria for pesticides by Anvisa**

In April 2019, Anvisa discussed the criteria to indicate active substances for reevaluation, whose purpose is to select those that are the highest priority, which represent the greatest health risk, and are the subject of the next registration reviews to

be conducted by the Agency. The measure seeks to comply with the provisions of RDC No. 221, of 2018, which establishes the criteria and procedures for the process of toxicological reassessment of the active substances in pesticides within the scope of the Agency (Agência Nacional de Vigilância Sanitária, 2018).

Entities like Fiocruz and Abrasco were invited to contribute to the debate. These institutions produced a joint document suggesting the modification of some admissibility criteria interrupted by Anvisa, as well as the inclusion of other criteria, seeking to achieve the final objective of the reevaluation, which is to protect the population from the harmful effects of pesticides.

Suggested measures include: a) expand the sources of information to define the admissibility criteria, since the restriction of the sources of toxicological data to the bases pointed out by Anvisa can negatively interfere in the toxicological re-evaluation process; b) expand of the results of the Program for the Analysis of Pesticide Residues in Food (Para) considered to define the admissibility criteria and the score, including the active substances not evaluated and punctuating any detected active substance, and not only when exceeding acute exposure limits, since the most relevant type of exposure in these cases is chronic; c) prioritize the reassessment of pesticides that have had increased use in recent years, according to marketing data from the Brazilian Institute of the Environment and Renewable Natural Resources (Ibama); d) include effect indicators to define prioritization and inclusion criteria, recognizing the commitment of different organs and physiological functions; and e) score products with older registration and that have not undergone recent reevaluation processes, considering that Brazil has no provision for periodic reevaluation of products with authorized use (Fundação Oswaldo Cruz; Associação Brasileira de Saúde Coletiva, 2019).

Although the adoption of the criteria proposed by Anvisa is strategic to provide transparency in the definition of registry review priorities, the technical requirements must be reconciled with respect for fundamental rights, ensuring that regulatory decisions have the priority of protecting life. Likewise, processes of this nature, which

deal with sensitive issues and have significant impacts on health and the environment, should count on the broad participation of society, with broad debates, and the establishment of reasonable deadlines for sending contributions to improve the decision-making process.

### f) Maintenance of Thiram registration

In November 2019, Anvisa published RDC no 320, publicizing the maintenance of the active substance pesticides in the country.

As with Glyphosate and 2,4-D, the reevaluation process was strongly influenced by the regulated sector, through the participation of a Task Force composed of members of the producing sector.

In the Anvisa document, the Task Force's interference in disqualifying and disregarding independent studies of the reassessment process is evident. For this reason, Anvisa's conclusions differ from those presented in the Technical Note prepared by Fiocruz, which indicated the ban especially due to the effects on reproduction and hormonal function.

Without even presenting toxicological aspects, such as studies of acute, subacute and chronic toxicity or even reproductive toxicity, in the Technical Review of Reassessment, Anvisa kept Thiram registration in Brazil.

### g) Automatic release of pesticides

In February 2020, Ordinance No. 43 was published (Ministério da Agricultura, Pecuária e Abastecimento, 2020a), which established a maximum period of 60 days for the approval of public acts for the release of pesticides under the responsibility of the Secretariat for Agricultural Defense of the Ministry of Agriculture, Livestock and Food Supply (MAPA). If the Secretariat does not analyze the registration request within the deadline, the pesticide is released, without going through any analysis procedure of the agency. The tacit approval of automatic release is under the "Economic Freedom Act" (law

nº 13,874) (Brasil 2019a) and its regulatory decree nº 10,178 (Brasil 2019c).

The measure represents a shift in the position of the Ministry of Agriculture as the maximum entity for the inspection and regulation of these products in Brazil, reducing its role as inducer and promoter of national agricultural planning to a mere ratifier, without instituting evaluation processes. (Souza et al., 2020). Likewise, the initiative represents a risk to society, because the evaluation of agronomic efficiency carried out by MAPA has important repercussions on health and environment issues. This is because, among other issues, it must provide the research for resistant species that can lead to increased use in volumes and diversity of pesticides, with negative repercussions for health and the environment.

In an exemplary way, the STF challenged the ordinance, preventing the indiscriminate release from being instituted through a normative act.

### h) Beginning of the judgment of the Direct Action of Unconstitutionality (ADI) no 5.553

Brazil has a package of tax reductions and exemptions that include tax waivers and exemptions related to pesticides. Thus, agribusiness is exempt or pays reduced amounts of the Contribution for Financing of Social Security (Cofins), contribution to the Social Integration Program and to the Social Integration Program/Public Service Employee Savings Program (PIS / Pasep) and Industrialized Tax. In 2016, the Socialism and Liberty Party (PSOL) filed a Direct Action of Unconstitutionality (ADI) No. 5,553, challenging the Constitutionality of these benefits, which in 2017 alone totaled around US \$ 10 billion dollars (Fundação Oswaldo Cruz, 2019a).

In February 2020, ADI No. 5,553 was included in the Supreme Federal Court's (STF) judgment agenda. However, taking advantage of the pandemic scenario, a meeting held on April 3, 2020 between the Secretaries of Finance of the 26 states and the Federal District approved the renewal of Agreement No. 100/1997 of the National Council for Farm Policy, continuing non-taxation of pesticides. The extension was due to the insistence of



agribusiness associations and organizations (Souza et al., 2020).

Thus, the process only went on to be considered in October, and its trial started on the 30th of that month. The reporting Minister Edson Fachin voted to declare the tax benefits to pesticides unconstitutional. However, on November 3, Minister Gilmar Mendes asked to analyze the process, and there is no date set for the process to return to the agenda and be concluded. Until then, companies continue to take advantage of tax exemptions and reductions that prevail in Brazil, privatizing the bonus and socializing the burden associated with the use of pesticides.

### i) Normative Instruction (NI) No. 13, of April 8, 2020

In April 2020, MAPA published an NI that allows aerial spraying of agricultural fungicides and mineral oil on banana crops, reducing the minimum safety distance from neighborhoods, cities, towns and villages from 500 to 250 meters (Ministério da Agricultura, Pecuária e Abastecimento, 2020b). The change occurred without any scientific justification to indicate the safety of this reduction in the distance of aerial spraying.

In fact, aerial spraying of pesticides using aircraft is not efficient or safe even if the distance of 500 meters is respected, given the many of conditions that determine the loss/drift of the poison—whether technical or accidental. The drift indicates that aerial spraying is a low-efficiency method, as a significant amount of the applied pesticides does not reach the plant. Studies carried out in Brazil and in the world show losses ranging from 34.5% to 82% (Fundação Oswaldo Cruz, 2019b).

In Brazil, two emblematic cases that highlight the dangers of this technique stand out: in Lucas do Rio Verde-MT, drifts of aerial spraying reached the urban space of the city in 2005 (Pignatti, Machado, Cabral, 2007) and in Rio Verde-GO, in which aerial spraying of pesticides on a rural school in 2013 reached 122 children and generated dozens of intoxications (Oliveira, 2014). Likewise, aerial spraying in indigenous territories and in areas of land conflict is not uncommon (Freitas, 2016). Due to the high danger, Human Rights Watch, an organization that is an international reference in the

defense of human rights, published in a report in 2018 recommending the suspension of the practice in Brazil (Human Rights Watch, 2108).

### j) Authorization of pesticides in emergency situations

In June 2020, a locust swarm (*Schistocerca gregaria*) coming from Argentina towards Southern Brazil led to the publication of Ordinance No. 201, declaring an “emergency situation in plant protection” in Rio Grande do Sul and Santa Catarina, due to the risk of damage to crops in both states. (Ministério da Agricultura, Pecuária e Abastecimento, 2020c). The Ordinance provides for the adoption of emergency measures, such as the use of pesticides to eliminate the “agricultural pest”, even if the product has no authorized use in the country.

This decision is based on Law No. 12,873, of 2013, which authorizes the Executive Branch to declare an emergency situation in plant or animal protection, allowing the agricultural authority to import and grant temporary emergency authorization for the production, distribution, commercialization and use of pesticides that are unauthorized in Brazil (Brasil, 2013). This measure led MAPA solely to decide to derogate from the requirement for a pesticide authorization if there is an emergency situation. The unilateral authorization for the use of pesticides dismantles the tripartite structure, where the decision depends on the consent of MAPA, Anvisa and the Brazilian Institute of the Environment and Renewable Natural Resources (Ibama). This authorization occurs without the requirement to analyze potential damage to health and the environment representing a risk to public health. This measure was motivated by the outbreak of the *Helicoverpa armigera* caterpillar, leading MAPA to authorize the import and use of emamectin benzoate (Gurgel et al., 2017a).

This case evidences the overlapping of economic interests with those of health, since emamectin benzoate had a lower cost than other pesticides with the same purpose, although the technical opinion produced by Anvisa rejected the request for registration of a technical product based on this active substance due to unacceptable

risks to human health, such as its high neurotoxic potential and evidence of teratogenesis (Gurgel et al., 2017a).

The release of pesticides in an emergency situation is subject to criticism and questioning, especially considering that products already evaluated and not authorized in Brazil due to the potential for damage and unacceptable risks to health and the environment can be released unilaterally by the MAPA, even though the Agrochemicals Law mandates that this process must be tripartite.

### k) Review of the Water Potability Ordinance

From March to June 2020, the Ministry of Health placed in Public Consultation the draft review of the drinking water standard for human consumption, which defines the procedures for the control and surveillance of the quality of water for human consumption and its potability standard (Ministério da Saúde, 2017). One of the evaluated items in the ordinance was the presence of pesticides in water, monitored from the parameters defined in the document.

The legal provision establishes the maximum concentration level (MCL) of 64 chemical substances, including 27 pesticides—although more than 500 active pesticide substances have been authorized in the country. However, the 27 pesticides defined in the ordinance for monitoring purposes do not include those most used in Brazil, such as Glyphosate and 2,4-D. Of the 27 pesticides defined, 21 of them are on PAN's list of highly dangerous pesticides; eleven of these are listed as a result of proven chronic risks to human health.

Although the reevaluation process represents an important initiative on the part of the Ministry of Health, a number of limitations can be observed, for which the Fiocruz Pesticide Working Group indicated a series of recommendations, organized into three sets of initiatives: 1) include pesticides in the list of priorities for assessing potability; 2) redefine the number of Active Substances and the maximum permitted concentrations per sample; and 3) delineate actions to be taken in case of non-compliance and

recommendations for businesses (Rosa; Gurgel; Friedrich, 2020).

The main recommendations were:

i) Include in the list of pesticides considered for the assessment of potability those banned in Brazil and those still authorized in Brazil but banned or discontinued in their countries of origin or in at least three other countries due to their negative impacts on human health or the environment (Rosa; Gurgel; Friedrich, 2020).

ii) Adopt the limits defined in the European Community for pesticides in water. The European Union, through Directive 2015/1787, of 06/10/2015, which amended Directive 98/82 / EC, determines that no pesticide can exceed the concentration of 0.1 µg/L and the sum of all pesticides in the same sample cannot exceed 0.5 µg/L. The pesticides aldrin, dieldrin, heptachlor and heptachlor epoxide cannot exceed 0.03 µg/L (Rosa; Gurgel; Friedrich, 2020).

iii) Define a maximum limit of active substances in a single sample. Simultaneous exposure to various pesticides can result in synergistic, additive, antagonistic effects, making it impossible to reproduce in the laboratory, using the dose-response model, the effects that the population may develop. However, Brazil does not adopt a limit considering the total of pesticides present in a single sample. The adoption of the European standard is recommended, where the sum of all pesticides in the same sample cannot exceed 0.5 µg/L, as well as the adoption of a maximum limit of active substances present in water for human consumption, providing for surveillance measures and accountability of water service providers (Rosa; Gurgel; Friedrich, 2020).

iv) Define MCL according to factors that configure greater precaution, using less allocation factor and greater uncertainty factor. The MCL suggested by Fiocruz, as defined in the revision of the ordinance, was also calculated from the lowest NOAEL (No-observed-adverse-effect level) reviewed in international guidelines. However, the interspecies safety factor adopted was more conservative for all monitored pesticides (divided by 1000), and the allocation factor of 0.1 (assuming that 10% of IDA-Acceptable daily intake -, comes from water, as recommended the WHO), considering a water

consumption of 2L per day and an adult body weight of 60 kg. The calculation used was performed based on the equation recommended by the WHO. It is noteworthy that children are more vulnerable, as they have half the body weight and the calculation of the mean MCL does not make this distinction, even though the maximum values allowed should be more protective for this group, because in this stage of development the damage can be more serious and potentially irreversible (Rosa; Gurgel; Friedrich, 2020).

The pandemic scenario impaired the social participation in the public consultation process, making it difficult for entities and institutions to participate in face-to-face meetings in the five regions of the country, and also affected the debate and construction of proposals and suggestions to improve the ordinance. Although important entities contributed to the debate, despite the difficulties mentioned, it is not yet known whether the suggestions and recommendations were incorporated into the new ordinance.

## l) Maintenance of the Paraquat registration

In September 2020, the Paraquat reassessment process, which started in 2008, was finally completed. The decision was for the ban, but with a great controversy because the measure allowed the use of product stocks until 2021. In addition to the delay of more than a decade to complete the reevaluation process, the decision allows the population to continue exposing themselves to a product considered by the Brazilian Regulatory Agency as a cause of serious health problems, such as neurodegenerative disorders like Parkinsonism, mutagenic potential and high acute toxicity (Agência Nacional de Vigilância Sanitária, 2017).

The authorization for the use of stocks, in October 2020, sought to comply with the request of the Minister of Agriculture, Livestock, and Food Supply, which led Anvisa's Collegiate Board, through RDC No. 428, to change its understanding to allow the use of product stocks in the 2020/2021 agricultural harvest (Agência Nacional de Vigilância Sanitaria, 2020b).

The decision to ban Paraquat was, in fact, published in 2017, through RDC No. 177,

which established the ban by providing for transitional risk mitigation rules, the so-called "phase-out" or scheduled withdrawal. The DRC prohibited, "after 3 (three) years, counting from the date of publication of this Resolution, the production, import, commercialization and use of technical products and formulation based on the active substance Paraquat," establishing that from September 22, 2020, Paraquat could no longer be used in Brazil (Agência Nacional de Vigilância Sanitária, 2017). The regulated sector, therefore, had three years to plan and organize crops without using this input.

The Office of Anvisa's Legal Attorney corroborated the definitive ban on Paraquat in Brazil, without changing the terms, pointing out that "the management of Anvisa has not presented the motives and reasons that motivate and justify, with technical, scientific and sanitary support, the viability and the need to change the regulatory framework defined by RDC No. 177/2017" (Agência Nacional de Vigilância Sanitária, 2020c). In November 2020, the Attorney General's Office in Rio Grande do Sul, in a Public Civil Action, stated that "there is no other conclusion to be reached than that the permission to use Paraquat stocks held by farmers and cooperatives is configured evident gross error. Now, the risks hitherto known to the scientific community, and the Brazilian regulatory agency itself, militate in favor of maintaining the ban on pesticides, whether for production, commercialization or use" (Procuradora da República do Rio Grande do Sul, 2020).

**However, the lobby of the regulated sector pressed, especially via the Task Force composed of the companies that manufacture Paraquat, so that the product would not be banned from use on the scheduled date, which culminated in the decision to allow the use of inventories, although its ban has been ratified. The Task Force conducted genotoxicity studies on somatic and germinative cells and "commissioned" a researcher from Unicamp, a traditional Brazilian University, a biomonitoring study with the objective of determining Paraquat residues in the urine of workers with prolonged exposure to soybean cultivation in the Brazilian state of Mato Grosso. This measure led to the publication of a statement by Unicamp, which was "emphatically in favor of banning" Paraquat, recognizing the existence of "conflict of interest" in the study, in addition to**

**other problems in its design and execution (Universidade Estadual de Campinas, 2020).**

These studies were attempts to produce evidence contrary to those already described about damage to health, which are well established in the national and international scientific literature, to postpone the product ban.

The entire process of changing the RDC term occurred in the midst of the Covid-19 pandemic, in a scenario of social isolation, and did not ensure proper transparency or adequate social participation.

The pandemic argument was even used by the Attorney's Office of the State of Mato Grosso do Sul, one of the strongholds of Brazilian agribusiness, to justify maintaining the Paraquat registration. Among other arguments, it was argued that the ban on Paraquat in Brazil would have "a resounding, gigantic impact on Brazilian agricultural productivity, significantly reducing it", that there would be "harmful consequences for agricultural commodity exports, the trade balance, and, of course, Brazilian GDP", and GDP with consequent "loss of competitiveness of the Brazilian product". On the other hand, the maintenance of its use would support the economic growth of the agricultural sector, being "extremely relevant for the maintenance of the Brazilian economic stability" (Procuradoria da República do Mato Grosso do Sul, 2020).



**THUS, THE DECISION OF ANVISA'S COLLEGIATE BOARD OF DIRECTORS TO ALLOW THE USE OF INVENTORIES UNTIL 2021 WAS BASED EXCLUSIVELY ON ECONOMIC ARGUMENTS. THE BODY OF EVIDENCE POINTING TO THE HARMFULNESS OF PARAQUAT WAS DISREGARDED, AS WELL AS THE THREE-YEAR PERIOD GRANTED FOR SCHEDULING THE USE OF STOCK AND REPLACEMENT OF THE PRODUCT, SINCE THE DECISION TO BAN IT IN 2017, AND THE DEBATE WAS HELD WITH SOCIETY WHEN DEFINING THE END OF THE PHASE OUT PROCESS IN SEPTEMBER 2020. THUS, THE PRINCIPLES OF PREVENTION, PRECAUTION AND PROHIBITION OF SETBACKS PROVIDED FOR IN BRAZILIAN LEGISLATION WERE VIOLATED.**

#### **m) Authorization to burn pesticide residues in ovens used for cement production**

In September 2020, the National Environment Council (Conama) revoked resolution No 264 of 1999, which licensed waste coprocessing in rotary kilns for clinker production, except for: gross household waste, health care waste, radioactive waste, explosive waste, organochlorines and pesticides (Conselho Nacional do Meio Ambiente, 2000). In October, Conama Resolution 499/20 was published, which provides for the licensing of waste coprocessing in rotary kilns for clinker production (Conselho Nacional do Meio Ambiente, 2020). Although other Conama resolutions published in the same period were suspended by the Brazilian Supreme Court, the validity of this resolution was maintained.

Even more serious is that it authorized the burning of organochlorine pesticides, classified as persistent organic pollutants, which have a high capacity to bioaccumulate in living organisms and to remain in the environment for long periods. For them, the resolution establishes a maximum limit level, ignoring that for carcinogenic and endocrine disrupting substances, such as several organochlorines listed in the document, there is no safe exposure limit (Friedrich et al., 2021).

The maintenance of the resolution supports a governmental act that has major health repercussions resulting from the burning of pesticides.

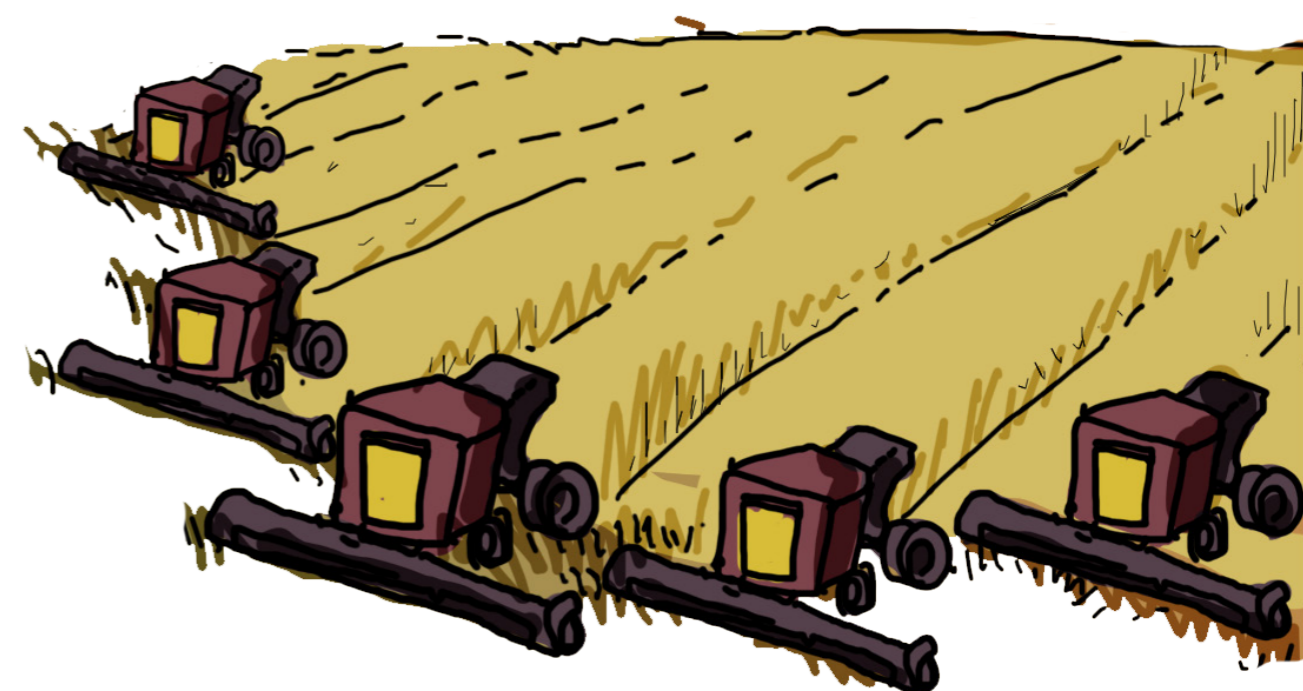
### n) Maintenance of the abamectin registration

In December 2020, RDC No. 442 (Agência Nacional de Vigilância Sanitária 2020d) was published, which provides for the maintenance of the active substance abamectin in pesticides in Brazil, determines measures to mitigate health risks and changes the registry because of its toxicological reassessment.

The toxicological reassessment of abamectin started in 2008. In 2019, Anvisa placed the proposal for a Technical Opinion in Public Consultation.

**IN 2020, ANVISA COMPLETED THE PROCESS, DECIDING TO MAINTAIN THE REGISTRY DESPITE HAVING CLASSIFIED ABAMECTIN AS SUSPECTED OF CAUSING REPRODUCTIVE TOXICITY IN HUMANS AND ADVERSE EFFECTS ON LACTATION. THE AGENCY ALSO INDICATED THAT THE LEAFLETS SHOULD PRESENT WARNINGS THAT THE PRODUCT HARMS THE FETUS, CAUSING CONGENITAL MALFORMATIONS, AND IT CAN BE HARMFUL TO CHILDREN FED BREAST MILK. (AGÊNCIA NACIONAL DE VIGILÂNCIA SANITÁRIA 2019D).**

As mentioned above, this example reinforces the non-compliance with the criteria foreseen in current legislation for banning pesticides in Brazil.





## 5. Some Brazilian epidemiological studies on pesticides

Long-term exposure to pesticides may have a positive association with chronic diseases. This exposure also causes increased vulnerability to microbial and viral infections. Pesticides can impact human health through cellular and extracellular avenues, as well as direct and indirect mechanisms in a complex and synergistic way. The pesticides induce pro-inflammatory mediators of macrophages, aromatase expression, growth factors and oxidative stress, DNA damage, genomic, epigenetic changes, carcinogenesis, estrogenicity, abnormal embryo development and obesity (Tsatsakis et al., 2020).

The following are reported epidemiological studies conducted in Brazil. The outcomes of the studies indicate effects on the health of populations exposed to pesticides. From a syndemic perspective, these populations are more vulnerable to worst clinical prognoses for Covid-19.

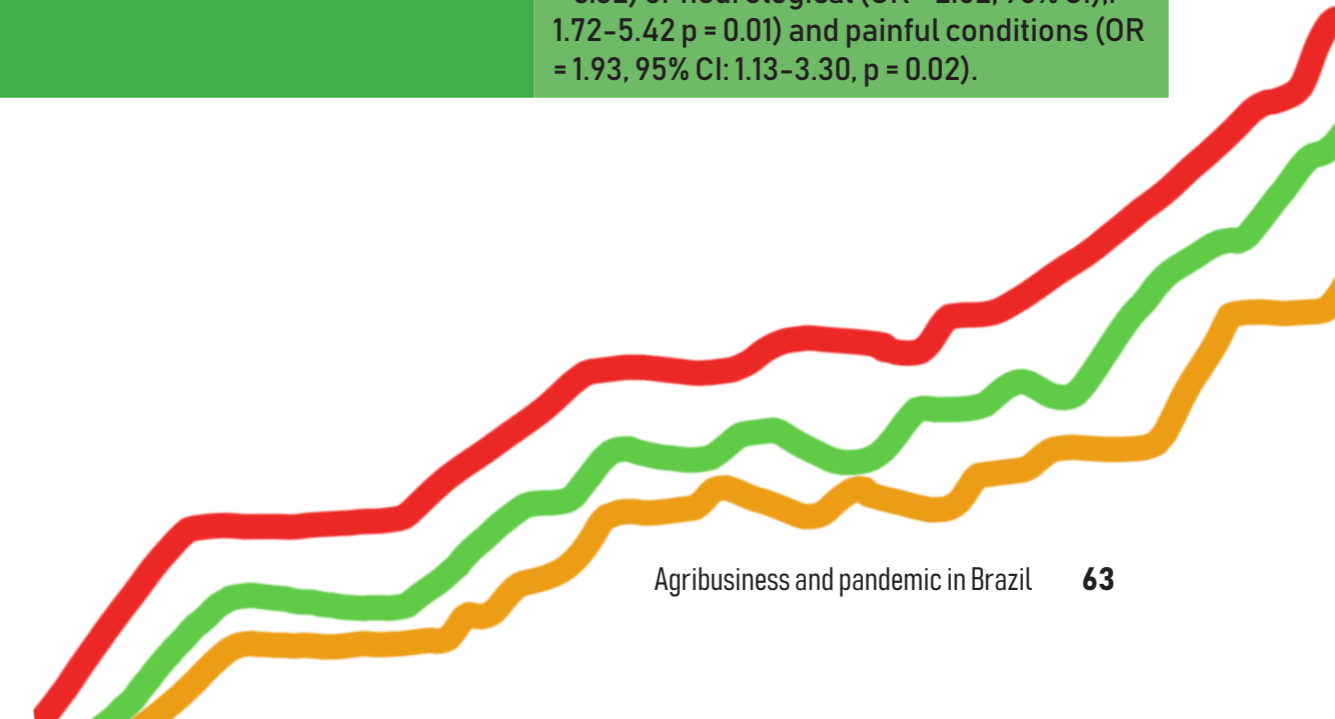
### 5.1 Neurotoxic effects

<b>Author</b>	Campos et al. 2017.
<b>Study period/Study location/Kind of study and objective</b>	October 2011 to March 2012/ Municipality of Dom Feliciano, Rio Grande do Sul. Cross-sectional study to determine the prevalence of common mental disorders and self-reported depression, and analyze their association with the exposure to pesticides.

<b>Main outcomes</b>	Common mental disorders and self-reported depression
	The prevalence of common mental disorders and self-reported depression in the sample population was 23% and 21%, respectively. An increase of 73% was observed in the odds of pesticide exposure at an age equal to or less than 15 years. There were positive associations between self-reported pesticide poisoning and common mental disorders (OR=2.63; 95% CI, 1.62-4.25); self-reported depression and exposure to pyrethroids (OR= 1,80; IC95% 1,01; 3,21) and aliphatic alcohol (OR= 1,99; IC95% 1,04; 3,83); self-reported depression positively correlated with a greater period of exposure to dinitroaniline (OR=2.20; 95% CI, 1.03-4.70) and sulphonylurea (OR=4.95; 95% CI, 1.06-23.04)
<b>Author</b>	Faria et al, 2014.
<b>Study period/Study location/Kind of study and objective</b>	2010/ São Lourenço do Sul, Rio Grande do Sul. Cross-sectional study with the objective of identifying the prevalence of minor psychiatric disorders (MPD) among tobacco farmers and associated factors, paying special attention to pesticide and nicotine exposure ≥18 years old.

<b>Main outcomes</b>	7 to 9 types of exposure to pesticides were observed PR= 1,88 (IC95% 1,38; 2,57); Pesticide poisoning: higher prevalence of MPD [1 episode: PR= 1,55 (IC95% 1,10; 2,18); ≥2 episodes: PR= 2,45 (IC95% 1,75; 3,43)]; Entering the treated area following application of pesticides: PR= 1,71 (IC95% 1,33; 2,20); Has contact through clothes wet from pesticides: PR= 1,35 (IC95% 1,06; 1,73); Longer time (years) of exposure to pesticides increased the prevalence of MP (p-trend= 0,01); Use of organophosphate: Uso de OF: RP= 1,52 (IC95% 1,19; 1,94).
<b>Author</b>	Poletto e Gontijo, 2012.
<b>Study period/Study location/Kind of study and objective</b>	Ituporanga, Santa Catarina. Cross-sectional study to investigate family farming worker's mental health problems and sociodemographical features and work process association.
<b>Main outcomes</b>	Prevalence of 33,8% of mental health problems. It was observed that women prevailed with 39,7%, in contrast with men with 26,1%; Higher prevalence of mental health problems in families (48,8 vs. 23,7) and farms (44,8 vs. 30,4) with reports of pesticide poisoning, when compared to those that did not report poisoning; Positive association between pesticide use and mental health problems (OR= 3,20; IC95% 1,41; 7,28); Positive association between pesticide poisoning in the family and mental health problems (OR= 3,04; IC95% 1,68; 5,50).
<b>Author</b>	Camarinha et al, 2011.
<b>Study period/Study location/Kind of study and objective</b>	Sapucaia, Rio de Janeiro. Transversal descriptive study to evaluate the auditory temporal processing in workers occupationally exposed to organophosphate pesticides.

<b>Main outcomes</b>	Median of measures the Recorded stimulus were played for the Frequency Pattern Test (FPT) and the Duration Pattern Test (DPT) were 47.2% and 52.8%, respectively. Such result is below normal standards
	The rural workers studied showed, on average, thresholds higher than the normal standard for the Gaps-In-Noise (GIN) test.
<b>Author</b>	De Souza et al, 2011.
<b>Study period/Study location/Kind of study and objective</b>	July to September 2005/ Vale do Taquari, Rio Grande do Sul. Cross-sectional study was to assess a possible link between contact with pesticides and the prevalence of chronic disease in the rural population.
<b>Main outcomes</b>	Significant association between occupation in rural areas and contact with pesticides versus (vs) occupation in urban areas and contact with pesticides (OR: 7,61, IC95%: 4,41-13,14, p=0,000). There was a positive association between: residence in a rural area and contact with pesticides vs residence in an urban area and contact with pesticides (OR = 8.90, 95% CI: 4.94-16.02, p = 0.000). Contact with pesticides and alcohol consumption (OR = 1.66; 95% CI: 1.02-2.72; p = 0.046). There was a significant association only between contact with pesticides and reports of oral (OR = 1.49, 95% CI: 1.37-1.61; p = 0.02) or neurological (OR = 2.52, 95% CI: 1.72-5.42 p = 0.01) and painful conditions (OR = 1.93, 95% CI: 1.13-3.30, p = 0.02).





## 5.2. Metabolic effects

<b>Author</b>	Piccoli et al, 2016.
<b>Study period/Study location/Kind of study and objective</b>	2012-2013 / Farroupilha, Rio Grande do Sul.
	Cross-sectional study to evaluate the association of agricultural work practices, use of contemporary-use pesticides, and organochlorine pesticides residue levels in serum with circulating thyroid hormone levels in an agricultural population.
<b>Main outcomes</b>	In men there was a significant association between the time of use of pesticides in general and the concentrations of FT4 (the longer the time of use, the higher the level of free circulating FT4). The time of use of fungicides was positively associated with the concentration of TSH in the blood (the longer the time, the greater the blood concentration) ( $p = 0.03$ ); The time of herbicide use was also significantly associated with TSH levels (the longer the time, the higher the levels) ( $p = 0.05$ ) and inversely with the levels of free FT4 ( $p = 0.01$ ).
	Fungicidal dithiocarbamates were inversely associated with free T4 concentrations ( $p = 0.05$ ) and had a positive trend with TSH levels ( $p = 0.06$ ). These associations were not observed for women.

## 5.3 Genetic damage and cancer

<b>Author</b>	Alves et al, 2016.
<b>Study period/Study location/Kind of study and objective</b>	2007-2008 / Santa Cruz do Sul, Rio Grande do Sul.
	Cross-sectional study to determine how this exposure to pesticides induces genetic alterations in workers.
<b>Main outcomes</b>	Exposed workers (tobacco growers) had average damage index (unexposed: $DI = 9.72 \pm 7.50$ ; exposed: $DI = 28.01 \pm 21.43$ ), frequency of damage (unexposed: $DF = 6.75 \pm 4.73$ ; exposed: $DF = 19.54 \pm 13.03$ ) and micronucle frequency (not exposed: $MF = 1.33 \pm 1.86$ ; exposed: $MF = 7.14 \pm 6.49$ ). Significantly higher than controls ( $p < 0.05$ ). A significant increase in MN frequencies was observed for PON1 Gln/Gln individuals in the exposed group compared to PON1 Arg/- individuals ( $P < 0.01$ ). After exposure to pesticides, a drastic increase in SOD activity was observed for the exposed group relative to the unexposed control group ( $P < 0.001$ ; Student t-test). Significant differences were observed with respect to band neutrophils (unexposed: $2.68 \pm 1.08$ ; exposed: $1.78 \pm 1.31$ , $p < 0,05$ ) and monocyte counts between the exposed and the unexposed group (unexposed: $1.31 \pm 0.64$ ; exposed $4.78 \pm 1.35$ , $p < 0,05$ )
	The inorganic elements that appear in significantly increased concentrations in the blood samples of exposed subjects are: zinc (Zn - unexposed: $99 \pm 28$ exposed: $207 \pm 67$ ; $p < 0,05$ ), magnesium (Mg - (unexposed: $562 \pm 134$ ; exposed: $1019 \pm 271$ , $p < 0,05$ ), and aluminum (Al - (unexposed: $76 \pm 4$ ; exposed: $648 \pm 83$ , $p < 0,05$ ).

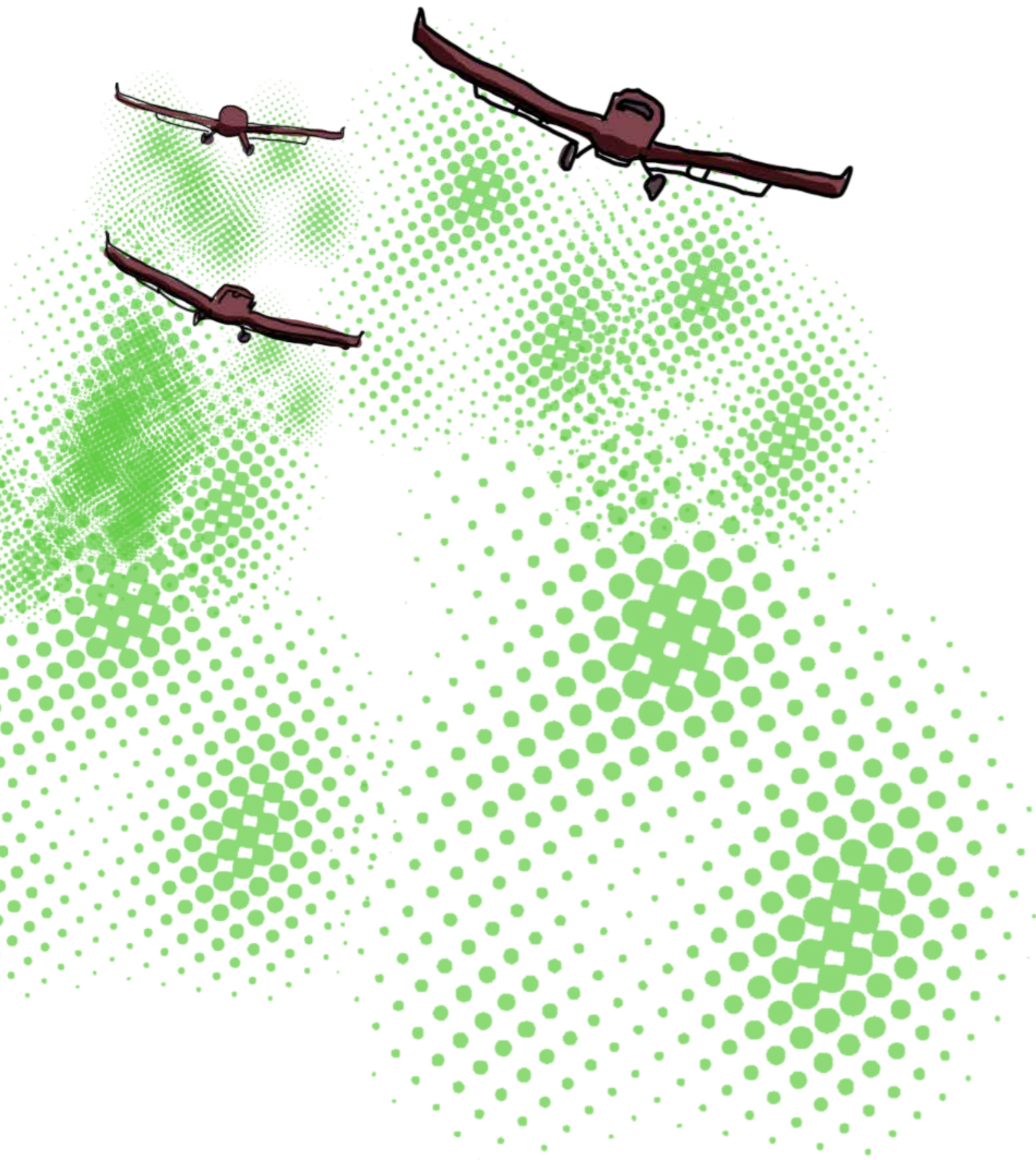
<b>Author</b>	Miranda-Filho et al, 2012
<b>Study period/Study location/Kind of study and objective</b>	1996-2005 / Rio de Janeiro state. A population-based case-control study. Estimating brain cancer mortality in workers exposed to pesticides.
<b>Main outcomes</b>	Pesticide exposure plays an important role in brain cancer development
<b>Author</b>	Miranda-Filho, 2014
<b>Study period/Study location/Kind of study and objective</b>	Rio de Janeiro State /. To evaluate the brain cancer mortality rate in adults living in the mountainous region and in the metropolitan region of the state.
<b>Main outcomes</b>	All individuals who died between 1996 to 2010 were evaluated. The results indicate that there is an increasing trend in brain cancer mortality rates in rural Brazil. Different environmental factors, especially exposure to pesticides, are related to these differences in the patterns of this mortality. The estimated annual percentage change in mortality from brain cancer was 3.8% in the Serrana region and -0.2% in the metropolitan region. The results indicated that the relative risk was greater in the rural region for the most recent birth cohorts (1954 and later).
	Compared to the reference birth cohort (1945-49, Serrana region), the relative risk was four times greater for individuals born between 1985 and 1989.
<b>Author</b>	Boccolini et al, 2014
<b>Study period/Study location/Kind of study and objective</b>	1996-2005 / Rio de Janeiro State. This study aimed to estimate the risk of death from stomach cancer among agricultural workers in an intensive pesticide-use area in Brazil, 1996-2005 in individuals aged 20 years or older

	Increased risk of death from stomach cancer (OR = 1.42 (95% CI: 1.33 - 1.78) adjusted for sex, age, ethnicity and education. This increase in risk of death was also associated with increased use of pesticides.
<b>Main outcomes</b>	Higher risk of death from stomach cancer (OR: 1.41 (95% CI 1.10 to 1.82)) compared to non-agricultural workers. Stratified analysis revealed that the risk was higher among younger (OR: 3.34 (1.58 to 7.08)) agricultural workers.
<b>Author</b>	Meyer et al, 2011.
<b>Study period/Study location/Kind of study and objective</b>	South region of Brazil. Case-control study. Association between agricultural work and esophageal cancer in the Brazilian southern region was investigated, by means of death certificate examination.
<b>Main outcomes</b>	5.782 cases and 5.782 controls were evaluated in the period between 1996 - 2005. These workers were at higher risk (OR: 1.38; CI95%: 1.26-1.51) to die by cancer of the esophagus (OR = 1,37; IC95% 1,21 - 1,55), when compared to non-farmers. Stratified analyzes also indicated that there is an increase in the magnitude of risk among illiterate farmers and among younger farmers. The author suggested that from the results found in his study, esophageal cancer should be included among the types of cancer etiologically associated with agriculture.
<b>Author</b>	Guimarães, 2014
<b>Study period/Study location/Kind of study and objective</b>	Nova Palma, Rio Grande do sul.
	Cross-sectional study carried out between 2010-2011 to describe the characteristics of rural population that work in an outdoor environment and analyse the association with the presence of premalignant skin lesions

<b>Main outcomes</b>	Prevalence of higher preneoplastic skin lesions in rural workers compared to other occupations
<b>Author</b>	Rigotto et al, 2013
<b>Study period/Study location/Kind of study and objective</b>	2000–2010 / Some cities in the state of Ceará. Quantitative ecological study to assess trends in chronic health problems associated with exposure to pesticides in a fruit-growing region.
<b>Main outcomes</b>	There was a trend of significant increase ( $p = 0.026$ ) in the hospitalization rate for neoplasms in the municipalities with high exposure to pesticides. The results of this study suggested that there was a greater morbidity and mortality from neoplasms in the municipalities with the highest consumption of pesticides.
<b>Author</b>	Moura et al., 2018
<b>Study period/Study location/Kind of study and objective</b>	Juazeiro, Bahia. To describe the clinical-epidemiological profile of workers with cancer undergoing treatment, in the month of August 2013, at an oncology center.
<b>Main outcomes</b>	The clinical profile of workers affected by cancer followed a pattern close to that described for agricultural regions, with a prevalence of hematological cancers.

<b>Author</b>	Curvo et al, 2013.
<b>Study period/Study location/Kind of study and objective</b>	To analyze the association between the agricultural use of pesticides and cancer morbidity and mortality in children under 20 years, an ecological study of the average time series of morbidity (2000–2005) and mortality (2000–2006) from cancer at the age 0–19 years and the use of pesticides in municipalities in the state of Mato Grosso was conducted.
<b>Main outcomes</b>	The average use of pesticides in the counties showed a statistically significant association for both morbidity ( $p=0.021$ ), as for mortality ( $p=0.005$ ) for cancer children and adolescents, with 95% confidence interval. The results indicate that exposure to pesticides is associated with morbidity and mortality from cancer in children and adolescents.

## 6. Pathways linking agribusiness to the COVID-19 syndemic



In the previous sections we described the macroeconomic, commercial and political determination of health effects related to agribusiness including the farming industry, industrial food production and use of pesticides to illustrate the complexity of the determination and health effects related to Covid-19. **We mentioned both social and territorial vulnerabilities but to understand the embodiment of those processes, we have to discuss what occurs on the individual level. Table 1 summarizes the conditions in three levels of the complexity: general, particular, and individual/singular with interdependent connections.**

Figure 4 illustrates the main pathways of the role played by agribusiness in the syndemic COVID-19. We illustrate the impact of the historical and political context (#1), how factory farming, etc is generating emergent zoonoses (#8), pesticide utilization (#7) and an obesogenic environment created by industrial food production (#9).

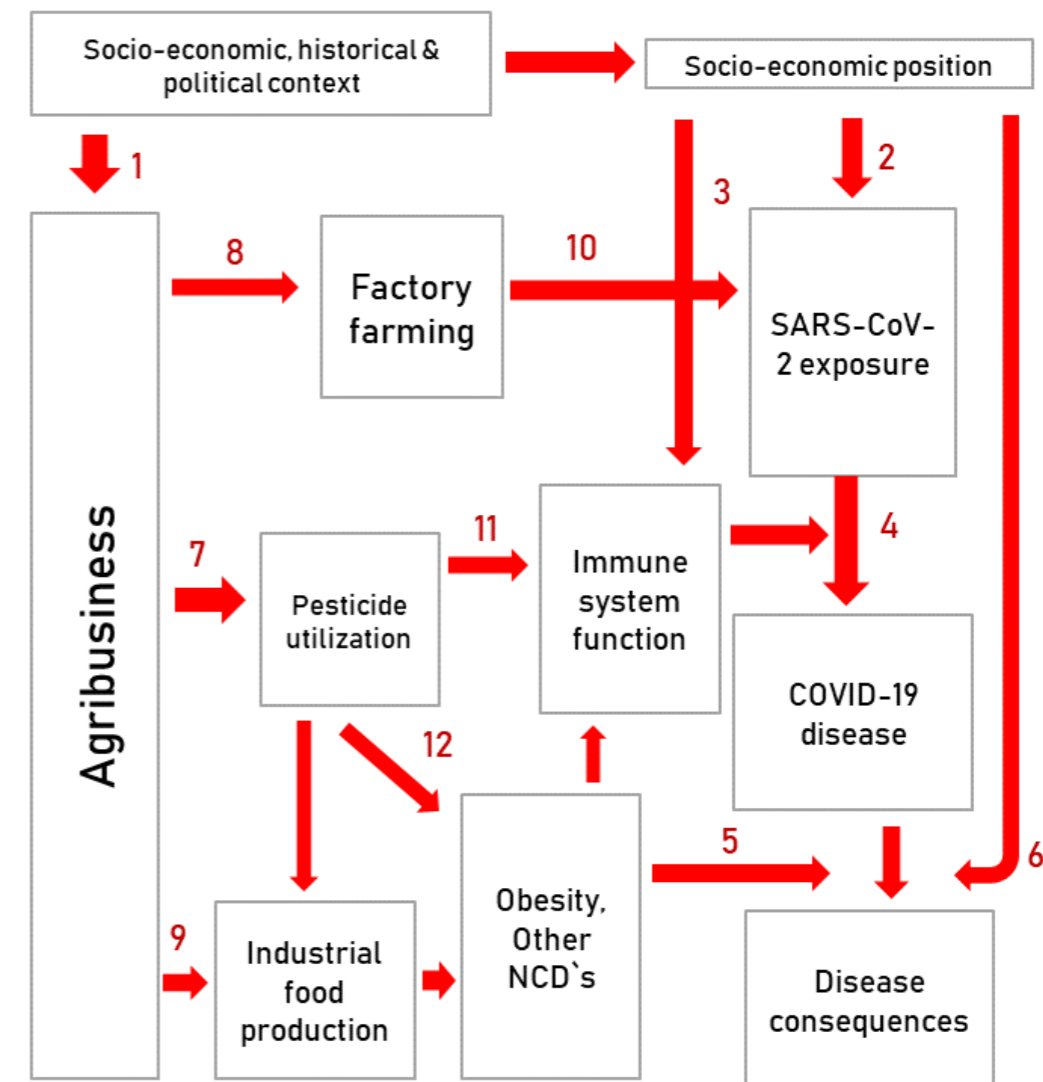
As mentioned above, the neurologic and immune systems are both susceptible to the effects of pesticides (#11). The neurological and immunological systems mature slowly during the prenatal period and childhood. Childhood is a sensitive period, more susceptible to health effects of both environmental and social exposures through epigenetic and other mechanisms. The long-term effects on inflammatory processes in adult health of early life adversities (ELA) are strongly linked to parents' social position (#3). Extensively studied in recent years (Kuhlmann et al. 2020), ELA seems to play a critical role in biasing the immune system towards a pro-inflammatory and ageing phenotype many years later. Cytotoxic T-lymphocytes appear to be particularly sensitive

# Levels of Social Determination on Health (DSS)

and interactive pathway on Covid -19 in the context of agrochemical exposure, food insecurity and syndemic effect

LEVEL CONTEXT	VULNERABILITIES	EXPOSURE	SUSCEPTIBILITIES	CONSEQUENCES
<b>GENERAL</b>	Socioeconomic Inequality			Deforestation
	Economical agribusiness protection	High consumption of pesticides on production		Hydric crises
Policies	Environmental deregulation	Environmental Pollution		Recession
Agrarian structure	Labor deregulation	Food insecurity	General Demographic character	Rural exodus
Livestock structure	Sanitary deregulation	SARS-COV-2 pandemic		Differential SARS-COV-2 spread throughout territory
Agroindustry	Unsafe food production			Lack of Capability to face Covid 19 in territory
	Unemployment level			Excess mobility and mortality
<b>PARTICULAR</b>	Socioeconomical position	Consumption of unsafe food		Epidemiological profile of the acute and chronic pesticide intoxication
	Slum areas/protected areas	Access to organic food		Epidemiological profile of DCNT linked with nutrition
	Social discrimination	Access to agroecological food	Specific Demographic character	Epidemiological profile of Covid-19 / Disparity in COVID-19 burden of disease
	Environmental injustice	Eating habits		
	Occupational groups			
	Inefficient health surveillance			
<b>SINGULAR</b>	Poverty / education	Pesticide exposure		Syndemic effect of Covid 19
	Food insecurity	Malnutrition / metabolic disfunction	Neurological, immunological, cardiovascular & endocrinological diseases	Clinical complication
	Housing / sanitation	SARS-COV-2 exposure		Hospital / Intensive Care demands
				High mortality

to the social environment in early life. The hypothesis has therefore been raised that the ELA may play a role in determining the clinical course of COVID-19. The convergence of ELA-induced senescence and COVID-19 induced exhaustion represents the worst-case scenario with the least effective T-cell response (Holuka et al. 2020).



(Figure 4) Pathways linking the activities of agrobusiness to COVID-19 and their syndemic health effects.

# SOCIOECONOMIC, HISTORICAL AND POLITICAL CONTEXT

# SOCIOECONOMIC POSITION



The majority of people infected with SARS-COV-2 do not get ill and have very little or no symptoms. In general, immunity is a critical factor (#4). In viral illnesses a previous infection and/or vaccination will provoke a specific response from the immune system. The function, however, of the immunological system might also be influenced by several other conditions including social, environmental and behavioral factors (Baumer et al. 2020). This response can be affected by other medical conditions due to immunosuppression such as HIV and cancer treatment. Obesity is another important condition that influences immune functions (Andersen et al. 2016) and is a huge growing public health problem in Brazil. The proportion of the burden of disease in Brazil attributable to obesity has nearly doubled since 1990 (Institute for Health Metrics and Evaluation, 2019), with growing disparities where low-income women are suffering the highest obesity levels (Diderichsen et al. 2020).

One of the most important processes behind the social disparity in hospitalizations and mortality in COVID-19 is the unequal prevalence of comorbidity (Bambra et al. 2020) (#6). The COVID-19 pandemic is occurring against a backdrop of rising social and economic inequalities that are expressed in existing noncommunicable diseases (NCDs), driven by, among other processes, the tobacco and industrial food-production industries (Swinburn et al. 2019). A large British study found that the rate of severe cases and deaths in COVID-19 is strongly influenced by comorbidity (#5) including obesity, diabetes, cardiovascular diseases, chronic lung disorders, chronic kidney conditions and malignancies, even when adjusted for age, ethnicity, sex and social deprivation (Williamson et al. 2020). The social inequality in the disease burden from COVID-19 is thus strongly linked to disparities in comorbidities. Some occupations, e.g. taxi drivers - are not only more exposed to the virus as mentioned above, but also suffer higher comorbidity rates.

Comorbidities are clearly a main driver of social disparities in COVID-19 mortality. Inequities in access, use and quality of health services are a well described problem in the Brazilian health system (Gurgel et al 2017b). Primary care was of course unprepared to

tackle the COVID-19 pandemic, but has also struggled with adequate handling of poisoning and other symptoms generated by pesticides (Silvério et al 2020). The health system has strong programs in place to handle some of the relevant comorbidities such as diabetes and hypertension, but obesity is another comorbidity pandemic that is largely out of control.

The exposure to the SARS-COV-2 is strongly linked to inequalities in living conditions, both in the territorial conditions and occupational and housing environment (#2). Few studies have been published about social and occupational inequalities in incidence and mortality of COVID-19. Data from the largest public hospital in Brazil, the Clinical Hospital of São Paulo University, shows that logistic workers (laundry, cleaning and security staff) had a higher incidence of COVID-19 than doctors in intensive care centers treating the disease (Faíco-filho et al, 2020). British data (Office for National Statistics 2020b) evidences mortality rates that are four times higher among unskilled workers compared to professionals. In this study, occupations with close contact to clients such as taxi drivers and social-care workers have particularly high mortality rates. Workers involved in food processing, such as meat production and markets, are also exposed. On the other hand, professions that can work at home have low rates that further declined during lock-down. Territorial studies have found large differences in mortality between affluent and poor neighborhoods in several cities (Office for National Statistics, 2020c). Territorial differences are partly due to socioeconomic and ethnic/racial inequalities in the population. Housing conditions in many densely populated and poor areas are so crowded, that social distancing is impossible (Ahmad et al. 2020).

Malnutrition has an impact on the immune-system and many other NCDs. Since 1997, the pattern of malnutrition in Brazil has changed from mainly undernutrition, which reduced from 11.9% to <2%, to obesity that in the same period increased from 11.9 to 22.3% (Ribeiro-Silva, 2020). The global development of obesity is driven by the shift in diets with growing consumption of foods and beverages with added sugars, added salt, refined carbohydrates, grain-based deserts and savory snacks (Fontes et al, 2019). Latin America has, in that respect, been hit earlier than most other low- and middle-income countries

(Popkin et al. 2018). This is an integral part of the development of agribusiness and food industry through more processed foods (Swinburn et al. 2019). Rapid urbanization and industrialization have adjusted the use of time and energy consumption; changed in physical activities at work and school; and affected domestic life, travel, and leisure activities, leading to growing sedentary behaviour.

Since the comorbidity of obesity seems to play an important role in COVID-19 morbidity, the evidence on whether pesticides influence obesity (#12) is worth investigating. A growing volume of research indicates that organophosphorus and endocrine-disrupting pesticides influence glucose and lipid metabolism and thereby may influence obesity and T2-diabetes. Often, this is not consensual, and the understanding of the processes involved is still limited (Czajka et al. 2020, Ribeiro et al. 2019, Heindel, Blumberg 2019). Epidemiological studies, in-vivo murine models, and in-vitro studies indicate an effect on obesity, and DDE has been the primary focus. (Ren et al. 2020, Czajka et al. 2019, Diels 2020, Gutgesell 2020, Gangemi 2016). Childhood is a sensitive period for the effects of pesticides and some studies have found that prenatal DDE was associated with increased BMI and waist circumference in girls (Silver, Meeker 2020). The interaction between genetic variants and environmental chemicals through epigenetic regulation has a potential effect on obesity (Diels et al. 2020). What is missing is a systematic effort to understand which of the many agrochemicals in current use can lead to adverse health outcomes including obesogenic effects, and an understanding of the mechanisms involved (Ren et al. 2020). Nevertheless, all these results emphasize the importance of applying the Precautionary Principle.

The interest in the immunotoxicity resulting from exposure to pesticides dates back to the 1980s (Blakley et al. 1999, Corsini 2008). Pesticides may influence the complex immunological system through many different pathways (#11). Immunotoxicity induced by pesticides is associated with their interference in the survival, proliferation, and differentiation of immune cells as well as the signaling pathways that occur in the immune cells. A recent review found effects on several types of cells, including T cells, B cells, NK cells, and macrophages (Lee, Choi 2020). Pesticides that are currently used or prohibited

from use were shown to have a variety of inhibitory effects on each type of immune cell. ATR, carbamate, two OP-compounds, DDVP and CPF inhibited T cell proliferation and cytokine production, particularly relevant for COVID-19. Most studies on pesticide-induced immunotoxicity use animals or cells that are exposed to only one type of pesticide. These studies may provide understanding of mechanisms and specific effects on model animals. The reality of rural workers and consumers of water and food contaminated by pesticide residues is complex, because of the vulnerabilities arising from living conditions and the mode of exposure, where they are generally exposed to multiple pesticides for a prolonged period (Jacobsen-Pereira et al. 2020). Samples of food analyzed in Brazil between 2017 and 2018 found that 34.5% presented from 2 to 21 pesticides residues (ANVISA, Agência Nacional de Vigilância Sanitária, 2019e).

**It is clear that metabolic disturbances, including obesity and a biased immunological system, interact and increase the vulnerability to the effects of SARS-COV2 exposure. The three conditions can also be assumed to cluster since they share causal pathways related to modern agribusiness in Brazil. These processes play out in the Brazilian context of large socio-economic inequalities. Thus, the criteria for a syndemic is fulfilled (Singer 2017, Gravlee 2020).**

We can therefore – as suggested by the editor of the Lancet – talk about a syndemic where COVID-19 clusters and interacts with comorbid NCDs in a context of structural inequalities (Horton 2020). Syndemics have been studied extensively for HIV and several comorbidities by Singer et al. (2017), but studies have also been conducted on NCDs including studies in Brazil (Diderichsen et al. 2020).

SYNDEMICS ARE DEFINED AS TWO OR MORE DISEASES OR HEALTH CONDITIONS CLUSTERING AND INTERACTING IN A CONTEXT OF STRUCTURAL INEQUALITIES (SINGER 2017). VULNERABILITY IS IN ENVIRONMENTAL SCIENCE USED AS AN UMBRELLA CONCEPT INCLUDING EXPOSURE; SUSCEPTIBILITY TO THE HEALTH EFFECT OF EXPOSURE; AND CAPABILITY TO CHANGE, COPE, OR ADAPT TO EXPOSURE (BIRKMANN ET AL., 2013).



## 7. Conclusions

In 2020 more than 200.000 Brazilians died of COVID-19, which is at least twice as high as expected in a country with such a young population. This is primarily due to bad protection with a higher rate of virus exposure, but there are reasons to believe that the health effects of the intensive extraction and industrialized agribusiness through at least three different pathways might aggravate both exposure and vulnerability to zoonotic disorders like COVID-19. The intensive use of pesticides influences the immunological system, industrialized farming increases the risk of new zoonoses, and industrialized food production promotes obesity and the vulnerability to COVID-19. The impact of coming pandemics might therefore be mitigated by making agribusiness more environmentally sustainable. However, several changes in Brazilian policies in health, agriculture and environment indicates that the situation is currently moving in the opposite direction.

THE ONGOING COVID-19 PANDEMIC HAS REDIRECTED AGRICULTURAL AND FOOD SYSTEMS IN TIME WITH AGROECOLOGICAL PRINCIPLES. AGROECOLOGY PROVIDES A PATH TO RECONSTRUCT A POST-COVID-19 AGRICULTURE, ONE THAT IS ABLE TO AVOID WIDESPREAD DISRUPTIONS OF FOOD SUPPLIES IN THE FUTURE BY TERRITORIALIZING FOOD PRODUCTION AND CONSUMPTION. THERE ARE FIVE MAIN AREAS IN WHICH AGROECOLOGY AREAS CAN POINT THE WAY TO A NEW POST-COVID-19 AGRICULTURE: OVERCOMING THE PESTICIDE TREADMILL, ENRICHING NATURE'S MATRIX, REVITALIZING SMALL FARMS, CREATING ALTERNATIVE ANIMAL PRODUCTION SYSTEMS, AND ENHANCING URBAN AGRICULTURE (ALTIERI, NICOLLS 2020).



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