



# One Year of Coronavirus Disease 2019 (COVID-19) in Brazil: A Political and Social Overview

REVIEW

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## ABSTRACT

**Background:** Coronavirus Disease 2019 (COVID-19) became the deadliest pandemic of the new millennium. One year after it became a pandemic, the current COVID-19 situation in Brazil is an example of how the impacts of a pandemic are beyond health outcomes and how health, social, and political actions are intertwined.

**Objectives:** We aimed to provide an overview of the first year of the COVID-19 pandemic in Brazil, from a social and political point of view, and to discuss the perspectives from now on.

**Methods:** This is a narrative review using official, scientific (PubMed, Medline, and SciELO databases) and publicly available data. Press articles were also used that contain important information not found in these databases.

**Findings:** We address the impacts of COVID-19 in different regions of Brazil, on indigenous populations, health care workers, and how internal social contrasts impacted the pandemic's advance across the country. We also discuss key points that culminated in the country's failed management of the COVID-19 spread, such as poor management of the public health care system, disparities between public and private health care infrastructure, lack of mass testing and viral spread tracking, lack of preparedness and planning to implement strict isolation and social distancing measures, and, most importantly, political instability, a deteriorating Health Ministry and sabotaging attitudes of the country's president, including anti-scientific actions, underplaying COVID-19 severity, spreading and powering fake news about the pandemic, promoting knowingly inefficient medications for COVID-19 treatment, and interference in collective health policies, including the country's vaccination plan.

**Conclusions:** After one year of COVID-19 and a disastrous management of the disease, Brazil has more than 11 million cases, 270,000 deaths, and the highest number of daily

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deaths due to COVID-19 in the world, most of which could have been avoided and can be credited to negligence of municipal, state, and federal authorities, especially President Jair Messias Bolsonaro. Unfortunately, the country is an example of what not to do in a pandemic setting.

**Key Points:**

- One year after COVID-19 was declared a pandemic, Brazil had the second higher number of cases and deaths, and the highest number of daily deaths due to the disease.
- Lack of massive testing, non-stringent and ineffective collective health policies, poor management of the public health care system, and political instability were the main drivers of the country's flawed management of the COVID-19 advancement.
- Anti-science and sabotaging actions by government had a pivotal role in the country's current situation.
- Brazil has a large territory and is marked by social contrasts among different regions and states, which showed contrasting data regarding the impact caused by COVID-19.
- COVID-19 databases and data sharing are important to provide an overview of epidemiological aspects of the disease; however, Brazil lacks standardization in these datasets.

## 1. INTRODUCTION

Coronavirus disease 2019 (COVID-19), the viral infection caused by the new coronavirus strain severe acute respiratory syndrome (SARS)-Coronavirus-2 (SARS-CoV-2) was discovered in the end of 2019 in the city of Wuhan, China, and, in a matter of months, became the deadliest pandemic of the new millennium [1]. Although most COVID-19 cases are asymptomatic infection or mild-to-moderate respiratory disease [2, 3], the virus' fast transmission in the community led to a striking impact in public health worldwide, which was mainly characterized by overload in intensive care units (ICUs) and collapse of health care systems [4]. This called for the implementation of social isolation and safety measures, including partial lockdowns in many countries, which, in turn, have caused dramatic changes in people's lifestyles and several economic consequences. The fast viral spread and its devastating consequences also led the scientific community to speed up the research on disease treatment and vaccines in a way never before seen in history. Vaccine trials skipped several conventional stages and bureaucratic steps were dropped in order to release the emergence use of newly developed vaccines in Europe, North America, and Asia [5].

To date, one year after the World Health Organization (WHO) declared COVID-19 as a pandemic, vaccines are available and many countries have started vaccinating their populations, and treatment alternatives for severe COVID-19 have also been developed that mainly consist of immunosuppressant agents targeting the intense inflammatory reaction following infection [6, 7]. However, as vaccination should take long to reach most of the world's population, social distancing, isolation, lockdowns and safety measures such as using facial masks and quarantine are still the best way to prevent the viral spread. As for health authorities worldwide, having the population respect the implemented measures, setting up the logistics for COVID-19 testing and vaccination, and working in conjunction with other sectors to prevent social gatherings in public spaces remain as major challenges, especially in an era of quick dissemination of contents, including the ones from unreliable sources, which is facilitated by internet and social network applications. Developing diagnostic tests that can be massively applied to allow better screening for infection is also a challenge, since the gold-standard test for COVID-19 diagnosis, SARS-CoV-2 reverse transcriptase polymerase chain reaction (RT-PCR), can only be performed in specialized laboratories and, therefore, is not accessible for the population in many countries.

The situation in Brazil is a good scenario to understand how the impacts caused by a pandemic of this magnitude go beyond health outcomes. The country's socio-economic inequalities, political instability, concentrated population and structurally defective public health system steeply

contribute to maximize the pandemic effects on people’s lives, the country’s finances and the country’s reputation abroad. In the present article, we aimed to provide an overview of the first year of the COVID-19 pandemic, in Brazil, from a social and political point of view, and to discuss the perspectives from now on.

## 2. METHODS

This is a narrative review. Our article *per se* is scientific in nature, and we based it mainly on official data and scientific literature, using the Worldometer, Our World in Data, PubMed, Medline, and SciELO databases. However, it is undeniable that the attitudes and conduct of political leaders around the globe were decisive for the pandemic’s course in different countries, shaping the behavior of their populations towards it and the way it was faced, which also has direct impact on science as a whole. In this sense, there were many controversies in Brazil, and we consider that the role of the Brazilian press and of the international press, reporting the way in which the Brazilian government has dealt with the pandemic, bringing to the attention of the lay population the causes and consequences of governmental actions, has been crucial. For this reason, we have also referred to articles from newspapers and websites aimed at the non-scientific public.

## 3. PERSPECTIVE

### 3.1. OVERVIEW OF THE COVID-19 CASES WORLDWIDE AND IN BRAZIL

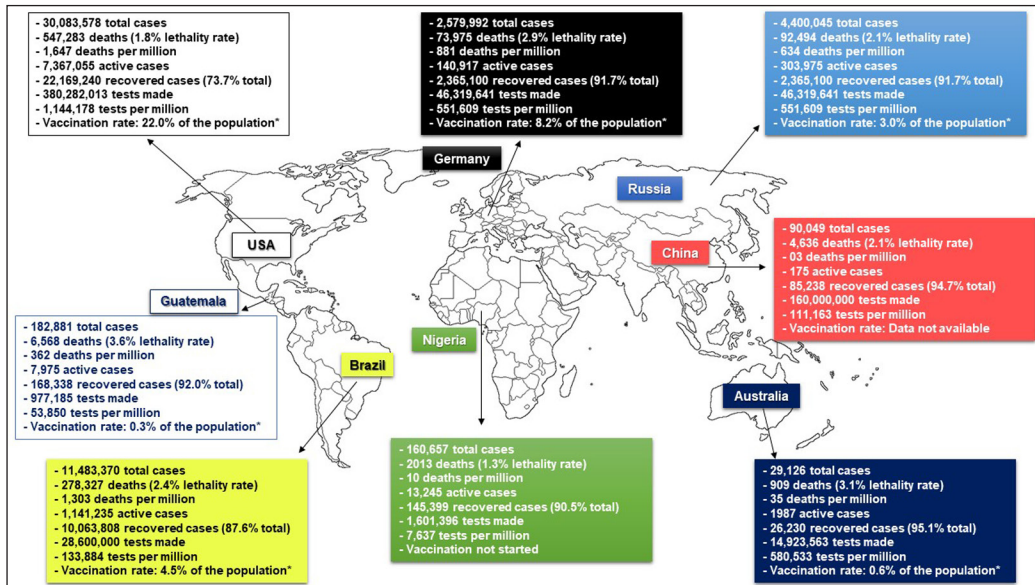
On March 12, 2021, exactly one year after being declared as a pandemic, there were 118,058,503 confirmed cases of COVID-19 worldwide, 258,735 of which were reported in the last 24 hours, and 2,621,046 confirmed deaths (2.22% lethality rate), 10,018 of which happened in the last 24 hours [8]. However, COVID-19 does not affect the world homogenously. The American continent has the highest number of cases (52,386,995 cases) and deaths (1,258,134, 2.40% lethality rate), whereas the Western Pacific region has the lowest figures, with 1,694,716 cases and 30,076 deaths (1.77% lethality rate) [8] (**Table 1**). Despite having the highest death toll, the lethality rate in the American continent is similar to what has been shown worldwide (2.40% vs. 2.22%) [8].

Brazil had 11,277,717 COVID-19 confirmed cases (ranking third worldwide), with 75,412 in the last 24 hours, and 272,899 confirmed deaths (ranking second worldwide), 2,283 of which happened in the last 24 hours [9]. On March 12, 2021, Brazil reached more than 2,000 daily deaths, the highest number in one year. In addition, Brazil had 1,052,579 active cases (ranking third worldwide), 10,231,690 total recovered cases (ranking third worldwide), 52,618 cases per one million inhabitants (ranking 39th worldwide), and 1,279 deaths per one million inhabitants (ranking 25th worldwide). Brazil performed SARS-CoV-2 RT-PCR tests for 28,600,000 samples (ranking 12th worldwide), which corresponds to only 133,892 per one million inhabitants (ranking 121th worldwide) [10]. Compared with the most populated countries in each continent, Brazil generally has more deaths and fewer tests per one million inhabitants (**Figure 1**), indicating not only that Brazil is one of the most affected countries, but also that the number of cases is underreported. In fact, a study using a serological approach estimated that the number of infected people is about six times higher than the number notified to the Ministry of Health [11], which means that the real number of COVID-19 cases in Brazil can be around 67 million, which, in turn, raises concern about the number of unreported deaths. Also, preliminary data from the Oswaldo Cruz Foundation (Fiocruz) showed that the prevalence of acute respiratory distress syndrome (ARDS) in

REGION	CONFIRMED CASES	DEATHS (% LETHALITY RATE)
Africa	2,924,244	74,143 (2.54)
Americas	52,386,995	1,258,134 (2.40)
Eastern Mediterranean	6,793,641	149,400 (2.20)
Europe	40,438,291	897,540 (2.22)
South-East Asia	13,819,871	211,740 (1.53)
Western Pacific	1,694,716	30,076 (1.77)
<b>Globally</b>	<b>118,058,503</b>	<b>2,621,046 (2.22)</b>

**Table 1** Total of confirmed cases and deaths due to COVID-19 in each region and globally (adapted from WHO, 2021) [8].

WHO, World Health Organization; %, percentage.



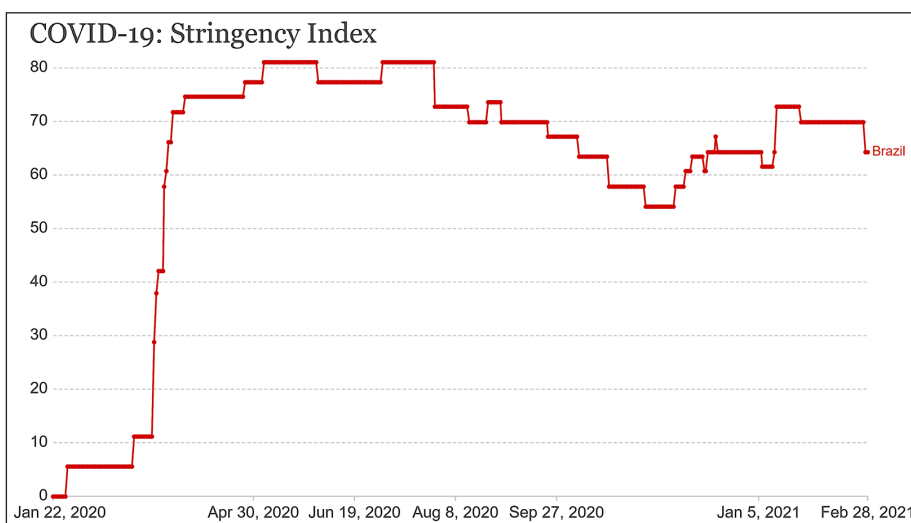
**Figure 1** Comparison of COVID-19 data between Brazil and the most populated country of each continent (North America, Central America, Europe, Africa, Asia, Oceania) and Russia, as for March 12 2021. Total number of COVID-19 patients, total number of deaths (and total death rate), number of and deaths per one million of inhabitants, total number of active COVID-19 cases, total number of recovered cases (and total recovery rate), total number of SARS-CoV-2 RT-PCR tests made in the country, and number of inhabitants of SARS-CoV-2 RT-PCR tests made per one million inhabitants and vaccination rate. \*People who have received at least one shot of a vaccine. The data were retrieved from WorldOMeter (<https://www.worldometers.info/coronavirus/country/>) and Our World In Data (<http://ourworldindata.org/policy-responses-covid>) [10, 24].

Brazil increased from 0.8/100,000 inhabitants in 2019 to 7.5/100,000 inhabitants in 2020, which is likely to be explained by several COVID-19 cases being diagnosed as ARDS from unknown source, corroborating the underreporting hypothesis [12].

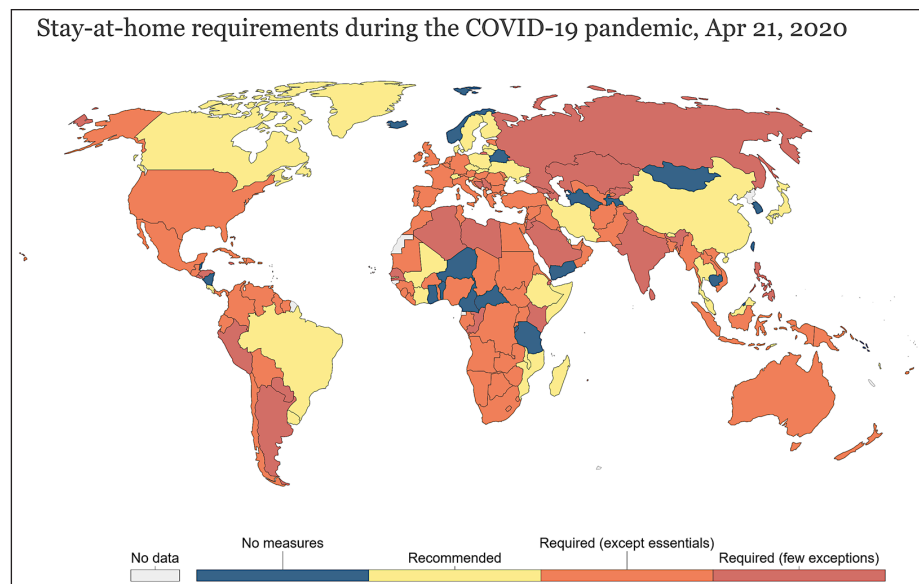
Brazil and the United States of America (USA) are the most affected countries in the Americas. Together, the two countries account for 40,142,442 confirmed COVID-19 cases (76.63% of the cases in the Americas) and 796,151 deaths (63.28% of the deaths in the Americas) [8, 10]. There are differences between Brazil and USA in the management of the COVID-19 outbreak. One of these differences concerns the number of SARS-CoV-2 RT-PCR assays, which is visibly higher in the USA [10]. However, after President Joe Biden took office as the new president of the USA on January 2021, several measures have been taken in order to properly face this pandemic, such as rejoin the WHO, a safe, effective, and equitable vaccination campaign, and expanding the use of masks, tests, and treatment. Even though these actions were made in January, it is clear the number of deaths is already decreasing in the USA [13]. Interestingly, a lower number of tests and poor governmental health policies have shown to be associated with a higher mortality due to COVID-19, which may explain the higher death rate in Brazil [14].

Also, compared to the most populous countries [15–22], the measures taken by the Brazilian government were not efficient to contain the advancement of COVID-19, and took longer to enter into force (Figure 2). After the first case, on December 31, 2019, COVID-19 was rapidly reported by the Chinese government, on January 31, 2020, to the WHO, which, in turn, warned about the risk

**Figure 2** COVID-19: Stringency Index from Brazil. The graph represents a composite measure based on nine response indicators including school closures, workplaces closures, and travels ban, rescaled to value from 0 to 100 (100 = strictest). If policies vary at the subnational level, the index is shown as the response level of the strictest sub-region. Source: Hale, Webster, Petherick, Phillips, and Kira (2020). Oxford COVID-19 Government Response Tracker – Last Update 15 March 2021, 08:00 (London time). Note: The index records the number and strictness of government policies and should be interpreted as “scoring” the appropriateness or effectiveness of a country’s response. Data search: OurWorldInData/coronavirus [24].



of a new pandemic. The first case in Brazil was identified on February 26, 2020 [9], when thousands of cases had already been reported across Europe [8]. In the first COVID-19 wave, health care units in Brazil started to collapse by mid-April, more than one month after the pandemic was declared, and, by then, circulation restrictions were not mandatory yet (*Figures 2 and 3*) [23, 24]. This means that, from the moment when COVID-19 was reported to the WHO, Brazil had one and a half months to implement containment measures and at least two months to prepare for the worst scenario.



**Figure 3** Stay-at-Home requirements during the COVID-19 pandemic. Source: Hale, Webster, Petherick, Phillips, and Kira (2020). Oxford COVID-19 Government Response Tracker – Last Update 15 March 2021, 08:00 (London time). Note: There may be sub-national or regional differences in restrictions. The policy categories show may not apply at all sub-national levels. A country is coded as having these restrictions if a least some sub-national regions have implemented them. Data search: OurWorldInData/coronavirus [24].

### 3.2. COVID-19 CASES BY STATES, FEDERAL DISTRICT AND REGIONS IN BRAZIL

Brazil has a large geographic area that comprises 26 states and the Federal District, divided into five major regions (North, Northeast, Midwest, Southeast, and South). These regions are contrasting in terms of population number and density, number of COVID-19 cases, ICU facilities, ICUs per number of inhabitants, and infrastructure to conduct high numbers of the SARS-CoV-2 RT-PCR tests [9, 25]. Concomitantly, Brazil has many social contrasts regarding access to basic sanitation, health care, transport, education, and security, which reflects the contrasting human development indexes among different states and regions, and even among different spots within the same state or city. All these factors play a role in the risk of COVID-19 infection and dissemination, as well as in the ability of a given population to follow the isolation and social distance measures [26–31]. According to official reports [9], on March 12, 2021, the Southeast region had the highest number of confirmed COVID-19 cases. Among the federation states, São Paulo, which has both the largest population and highest population density, accounted for the highest number of reported cases, while Rio de Janeiro had the highest lethality rate [9, 32]. The number of cases per 100,000 inhabitants also varies across Brazil. The country’s average number was 5,366.6 per 100,000 inhabitants for COVID-19. The State of Roraima had the highest number, while the State of Maranhão had the lowest. Among the five regions, the highest and lowest numbers were reported in the Midwest and Southeast Regions, respectively. The average number of deaths was 129.9 per 100,000 inhabitants, the highest one being reported in the State of Amazonas and the lowest one in the State of Maranhão. Among the five regions, the highest number of deaths per 100,000 inhabitants was reported in the North Region (157.2 deaths per 100,000 inhabitants) and the lowest in the Northeast Region (*Table 2*). The State of Amazonas was the first one to have its health care system collapsed in the first Covid-19 wave [33].

### 3.3. INDIGENOUS PEOPLE AND COVID-19 IN BRAZIL: DEMOGRAPHIC DATA

There are 896,917 indigenous (native Brazilian descent) individuals of 305 different ethnic groups (with 274 different languages and dialects) distributed among 505 indigenous lands in Brazil [9]. The indigenous population can be more vulnerable to the pandemic’s impact, given their poor social and economic conditions and poor access to health care services, especially populations

**Table 2** Demographic characteristics of COVID-19 in Brazil on March 12, 2021 [9, 32].

NI, not informed. The data was collected at <https://covid.saude.gov.br>. Accessed on March 12, 2021. The number for social isolation was obtained at InLoco [56]. The number of respiratory ventilators distributed by Ministry of Health was collected on <https://www.gov.br/pt-br/noticias/saude-e-vigilancia-sanitaria/2020/07/governo-federal-ja-entregou-mais-de-8-4-mil-ventiladores-pulmonares> [9]. \*, the purchase was canceled due to possible irregularities; \*\*, the information was retrieved during July 2020. †, 1,820 were purchased with a cost of R\$ 242,200,000.

STATES AND THE FEDERAL DISTRICT	CASES	DEATHS	CASE FATALITY RATE	CASES/100,00 INHABITANTS	DEATHS/100,00 INHABITANTS	ADHESION FOR SOCIAL ISOLATION (%)	RESPIRATORY VENTILATORS DISTRIBUTED BY MINISTRY OF HEALTH	RESPIRATORY VENTILATORS BILLED BY STATES	TOTAL AMOUNT PAID (R\$) PER MILLION	TOTAL AMOUNT PAID (R\$) PER MILLION ON (THOUSAND)	TOTAL RT-PCR TESTS (TOTAL PAID R\$)	TOTAL QUICK TESTS
<b>Brazil</b>	11,277,717	272,889	2.42	5,366.6	129.9						14,725,497 (748,194,799)	8,836,305
<b>Midwest region</b>	1,196,427	24,014	2.01	7,341.4	147.4						972,888 (49,661,242)	770,120
Goiás	425,206	9,332	2.19	6,058.5	133.0	36.6	413				156,272 (8,281,255)	252,240
Mato Grosso	266,939	6,097	2.28	7,660.8	175.0	38.8	216	120 (50 national)	7.4 (2.2)	61.7 (44)	203,808 (9,972,691)	116,540
Distrito Federal	312,956	5,048	1.61	10,379.0	167.4	40.3	250				274,680 (14,013,668)	300,640
Mato Grosso do Sul	191,326	3,537	1.85	6,884.7	127.3	37.1	155	11 (+ 25 portable)	1.5 (1.4)	135 (55.7)	338,128 (17,393,626)	100,700
<b>South region</b>	2,183,813	35,899	1.64	7,285.2	119.8						2,887,556 (147,765,115)	1,162,040
Santa Catarina	717,454	8,377	1.17	10,013.6	116.9	38.7	98	50*	33*	165*	334,264 (18,230,532)	266,140
Rio Grande do Sul	720,461	14,363	1.99	6,332.5	126.2	43.6	486	486			571,284 (27,305,593)	468,300
Paraná	745,898	13,159	1.76	6,523.5	115.1	37.6	544	544			1,982,008 (102,228,989)	427,600
<b>North region</b>	1,226,601	28,982	2.36	6,655.1	157.2						1,440,140 (73,190,252)	606,000
Acre	61,394	1,094	1.78	6,961.3	124.0	4.3	170	170			129,724 (6,666,490)	26,560
Rondônia	162,818	3,278	2.01	9,161.4	184.4	4.1	248	248			208,696 (10,412,872)	58,060
Tocantins	122,426	1,623	1.33	7,783.6	103.2	3.5	115	115			168,196 (8,423,864)	59,200
Amazonas	328,763	11,431	3.48	7,932.3	275.8	40.6	222	28	2.9	103.5	237,668 (11,761,688)	162,060
Amapá	87,095	1,169	1.34	10,298.2	138.2	4.1.8	125	125			325,516 (15,139,839)	23,840
Pará	379,196	9,171	2.42	4,407.8	106.6	38.2	409	400	50.4	126	260,236 (14,809,776)	258,940
Roraima	84,909	1,216	1.43	14,016.9	200.7	39.4	162	NI	NI	215.4	110,104 (5,975,729)	17,340
<b>Northeast region</b>	2,617,780	60,158	2.30	4,586.8	105.4						3,718,896 (187,054,809)	2,103,440
Alagoas	138,065	3,150	2.28	4,137.0	94.4	4.1.7	185	185			106,884 (5,947,398)	112,920
Pernambuco	313,227	11,269	3.60	3,277.4	117.9	44.5	205	500	NI	NI	314,552 (17,009,411)	335,640
Bahia	730,542	12,961	1.77	4,911.8	87.1	42.2	491	300	48.7	162.4	836,932 (40,490,720)	531,300
Paraliba	234,254	4,832	2.06	5,829.9	120.3	41.8	285	30	4.9	164	155,548 (8,147,262)	164,260
Sergipe	157,340	3,072	1.95	6,844.8	133.6	42.5	140	140			571,728 (26,433,375)	79,760
Piauí	182,650	3,545	1.94	5,580.1	108.3	43.1	105	105			204,492 (10,183,466)	147,780
Ceará	456,948	12,087	2.65	5,003.8	132.4	42.1	268	268			1,039,460 (54,432,045)	318,600
Maranhão	226,172	5,413	2.39	3,196.7	76.5	39.1	281	281			215,412 (10,812,174)	233,800
Rio Grande do Norte	178,582	3,829	2.14	5,092.4	109.2	40.4	274	NI	NI	~70.4	273,888 (13,598,954)	179,380
<b>Southeast region</b>	4,053,096	123,836	3.06	4,586.4	140.1						5,705,712 (290,523,379)	3,816,545
São Paulo	2,164,066	63,010	2.91	4,712.8	137.2	38.5	838	3,000 <sup>b</sup>	550	189.2	2,536,944 (133,193,867)	1,743,880
Espirito Santo	340,808	6,656	1.95	8,480.7	165.6	38.6	210	210			178,728 (8,856,083)	202,300
Rio de Janeiro	601,666	34,083	5.66	3,484.9	197.4	40.8	993	1,000*	183.5*	183.5*	2,228,728 (114,858,287)	1,049,245
Minas Gerais	946,556	20,087	2.12	4,471.5	94.9	37.8	561	1,047	51	48.7	761,312 (33,615,140)	821,120

living in very remote locations. In order to improve the access of indigenous people to health care and adapt the public health care system to their particularities, the Brazilian government created, in 1999, an indigenous health care subsystem, comprised of 34 units named Special Indigenous Health Districts (Supplement 1). Additionally, in 2010, the government created the Special Secretariat for Indigenous Health, which was linked to the Ministry of Health.

Indigenous individuals are under risk of other diseases, such as tuberculosis, which is endemic in Brazil's Amazon region as its rates decline worldwide. In the literature, the genetical aspects related with Amerindian genetic ancestry is set as risk factor for tuberculosis [34]. Invasion of indigenous lands is also an old social problem in Brazil due to centuries of predatory agricultural expansion, cattle raising, and even illegal activities, such as wood removal and commercialization, traffic of wild animals, and mining [35]. Such uncontrolled invasion and its consequent harms expose indigenous people to pathogens they are not often in contact with. The indigenous lifestyle can also play a role in the disease spread, as they usually live in collective houses and share utensils. One year after COVID-19 was declared a pandemic, 44,648 indigenous people had been infected, out of whom 605 died and 41,589 recovered (Table 3) [9]. Like in the general population, older indigenous

DSEI	SUSPECTED CASES	CONFIRMED CASES	ACTIVE CASES	CLINICAL CURE (RECOVERED CASES)	DEATHS
Alagoas and Sergipe	18	331	13	311	5
Altamira	0	1,713	3	1,707	2
Alto Rio Juruá	0	863	8	844	10
Alto Rio Negro	34	2,234	144	2,063	25
Alto Rio Purus	0	638	9	621	7
Alto Rio Solimões	0	2154	25	2074	47
Amapá and Norte do Pará	25	978	37	934	5
Araguaia	0	346	8	331	7
Bahia	18	932	70	852	8
Ceará	90	1,092	113	969	8
Cuiabá	32	1,301	56	1,221	24
Guamá-Tocantins	12	1,509	8	1,481	17
Interior Sul	103	2,647	143	2,456	46
Kaiapó do Mato Grosso	9	1,000	0	994	5
Kaiapó do Pará	29	1,222	0	1,177	9
Leste de Roraima	22	3,855	238	3,553	56
Litoral Sul	7	1,279	3	1,257	17
Manaus	28	1,136	2,252	962	16
Maranhão	0	1,687	1,042	1,654	27
Mato Grosso Do Sul	0	4,261	25	4,143	85
Médio Rio Purus	0	517	0	512	5
Médio Rio Solimões and Afluentes	6	765	22	730	11
Minas Gerais and Espírito Santo	14	580	39	534	6
Parintins	45	596	11	570	12
Pernambuco	17	624	4	607	10
Porto Velho	23	1,344	31	1,301	11
Potiguara	2	709	1	704	4
Rio Tapajós	0	2,016	47	1,950	16
Tocantins	1	1,176	0	1,162	10
Vale do Javari	0	822	0	818	2
Vilhena	70	899	0	883	15
Xavante	1	908	20	832	50
Xingu	103	1,029	278	718	16
Yanomami	9	1,485	807	664	11
<b>Total</b>	<b>718</b>	<b>44,648</b>	<b>2,309</b>	<b>41,589</b>	<b>605</b>

**Table 3** Distribution of indigenous people affected by COVID-19. Suspected, confirmed, recovered cases, and deaths distributed by the special indigenous health district (dSEI) on March 12, 2021 [9].

adults were the most affected by the COVID-19 pandemic. Culturally, senior individuals are very valued among the indigenous, as they are very representative of the knowledge and culture of each ethnic group, so that their deaths are regarded as great losses. In this context, policies should be urgently adopted by the government, with the support of non-governmental organizations, to reduce the viral spread among the indigenous. Indigenous lands must be kept protected both in order to preserve the indigenous culture and to prevent deforestation of preserved areas [35, 36]. Of note, COVID-19 can be devastating for specific indigenous ethnic groups whose populations are smaller. An example is the Juma tribe, which lost its last individual, an 86-year-old man who died after developing severe complications of the disease.

Other ethnic groups in Brazil should be looked at more carefully, as there is evidence of increased mortality in Pardo and Black individuals, and individuals who live in the North region as a whole [37, 38]. These account for the largest fraction of poor individuals in Brazil [39]. Such a socioeconomic disparity contributes to low access to health care, diagnosis, and treatment, which is likely to put them at a higher risk of getting COVID-19 and die of it. In a pandemic scenario, federal and state government measures are urgent and crucial in order to screen these vulnerable groups for COVID-19, curb the viral spread within these populations and facilitate their access to health care services.

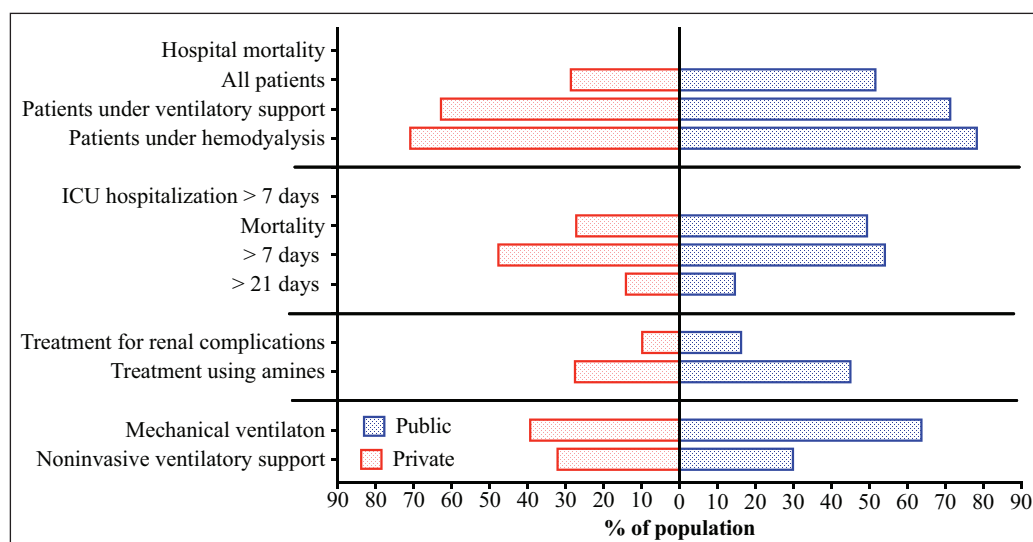
#### **3.4. PUBLIC AND PRIVATE HEALTH CARE SYSTEMS AND THE MANAGEMENT OF THE COVID-19 OUTBREAK IN BRAZIL**

There are two types of health care services in Brazil, the main of which is the public service, administered by Brazil's Unified Health System (SUS), which covers all the Brazilian territory and any and every Brazilian citizen has access to, with no direct costs. The other type is the private health care service, which is individually or collectively paid and acts in a supplementary manner, being regulated by Brazil's National Agency of Supplementary Health Care (ANS). It is a legal obligation of private health care providers to refund SUS when any of their users is served by the public health care service for a procedure that is covered by the provider [40].

The private health care service in Brazil is marked by restrictions and disparities, both in its operation and in its access by the population. Currently, 14 companies have 40% of the market and only 20–25% of the population have access to private health care assistance. Within this part of the population, 70% reside in the Southeast region. Such disparities reflect in the ICU bed capacity. According to data of the Brazilian Society of Intensive Care Medicine, there are 45,848 ICU beds in the country, out of which 22,844 are available for SUS patients, corresponding to an average of 2.2 total beds per 10,000 inhabitants, and only 1.4 SUS beds per 10,000 inhabitants. However, this number is lower in some regions, especially in the North (Amazonian) and Northeast regions [41]. It is problematic that 21.5% of the ICU beds registered in the SUS are originally private and about 64% are offered by philanthropic entities, meaning that the number of beds offered by the public service itself is even lower. This happens because hospitals in Brazil can simultaneously link up with the public and private health care networks. Also, approximately 31% of the ICU beds in Brazil are destined to private health care. A Fiocruz report shows that, although being accessed by a minor part of the population, the private health care network has a larger amount of ICU beds available per users (62.6 per 100,000 users) than does the SUS (13.6 per 100,000 inhabitants) [12]. This number can be even smaller, as indicated by the Institute of Studies for Health Policies, which reports an average of 7.1 beds per 100,000 inhabitants. Still according to this report, the ICU capacity should at least have been doubled in 53% of the Brazilian territory in order to prevent the public health care system to collapse by the beginning of the COVID-19 outbreak in the country [12].

There is also a great disparity between patients with COVID-19 treated in public and private health systems ([Table 6](#) and [Figure 4](#)). According to a research conducted by the Intensive Medicine Association of Brazil (AMIB) from March 1, 2020, to March 10, 2021, 106,546 patients with COVID-19 were hospitalized, 74,405 (69.83%) of whom in the private health care system and 32,141 (30.16%) in the public health system. Individuals in the private health care system needed more noninvasive ventilatory support than the ones in the public health care system (32.40% vs. 30.20%) [42]. This may be explained by the higher proportion of patients with COVID-19 who





**Figure 4** Differences between the Brazilian Private and Public health care systems from 01 March 2020 to 10 March 2021; ICU (Intensive Care Unit). The data were retrieved from Registro Nacional de Terapia Intensiva. [42].

needed mechanical ventilation in the public health system (64.00% vs. 39.60%). Individuals in the public health care system also needed mechanical ventilation for less time when compared to individuals from private (11.5 days vs. 14 days), which is possibly due to a higher mortality rate, both in ICU (49.70% vs. 27.50%) and in-hospital (51.90% vs. 28.90%) [42]. It is clear the private health system has a better infrastructure for COVID-19 management than the public health care system; however, the latter is used by most Brazilian citizens, who are not receiving a suitable health care. Increasing the investment in the public health care system is therefore imperative for the Federal Government, in order to decrease COVID-19 mortality.

The main consequence of these disparities in a pandemic setting is that the occupation of ICU beds is lower in private health care units than in the public ones, yielding several idle beds. Solving this issue becomes more difficult in Brazil, as most states in the country do not inform the data about the occupation of ICU beds in the private setting. In some cases, such as the states of São Paulo and Rio de Janeiro, the data concerning public and private networks are merged [43]. There is also no legislation that obliges private health care providers to inform such data. This scenario led the Brazilian National Health Council (CNS) to recommend the Ministry of Health, State and Municipal health authorities to implement a single policy for occupation of ICU beds, which should be made upon demand and regardless of whether these beds are located in public or private units [9], similarly to what has been done in France, Italy, Spain, and Ireland, for instance [44]. A law project was also proposed that sets the mandatory use of beds located in private units by the SUS for the single purpose of admission of patients with ARDS with suspected or diagnosed COVID-19, in addition to the obligation of private health care providers of informing the number of available beds [45]. However, private entities are against this policy and would rather have the government handle the costs of private ICU beds [43]. Public-private partnerships are seen as an interesting alternative in this regard and have been set in the cities of São Paulo and Rio de Janeiro, where private companies, including (but not limited to) health care providers handled the costs of temporary ICU facilities in public spaces of these cities, such as parks and football stadiums [46]. Still, it is worrisome that the current scenario allows private hospitals to deny participating on joint efforts for breaking the advancement of COVID-19, and most private hospitals merely end up making donations of minimal resources.

Within the universe of the private health care network, there are several criticisms of attorneys and consumer protection entities about the lack of austerity of the ANS with services of this nature. About 80% of private health care plans are collective or part of the benefit package offered by companies or institutions to their employees. Also, individual and family plans, which would be susceptible to a more severe control, have become rare. This situation opens gaps for private health care companies to charge a lower price for this kind of plan and to offer services with a lower quality than the standards recommended by the ANS, which is critical in a pandemic setting like COVID-19, where disorganization, insufficient staff board and poor management become

more evident [47]. This was the case for a private health care company that offers individual and family plans, in the city of São Paulo. Mainly focused on older adults, this company faced a substantial increase in the demand for ICU admissions shortly after the beginning of the COVID-19 outbreak in the city and is currently under investigation for concealment of COVID-19 cases in its hospitals [48].

### **3.5. THE SARS-COV-2 RT-PCR ASSAY AT BRAZIL: A MISTAKE MADE IN THE MANAGEMENT OF PUBLIC HEALTH**

In Brazil, as stated at the literature, there are different moments associated with the diagnosis and data sharing for COVID-19 diagnosis [49]. However, it is evident that Brazil needs to optimize the diagnosis by SARS-CoV-2 RT-PCR, including for health professionals, as many of them are set as suspicious cases due to underdiagnosis [50]. According to the Ministry of Health, Brazil performed a total of 14,725,192 SARS-CoV-2 RT-PCR tests, most of which (about 39%) were performed in the Southeast region ([Table 2](#)). The Midwest region has the lowest number of tests, most of which are performed in the Federal District, even though the Federal District is the least populated region within the Midwest [9]. The fact that the Federal District is the federal government's seat is likely to be the reason for this. As for the other regions, 2,887,556 tests have been performed in the South region, 3,718,896 in the Northeast Region, and 1,440,140 in the North region ([Table 2](#)). The lack of tests in the North region is worrisome and can be explained by the difficulty in delivering tests to remote locations in this region, which is the most underdeveloped region in Brazil.

To date, the Brazilian government has spent around R\$ 750 million (approximately US\$ 134 million) with SARS-CoV-2 RT-PCR tests. Although Brazil has more RT-PCR tests (14,725,192) than quick blood- and antibody-based tests (8,836,305), especially those based on lateral-flow immunoassays (LFIA), performed so far ([Table 2](#)) [9], only by mid-late 2020 the Federal government started to increase the investment in RT-PCR, meaning that quick tests were most made in the beginning of the pandemic, even though the gold standard for COVID-19 diagnosis is RT-PCR [51]. Quick tests basically rely upon the detection of SARS-CoV-2-specific IgM and IgG, which typically take 10–14 days for seroconversion [52, 53]. Although antibody-based tests can be appropriate for surveillance studies [54], they do not have the capacity of early diagnosis that SARS-CoV-2 RT-PCR does. Also, a metaanalysis found that antibody-based tests were not very well assessed so far and have considerable variation in sensitivity and specificity. LFIA-based tests are of particular concern, as commercial LFIA kits showed a pooled sensitivity of 65% (ranging from 49% to 78.2%), meaning at least 21.8% of false-negative results [55].

Notwithstanding with the insufficient testing, the slow delivery of tests is also worrisome in Brazil. In April 2020, the Ministry of Health announced the purchase of 46.2 million COVID-19 tests, out of which 24.3 million were SARS-CoV-2 RT-PCR tests [9]. Out of 24.3 million, only 8.8 million (36%) were delivered to the Ministry of Health until June, 3.2 million (36%) out of which had been distributed among the Federation states. Other 14.5 million fast antibody-based tests had not been delivered back then and there was no detailed information about these tests in the Ministry of Health information channels [9]. As for SARS-CoV-2 RT-PCR, this scenario can be explained by the difficulty to purchase basic components of the test, due to the high market demand, increase in the price of materials and equipment to perform the RT-PCR, low equipment availability, low number of qualified people available to run the tests, low number of centers and laboratories with infrastructure to run them, and difficulties in the transportation of samples to places where the test can be performed [50, 56].

The WHO has emphasized the importance of massive testing, which is the main measure for tracking the viral spread and breaking the SARS-CoV-2 transmission, as about 30% of infected individuals are asymptomatic and can spread the virus unintentionally [57]. The lack of a well-set testing policy, along with the slow distribution of tests across the country makes COVID-19 very difficult to be handled in Brazil. In a country where social distancing is not a possibility in many locations, mass testing is more than essential to prevent a higher number of deaths due to the disease than the one the country already has.

The Brazilian President, Jair Messias Bolsonaro, has tested positive for COVID-19 on July 14, 2020 [58]. President Jair Messias Bolsonaro first announced his diagnosis on July 7, 2020, after underplaying the severity of the COVID-19 pandemic several times, even after Brazil's outbreak became the worst in the world outside the USA. First Lady Michelle Bolsonaro also tested positive for COVID-19, as well as her 80-year-old grandmother, who underwent intubation after developing severe symptoms of the disease and died [59]. Other members of the government who tested positive to COVID-19 include Marcos Pontes (Minister of Science and Technology), Onyx Lorenzoni (Minister of Citizenship), Milton Ribeiro (Minister of Education), Augusto Heleno (Minister of the Institutional Security Office), Bento Albuquerque (Minister of Mines and Energy), Otávio Rego (President Jair Messias Bolsonaro's spokesman), and Fabio Wajngarten (Ministry of Communications' Executive Secretary) [60].

Several sayings and attitudes by President Jair Messias Bolsonaro had a strong backlash over the globe and were very criticized by many specialists in the field and by the national and international media. Those include President Jair Messias Bolsonaro claiming that his good physical condition and athlete history would prevent him from developing severe symptoms in case he would be infected with SARS-CoV-2 [61]. The President also pushed back against lockdown measures in the Federation states and in the cities, incentivizing most of the population to keep their normal lives. Scenes of President Jair Messias Bolsonaro circulating without a facial mask in public spaces were very frequent [62], including when he was knowingly infected, when the President was seen driving a motorcycle without either facial mask or individual protection equipment and talking to street sweepers who were working in the Federal District capital, Brasília [63]. Before his COVID-19 diagnosis was confirmed, President Jair Messias Bolsonaro frequently attended events in which his group of supporters agglomerated in public places demanding the end of the social isolation measures. Politically, President Jair Messias Bolsonaro has shown a faithful submission to former USA President Donald Trump, who also insisted on underplaying the pandemic when it was declared and continued to do so regularly. Some terms were used by each or both to refer to COVID-19, such as "Chinese virus", "hoax", "little flu", and "mediatic exaggeration" [64, 65]. Both executive leaders also took COVID-19 to the political field, with statements that flirt with conspiracy theories, arguing that the disease's impact is overestimated, both by the media and opposition politicians and parties, to degrade the government's image [66, 67].

Moreover, the Brazilian population is influenced by massive fake news involving COVID-19, many of which are powered by President Jair Messias Bolsonaro. Common stories in fake news are that the number of COVID-19 cases and deaths are inflated; drugs that were ruled out as possible treatments for COVID-19 are efficient, such as hydroxychloroquine and ivermectin; images of empty coffins being buried have been used to scare the population about the COVID-19 "hoax"; and social isolation and use of facial masks are not efficient against the viral spread [68]. Interestingly, a study comprising 104 cities with 70,000 or more inhabitants in the São Paulo State found an inverse correlation between the rate of adherence to social isolation and the number of votes to President Jair Messias Bolsonaro (% of population in the first and second round of election; [Table 4](#)). The social isolation index was computed by São Paulo government [69].

PHYSICAL ISOLATION	CORRELATION	FIRST ROUND OF ELECTIONS	SECOND ROUND OF ELECTIONS
First month (% after 30 days of first confirmed case)	Correlation coefficient	-0.299**	-0.197*
	p-value	0.002	0.046
Minor adhesion (%)	Correlation coefficient	-0.280**	-0.175
	p-value	0.004	0.076
Major adhesion (%)	Correlation coefficient	-0.293**	-0.218*
	p-value	0.003	0.027

**Table 4** Spearman correlation between adherence to social isolation measures (% of population) during the COVID-19 pandemic and number of votes to President Jair Messias Bolsonaro (% of population in the first and second round of election) [69].

### 3.7. FROM PHOSPHOETHANOLAMINE TO CHLOROQUINE AND IVERMECTIN: PRESIDENT JAIR MESSIAS BOLSONARO'S "MIRACULOUS" PILLS

The belief of President Jair Messias Bolsonaro in miraculous drugs is not new and dates to 2016. Before that year, Carlos Witthoeft, a citizen of the town of Pomerode, in the state of Santa Catarina, was arrested in June 2015 by the state police, after illegal production of a pharmacological component named phosphoethanolamine, which allegedly had the potential of curing cancer. Witthoeft claimed that the drug had a pivotal role in curing his mother's cancer in only 18 days back in 2007. He was instructed by Gilberto Chierice, a professor at the University of São Paulo (USP) São Carlos. Chierice was forbidden both by USP São Carlos and by the São Paulo state court to produce and distribute phosphoethanolamine, which caused a race of its users to the state's judiciary system to claim access to it. The phosphoethanolamine ban was then revoked by the National Supreme Court, which authorized its use as a palliative treatment option for cancer, but not really as a medication [70]. Phosphoethanolamine was extremely endorsed by, at the time deputy, President Jair Messias Bolsonaro in his social medias, and the President co-authored a law project (n. 13.269, 2016) that predicted the regulation and authorization of the use and distribution of phosphoethanolamine [71]. The law was sanctioned by, at the time, President Dilma Rousseff. In 2017, one year after the law's approval, phosphoethanolamine still would not show antitumoral efficacy [72]. The phosphoethanolamine hype started to fade out and, nowadays, the drug is barely remembered as an alternative to cancer treatment by the medical and scientific communities, government, and society.

When the number of COVID-19 cases started to show a sharp increase in Brazil, President Jair Messias Bolsonaro stated "A miracle drug was on hand". The drug was hydroxychloroquine, used in the treatment of malaria and chronic inflammatory diseases, especially systemic lupus erythematosus (SLE) and rheumatoid arthritis. The President Jair Messias Bolsonaro's excitement about hydroxychloroquine had its origin in the drug's promotion by former USA President Donald Trump. After learning about the alleged benefits of the drug in patients with COVID-19 reported by a French study [73], which was criticized in the very same journal that published it and happened to have severe methodological gaps that were admitted by the corresponding author [74, 75]. President Donald Trump claimed that hydroxychloroquine could be a game-changer in the fight against SARS-CoV-2 [76]. Reinforcing Trump's statements, President Jair Messias Bolsonaro also recommended hydroxychloroquine as a treatment for COVID-19 in a live address [77]. The Brazilian president excitement about hydroxychloroquine was boosted by a study performed in Brazil and sponsored by a private health care provider, which suggested the use of the drug for COVID-19 treatment. However, like the French report Trump based upon, this study was strongly criticized by the scientific community due to several methodological issues, which included strong risks of bias. As a matter of fact, the study made in Brazil was suspended by the Brazilian National Council on Research Ethics due to fraud suspicions [78].

The criticisms of the scientific community did not stop President Jair Messias Bolsonaro from promoting the use of hydroxychloroquine for COVID-19 treatment. In the State of Rio de Janeiro, the drug started to lack in the stocks of pharmacies, after an uncontrolled search by people. President Jair Messias Bolsonaro's insistence on the this costed the loss of two Ministers of Health in less than one month, as we will address in the next section (3.8). To date, the hydroxychloroquine use for COVID-19 treatment is authorized by the Ministry of Health in specific cases and through informed consent. President Jair Messias Bolsonaro also promoted Ivermectin as a treatment for COVID-19 [79]. This vermifuge is used to treat several diseases caused by ectoparasites, such as *Strongyloides stercoralis* [80], and is not effective against COVID-19 [81], as stated by its own manufacturer [82].

President Jair Messias Bolsonaro is a fierce defender of the early COVID-19 treatment, even though there are no studies showing any evidence that such an approach exists. Immunosuppressant drugs, such as dexamethasone, which have been proven useful to treat severe COVID-19 and help to decrease mortality [6], have not been promoted by President Jair Messias Bolsonaro at all. Notably, under President Jair Messias Bolsonaro's command, the availability of chloroquine and hydroxychloroquine has strikingly increased in Brazil, both by massive production in the

laboratories of the Brazilian armed forces and by importing these drugs from abroad with no binding [9]. A total of 5,416,510 tablets of chloroquine and 481,500 tablets of hydroxychloroquine have been purchased by the federal government in the last year, corresponding to R\$ 200,000 spent with chloroquine, while the total expenses with hydroxychloroquine are not informed by the Ministry of Health official platforms [9]. Also, the federal government expend a huge value for advertisements highlighting the important of early treatment and to distribute chloroquine and hydroxychloroquine during the year 2020. Concomitantly, essential drugs for treatment of severe and critical COVID-19 cases, such as sedatives used in orotracheal intubation, are missing in hospitals [9].

SARS-CoV-2 RT-PCR tests are also important to determine the positive cases for infection and to give the opportunity for a prompt response to the viral spread. Also, these markers demonstrated a positive Spearman correlation with (i) confirmed COVID-19 cases (CC: 0.849,  $p < 0.001$ ); (ii) death due to COVID-19 (CC: 0.802,  $p < 0.001$ ); (iii) lethality (CC: 0.335,  $p < 0.001$ ); and (iv) deaths due COVID-19 per one million of inhabitants (CC: 0.260,  $p = 0.006$ ). Finally, the number of SARS-CoV-2 RT-PCR tests per one million of inhabitants was positively correlated with and confirmed COVID-19 cases per one million of inhabitants (CC: 0.533,  $p < 0.001$ ) and deaths due to COVID-19 per one million of inhabitants (CC: 0.274,  $p = 0.004$ ) (Table 5). Although medical and pharmaceutical sciences are not President Jair Messias Bolsonaro's areas of expertise, the President insists on spreading fake news about the efficacy of knowingly inefficient drugs in one of the most delicate moments in Brazil's history, raising concern about President Jair Messias Bolsonaro's real interests in their promotion and use by people. The situation is aggravated by President Jair Messias Bolsonaro's solid support base, which endorses the use of these drugs. After all, the phosphoethanolamine episode in 2016 was a preview of the chloroquine-hydroxychloroquine-ivermectin hype of 2020, which have no proven efficacy in the treatment of COVID-19 and have several adverse effects [83–89]. However, the backlash was not so high back then as it was in 2020, and the phosphoethanolamine case did not draw the attention of the Brazilian population, in general. One might remind the quote by Edmund Burke: "Those who don't know history are doomed to repeat it".

### 3.8. AN UNHEALTHY HEALTH MINISTRY

During the onset of the COVID-19 pandemic, Brazil had three ministers of health. Luiz Henrique Mandetta, the first one, took office on January 01, 2019 staying until April 04, 2020. Mandetta is a medical doctor who saw his popularity increase when the outbreak reached Brazil, after being active in several media vehicles, both talking about the severity of the COVID-19 situation and announcing the measures taken by the Ministry of Health aimed at controlling the SARS-CoV-2 spread, which included the recommendation of social isolation, quarantine, personal hygiene, and

**Table 5** Correlation between number of vaccine shots, SARS-CoV-2 RT-PCR tests and confirmed COVID-19 cases, deaths due COVID-19, and lethality rate. Data retrieved from 112 countries and territories.

CC, coefficient correlation; 1M, one million; RT-PCR, real time polymerase chain reaction. The Supplement 2 demonstrated the data used to perform the correlation. The information for COVID-19 Cases, Death due COVID-19, Lethality and SARS-CoV-2 RT-PCR was obtained using WorldOMeter. Cases of Coronavirus in Brazil, 2021. Accessed on March 11, 2021. Available at <https://www.worldometers.info/coronavirus/country/> [10]. The reference for the number of vaccination's dosages was retrieved from Coronavirus (COVID-19) Vaccinations on March 11, 2021 at <https://ourworldindata.org/covid-vaccinations>.

MARKERS	DATA	VACCINATION'S DOSAGES	VACCINATION PER 100 PEOPLE	NUMBER OF RT-PCR TESTS	NUMBER OF RT-PCR TESTS/1M INHABITANTS
Confirmed COVID-19 Cases	CC	<b>0.832</b>	-0.051	<b>0.849</b>	-0.075
	P-value	<b>&lt;0.001</b>	0.593	<b>&lt;0.001</b>	0.438
Death due COVID-19	CC	<b>0.786</b>	-0.104	<b>0.802</b>	-0.138
	P-value	<b>&lt;0.001</b>	0.274	<b>&lt;0.001</b>	0.152
Lethality	CC	<b>0.284</b>	<b>-0.210</b>	<b>0.335</b>	<b>-0.251</b>
	P-value	<b>0.002</b>	<b>0.026</b>	<b>&lt;0.001</b>	<b>0.008</b>
Confirmed cases/1M	CC	<b>0.235</b>	<b>0.418</b>	0.164	<b>0.533</b>
	P-value	<b>0.013</b>	<b>&lt;0.001</b>	0.087	<b>&lt;0.001</b>
Death/1M	CC	<b>0.303</b>	<b>0.209</b>	<b>0.260</b>	<b>0.274</b>
	P-value	<b>0.001</b>	<b>0.027</b>	<b>0.006</b>	<b>0.004</b>
Number of RT-PCR tests	CC	<b>0.849</b>	-0.033		0.095
	P-value	<b>&lt;0.001</b>	0.731		0.327
Number of RT-PCR tests/1M Inhabitants	CC	0.023	<b>0.645</b>	0.095	
	P-value	0.812	<b>&lt;0.001</b>	0.327	

MARKERS	ALL	PRIVATE	PUBLIC
COVID-19 new hospitalizations	106,546	74,405	32,141
Ventilatory support			
Noninvasive ventilatory support	31.8%	32.4%	30.2%
Mechanical ventilation	46.9%	39.6%	64.0%
Mechanical ventilation (days)	13	14	11.5
Amines	33.0%	27.8%	45.3%
Kidney Support	12.0%	10.1%	16.5%
ICU hospitalizations (days)	12.2	11.9	12.7
> 7 days	49.9%	48.0%	54.4%
> 21 days	14.5%	14.4%	14.9%
ICU mortality	34.1%	27.5%	49.7%
Hospital mortality			
All patients	35.6%	28.9%	51.9%
All patients with no ventilatory support	9.2%	7.4%	16.6%
All patients with ventilatory support	66.6%	63.1%	71.6%
Dialysate patients	74.2%	71.2%	78.6%

**Table 6** Major differences between in Brazilian private and public health care (March 01 2020 to March 10 2021) [42]. ICU, intensive care unit.

use of personal protective equipment, lockdowns, expansion of the RT-PCR testing capacity, and creation of temporary ICU facilities. However, Mandetta resigned after several conflicts with the government. His successor, Nelson Teich, also a medical doctor, took office on April 17, 2020 and resigned on May 15, 2020. During his short period as a Minister of Health, Teich had the burden of reconciling the guidelines recommended by the Brazilian government with those recommended by the WHO. However, Teich had several divergences with President Jair Messias Bolsonaro, and saw his authority as a minister be disrespected, including in an emblematic episode, when, during a live interview, he learned that President Jair Messias Bolsonaro, gave his own recommendations concerning the COVID-19 situation to the Brazilian population without prior consultation with the Ministry of Health. Teich also saw himself pressured to approve the use of chloroquine and hydroxychloroquine as treatments for COVID-19, which he did not agree with. Teich then resigned after less than one month in charge.

On May 15, 2020, Eduardo Pazuello, a general of the Brazilian Army, was nominated Brazil's interim Health Minister, and was made the official health minister in September. General Pazuello's background includes a parachutist course but no activities related to health care. Pazuello had previously acted as the Ministry of Health executive secretary and, upon President Jair Messias Bolsonaro's request, coordinated the transition period between Mandetta's and Teich's administrations. During Pazuello's mandate, little has been done in order to face the pandemic. When health specialists and authorities stressed the importance of mass testing, Pazuello said that the testing capacity in Brazil would be increased, but no deadlines for this were set, and the access of the population to COVID-19 diagnosis is still difficult nowadays. Although Pazuello was introduced as a specialist in logistics, during his term, about seven million SARS-CoV-2 RT-PCR tests were found to be retained in São Paulo by the Ministry of Health that were about to expire and had a cost nearly to R\$ 290 million. During his inauguration ceremony, Pazuello gave a speech that proved to be in line with what had been defended by President Jair Messias Bolsonaro, including the so-called "early COVID-19 treatment", which was put into practice afterwards, when Pazuello did what his predecessors refused to do and signed a technical opinion that set the guidelines for the use of hydroxychloroquine for COVID-19 treatment. Pazuello also appeared, on several occasions, without wearing a mask alongside authorities [90]. However, nothing was more remarkable during Pazuello's management than the lack of a vaccine policy, as better detailed in section 3.13, later in the present article.

In January 2021, the city of Manaus (Amazonas state), thought to have achieved herd immunity after the first COVID-19 wave [92], faced a devastating second wave of the disease, with a dramatic increase in the number of cases, hospitalizations, and deaths. Pazuello was notified about the lack

of oxygen cylinders in hospitals of Manaus and about the risk of collapse. Little was done by the Health Ministry in this regard and Pazuello's conduct in the Manaus crisis became an object of enquiry in the Brazilian supreme court, and Pazuello is currently being investigated for omission. The purchase of drugs without proven efficacy against COVID-19 as an alternative to face the health crisis in Manaus is also under investigation. As a new collapse of health care services became a reality nationwide again, and the country achieved more than 2,000 daily deaths due to COVID-19, Pazuello alleged that "Brazil's health system is surely impacted, but it has not collapsed and never will". After 10 months as a Health Minister, Pazuello resigned on March 14 2021 [90].

After Pazuello's resignation was made official, President Jair Messias Bolsonaro interviewed medical doctor Ludhmila Hajjar, candidate to the Health Ministry as per indication by the high command of the Brazilian congress. Hajjar is known to be pro-science and against the prescription of treatments with no proven efficacy against COVID-19. However, due to technical differences, Hajjar did not accept the post. President Jair Messias Bolsonaro then invited medical doctor Marcelo Queiroga, president of the Brazilian Society of Cardiology, to occupy the post, which he accepted. In 2020, the Brazilian Society of Cardiology, presided by Queiroga, recommended that chloroquine, hydroxychloroquine, and azithromycin were not used to treat COVID-19. However, after the backlash, the Society and the Ministry of Health released a joint note, opening the possibility for COVID-19 patients to use these drugs upon written informed consent and offering to monitor any resulting side effects [93]. Also, Queiroga is a defender of social isolation measures and use of facial mask [94].

Decision making to implement public health policies must be effective and guided by the government's health representative, especially during events like the COVID-19 pandemic. International recommendations be followed with minor adaptations according to local characteristics. However, in Brazil, one minister of health resigned after a disastrous management, and two others resigned after being pressured by the country's president to implement measures that do not follow the international and scientific-based recommendations to control the increase in the number of COVID-19 cases and to treat infected patients, including the use of chloroquine and hydroxychloroquine. President Jair Messias Bolsonaro's attitude and the lack of a fixed minister of health not only impair the implementation of appropriate measures to handle the outbreak, but also lead to a decreased adherence of the population to the safety measures.

### **3.9. HOW MUCH CAN WE PAY TO BREATHE? THE COST OF MECHANICAL VENTILATORS IN BRAZIL**

Respiratory failure contributes to worse prognosis in COVID-19, so that oxygen therapy and ventilatory support, including mechanic ventilation with positive pressure, are crucial to treat severe cases of the disease in order to avoid airway collapse and to optimize hemostasis [95]. Due to a high demand for mechanical respirators caused by the COVID-19 outbreak, the government had to purchase a great number of new equipment. Until the first fifteen days of July 2020, 7,994 pulmonary ventilators were delivered across the country via Ministry of Health. The criteria for distribution of these respirators considered the structure of a given service and the presence of specialized teams to operate them, which, in turn, had the participation of the National Council of Health Secretaries (CONASS) and the National Council of Municipal Health Secretariats (CONASEMS).

Until July 2020, the Ministry of Health had signed five contracts with Brazilian companies so they could start producing 16,252 respiratory ventilators, out of which 6,500 were produced by Magnamed, with a cost of R\$ 332.5 million (US\$ 60.219 million); 4,300 by Intermed, with a cost of R\$ 258 million (US\$ 48.175 million); 3,300 by KTK, with a cost of R\$ 78 million (US\$ 14.564 million); 1,202 by Leistung, with a cost of R\$ 72 million (US\$ 13.444 million); and 950 by WEG, with a cost of R\$ 57 million (US\$ 10.643 million) [9]. The mechanical ventilators were distributed to the states and the Federal District as shown in [Table 2](#). At the same time, some Brazilian states also purchased mechanical ventilators separately, which a large difference seen among the paid values [96]. The state of Mato Grosso paid R\$ 44,000 per unit for ventilators made in Brazil and R\$ 61,700 per unit for imported equipment. In contrast, the State of Roraima paid R\$ 215,4 per unit. Some of these cases under investigation for over-purchase and diversion of public money. In the State of Santa

Catarina, a scandal came to light revealing that the state's government ordered the purchase of 200 respirators, with a final cost of R\$ 33 million by using fake data and quotes. Five people were arrested so far, under the accusations of embezzlement, active and passive corruption, and money laundering. The case was assigned to the Brazilian Supreme Court after Santa Catarina governor Carlos Moisés became a suspect [97].

### **3.10. THE AVAILABILITY OF DRUGS TO PERFORM INTUBATION IN PATIENTS WITH COVID-19**

On July 3, 2020, a public hearing was held in the Brazilian Congress. At the hearing, the CONASS adviser, Heber Dobis, participated in a debate on pricing and order of sedatives and other drugs to perform intubation of patients with severe or critical COVID-19, promoted by the External Commission for Actions against coronavirus. At least three weeks ago, the health departments of several Brazilian states were facing difficulties in supplying drugs used in the process of orotracheal intubation for mechanical ventilation. A survey performed by the CONASS and answered by the health secretariats of 25 states found that muscle blockers were lacking in 24 states, and 11 other essential drugs were lacking in more than half of the states. The lack of medication for inducing sedation, anesthesia, and muscle relaxation was described as extremely serious, which could make mechanical ventilation unfeasible [98].

Subsequently, the CONASS mapped the stocks of medicines in health units in the states and found that several states were facing shortages of essential medications or risk of shortages in the coming days from the end of June. The State of Mato Grosso had the highest number of missing items (13), followed by the states of Ceará and Maranhão (12), Amapá and Tocantins (11), Rio Grande do Norte (10), Roraima, Amazonas, and Bahia (9), and Pernambuco (8). The States of Alagoas, Minas Gerais, Paraná, Piauí, Santa Catarina, and Sergipe are fully supplied. Additionally, nine drugs were only sufficient to meet the demand expected for the next five days in Mato Grosso. In Pernambuco, eight drugs were missing and nine were due to expire in a week. São Paulo, the COVID-19 epicenter in Brazil, had only one medication unavailable, but 14 other drugs were available, enough for only five days [99].

### **3.11. HEALTH CARE PROFESSIONALS AFFECTED BY COVID-19 IN BRAZIL**

Health care workers have a higher risk of being infected with SARS-CoV-2 [100]. A study with 32,583 Chinese patients with COVID-19 [101] found that health care workers represented 4.6% of confirmed cases. Overall, the COVID-19 incidence seems to be three times higher in health care workers, if compared to the general population [102]. In Brazil, one year after pandemic was declared, 481,285 COVID-19 cases had been confirmed among health care workers, with nursing assistants being the most affected group (33.2%), followed by nurses (15.3%), physicians (11.1%), health care community agents (5.1%), and receptionists of health units (3.9%) ([Table 7](#) and [Figure 5](#)) [9]. In addition, 470 health care workers died of COVID-19 in Brazil, 153 of whom were nursing assistants, 95 were physicians, and 59 were nurses. In January 2021, the International Council of Nurses reported 2,262 deaths of nurses due to COVID-19 [103]. By the same period, Brazil accounted for at least 30% of the deaths of health care workers due to COVID-19, according to Brazil's Federal Nursing Council [104]. These figures may be explained by the lack of personal protective equipment, such as N95 facial masks, and sanitizers in many health care units across the country. Health care workers should be carefully monitored, as they are the key workers in the fight against the outbreak. Also, health care workers with asymptomatic COVID-19 who are not tested are more likely to infect people in health care settings. In fact, massive and continuous testing is crucial to prevent contagion and to reduce the in-hospital SARS-CoV-2 transmission [105–107]. Not by chance, health care workers were the first group to be vaccinated against COVID-19 in Brazil and in most countries of the world [24].

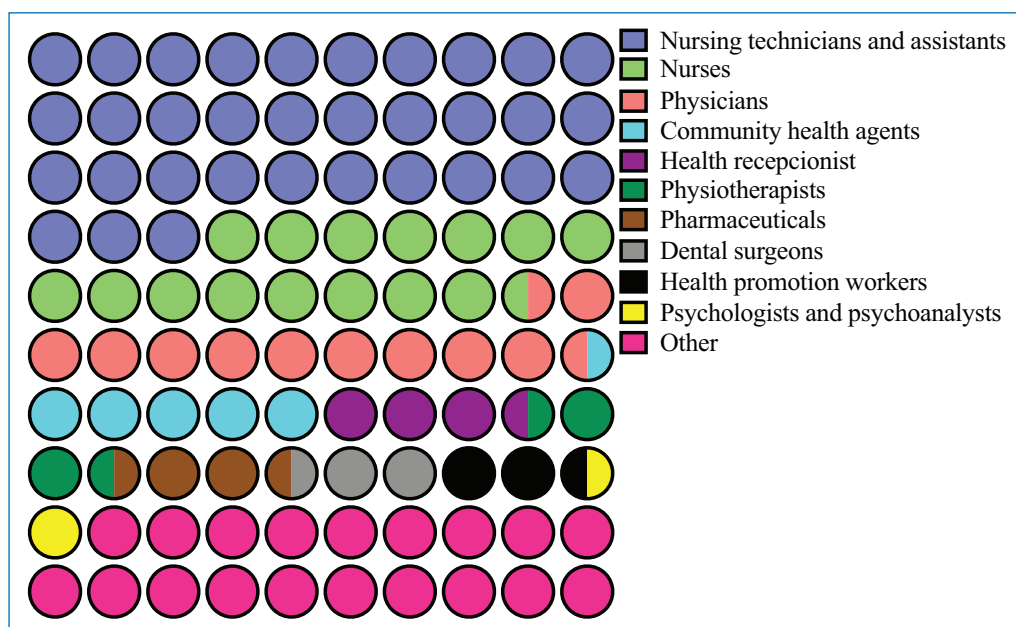
Keeping health professionals protected against SARS-CoV-2 infection is not only a manner of avoiding in-hospital infection, but also to improve the management of infected individuals, especially those with severe and critical disease, in need of ICU referral and intubation.



HEALTH CARE WORKER	NUMBER OF COVID-19 CASES UNTIL 27 FEBRUARY 2021 (%)
Nursing technicians and assistants	159,786 (33.2%)
Nurses	73,819 (15.3%)
Physicians	53,549 (11.1%)
Community health agents	24,540 (5.1%)
Health receptionist	18,672 (3.9%)
Physiotherapists	14,439 (3.0%)
Pharmaceuticals	13,031 (2.7%)
Dental surgeons	12,958 (2.7%)
Health promotion workers	11,641 (2.4%)
Psychologists and psychoanalysts	7,421 (1.5%)
Other HCW*	91,429 (19.0%)
Total	481,285

**Table 7** Number of health care worker accmpted by SARS-CoV-2 infection during the first year of COVID-19 pandemic in Brazil.

\* Other HCW accounts for: managers and operations specialists in companies, departments, and health service units, endemic health agents, ambulance drivers, caregivers, health managers, dentistry technician, nutritionists, pharmacy and pharmaceutical manipulation technicians, social workers and home economists, technicians from health laboratories and blood banks, public health agents, biomedical, radiology assistants, attention, defense, and protection workers for people at risk and adolescents in conflict with the law, technologists and technicians in diagnostic and therapeutic methods, work safety technicians, other teaching professionals, health laboratory assistants, veterinarians and zootechnicians, telephone operators, speech therapists, rescuers (except doctors and nurses), physicists, technicians in food production, preservation and quality, physical education professionals, occupational therapists, orthopedists and psychomotricists, piotechnology professionals, teachers, biologists, production, quality, safety and related engineers, biological sciences researchers, electro-electronics and photonics technician working in healthcare, orthopedic immobilization technicians, health and environmental agents, technologists and technicians in complementary and aesthetic therapies, chemistry teachers, photographic and radiological laboratory workers, technicians in orthopedic prostheses, health records and information workers, optics and optometry technicians, food and related engineers, music therapists, art therapists, equo therapists or naturologists, doulas, lay midwives, electricity and electrotechnical technicians, professionals of creative, equo therapeutic, and naturological therapies, biotechnology support technicians, funeral service workers, osteopaths and chiropractors, bioengineering support technicians, necropsy technicians, and taxidermists. The information was acquired from Ministério da Saúde. 44<sup>o</sup> e 52<sup>o</sup> Boletim epidemiológico especial. 2020/2021. Accessed on 17 March 2021. Available at <https://coronavirus.saude.gov.br/boletins-epidemiologicos> [9].



**Figure 5** Health care workers affected by COVID-19 in Brazil after one year of pandemic. The data are given as percentages. Source: Brazil, Ministry of Health. 44<sup>th</sup> and 52<sup>nd</sup> Special Epidemiological Reports, 2020/2021. Accessed on 17 March 2021. Available at <https://coronavirus.saude.gov.br/boletins-epidemiologicos> [9].

### **3.12. HEALTH CARE INVESTMENT IS CRUCIAL TO ATTENUATE THE COVID-19 IMPACT**

Back in 2017, Brazil was among the 10 wealthiest countries in the world, with a gross domestic product (GDP) of US\$ 2.063 trillion, still far from the USA (USD 19.485 trillion) and China (USD 12.310 trillion). On the other hand, in terms of health investment, Brazil (9.47% of the GDP) was ahead of China (5.15% of the GDP), but not of the USA (17.06% of the GDP), which had the second highest percentage of the GDP invested in health [8]. Despite having a higher GDP percentage invested in health, Brazil and USA were not as successful as China in the management of the coronavirus crisis. Soon after its local outbreak, the Chinese government implemented stringent measures to curb the viral spread, managed to plateau the number of daily deaths by mid-April 2020 and faced a weak second wave, whereas Brazil and the USA kept seeing their numbers increasing every day [8], had a much worse second wave, and, together, account for nearly 30% of all deaths in the world. China's successful policies contrast with how the pandemic was handled in Brazil and in the USA in its beginning, when the main authorities in both countries underplayed its potential, as well as the recommendations given by both local specialists and WHO. In fact, the USA, upon Donald Trump's command, stopped directing funds to the WHO, with the former USA president also accusing the WHO of being under China's control [108]. After starting a massive vaccination campaign by late December 2020, the USA did not take long until it saw a noticeable decrease in the number of daily new cases and daily new deaths [10, 24].

It is well known that health investment is essential to improve the quality of health services and boost economy [109]. A solid public health system can also facilitate human development [8]. Still, this is not necessarily enough to succeed in a pandemic setting. Reckless actions, such as those taken by Brazil and USA, for instance, can be more harmful to the population during a pandemic than low health investment itself. After the world has seen the success of countries such as China, South Korea, Germany, Denmark, and New Zealand in breaking COVID-19 advancement, it became crystal clear that a high health investment, when associated with a proper conduct of a country's authorities, is crucial for the fate of any country in such a moment.

Last but not least, Brazil's SUS should be valued and strengthened, because it is used by most of the Brazilian population. The SUS still faces numerous issues nowadays, when it comes to its efficiency, most of which can be associated with failures in its decentralization process, poor administration – not only by the Federal Government, but also by states and municipalities – diversion of funds, corruption, poor transfer of funds coming from taxes, lack of new contracts in view of the current demand for the maintenance of several health services, and scrapping of facilities and equipment, leading to a poor investment in health, which is likely to have contributed to the health care collapse. Considering indirect and direct taxations, Brazil has one of the highest tax rates in the world. However, the way taxes are managed in the country is one of the major complaints of the Brazilian population, which has the perception that benefits coming from taxation are not satisfactory.

### **3.13. THE VACCINATION STATUS IN BRAZIL**

Manaus, in the Amazonas State, was the first Brazilian capital city to face a collapse in its health care system during the first wave of COVID-19, reaching an epidemic peak between March and April 2020. In June, the city had a cumulative rate of 52% of SARS-CoV-2 seropositivity, which started to decline in July and August of the same year, suggesting that herd immunity had been achieved [110]. However, Manaus not only faced a devastating second wave of COVID-19 but was also the source of emergence of the P1 lineage of SARS-CoV-2, which has been shown to be more transmissible and able to cause reinfection [111] and became a matter of concern worldwide. Manaus' case may have been the last hope of achieving natural herd immunity to infection, an outcome that was implicitly expected by the Swedish health authorities in their anti-COVID-19 strategies in the early days of the pandemic and did not succeed as well [112]. Manaus' and Sweden's cases make it clear that herd immunity is a distant reality and stress the importance of vaccination to reduce the viral spread. In this scenario, COVID-19 drove the development of next-

generation vaccines that entered human clinical testing with unprecedented rapidity [113], some of which are rolling out in many countries, namely mRNA-1273 (developed by USA's Moderna), BNT162b2 (developed by Pfizer and BioNTech), ChAdOx-1 (developed by the Oxford University and Astra-Zeneca), AD26.COV2.S (developed by Janssen – Johnson & Johnson) Sputnik-V (developed by Russia's Gamaleya Institut), CoronaVac (developed by the Chinese company Sinovac Biotech) and BBIBP-CorV (developed by the Chinese company Sinopharm).

As previously stated, the lack of a vaccination plan was the main mistake by Brazil's Health Ministry. After being stocked with active-duty and retired military officials with little or no public health experience, the Health Ministry, under Eduardo Pazuello's command back then, fell asleep at the wheel and failed when efforts were needed to ensure the acquisition of basic supplies, to build up a structure for a massive vaccination, and to set deals with vaccine makers. After being pressured by state governors, Pazuello announced the purchase of 46 million doses of the Chinese CoronaVac, whose production in Brazil was started after setting up a partnership with the Butantan Institute, which is located in the state of São Paulo, governed by João Dória. However, on the next day, Pazuello was unauthorized by President Jair Messias Bolsonaro, who alleged that “nobody was interested in this Chinese vaccine but Brazil”, as Pazuello quarantined after having COVID-19. The government went back on its decision, and Pazuello presented a plan for acquisition of 46 million doses of the Coronavac vaccine until the end of March, which was changed five times until the predicted estimate was reduced to 22–25 million doses. In the meantime, it came to light that the pharmaceutical company Pfizer had offered a deal for 70 million doses of its developing vaccine by the Brazilian government to be delivered on December 2020. The negotiation got stuck as the government did not agree with the terms. However, Brazil ended up missing the deadline to give Pfizer an answer and the vaccine doses were never delivered. In February 2021, Butantan Institute president Dimas Covas affirmed that the Ministry of Health declined an offer of 160 million doses of the CoronaVac by Sinovac. Altogether, the doses of the Pfizer/BioNTech and Sinovac vaccines would be enough to vaccinate 50% of the Brazilian population with two shots [90, 91].

So far, in addition to the Sinovac-Butantan agreement, two other agreements have been signed in Brazil that predict transfer of technology for vaccine production, one of which between AstraZeneca and Fiocruz, and the other one between the Gamalyea Institute and the State of Paraná's Institute of Technology [114]. Only the AstraZeneca-Fiocruz agreement was funded by the Ministry of Health. The initial plan predicted 15 million doses to be produced in December 2020 and other 15 million in January 2021. However, by that time, to produce the vaccine, Fiocruz lacked the active ingredient, which needed to be imported. Due to the international competition, the shipment of this ingredient to Brazil was slowed, directly impacting the vaccination plan. In mid-March 2021, the Brazilian government finally reached an agreement for acquisition of 138 million doses of vaccines, 100 million of which will be provided by Pfizer and 38 million by Janssen. The total cost of the operation will be around US\$ 1.38 billion; however, the deadline for delivery has not been revealed. Other agreements were announced with AstraZeneca, Sinovac Biotech, and the Covax Facility Consortium (coordinated by WHO), and another agreement is expected with the Gamaleya Institute. The Ministry of Health has affirmed that Brazil will have more than 400 million doses of the vaccine until December 2020 [115–117].

As vaccines were under development and most countries in the world were rushing to reach deals with vaccine makers, a skeptical President Jair Messias Bolsonaro stated, in October 2020, in one of his traditional live broadcasts on his Facebook page, that “we are not buying vaccines and no Brazilian will be a guinea pig”. Back then, Brazil's best hope for a short-term vaccination strategy was CoronaVac, which President Jair Messias Bolsonaro continuously attacked, suggesting that it could kill or disable people who take it, with no evidence at all [118]. In an outrageous episode, the CoronaVac Phase III clinical trial was stopped after the death of a volunteer, which President Jair Messias Bolsonaro celebrated as “Another victory” [119]. The death turned out to be a suicide and the volunteer was actually in the placebo group. Other statements include “I am not taking the vaccine. I got infected already and got antibodies. So, what is the point?”, “Only my dog can be obliged to be vaccinated”, “Half of the population will not take the vaccine”. These kinds of statements are dangerous in a pandemic setting, especially when anti-vaccine movements are rising around the world, including in Brazil, where vaccine hesitancy has been growing in the past five years [120].

Brazil started its vaccination plan on January 18, 2021, and individuals vaccinated in the first phase of the vaccination program included health care workers, older adults aged more than 60 years old or who lives in institutions, and indigenous people [9]. Given the history of successful vaccination strategies and the availability of state-funded facilities for large-scale vaccine production in Brazil, the country should be much better positioned in this regard. However, due to governmental negligence earlier in the pandemic, Brazil has around 12 million doses administered, only 5% of its population vaccinated with at least one shot ([Figure 1](#)), and only 1.5% vaccinated with two shots so far [24], which places the country behind other emergent nations like Chile and Bahrein in the vaccination rank (Supplement 2); at the same time the country is the epicenter of the pandemic. On the other hand, scientific efforts are seen, such as a Butantan Institute's study, in which 30,000 people in Serrana, a town with nearly 45,000 inhabitants in the countryside of São Paulo, will be vaccinated with the CoronaVac, aiming at a deeper evaluation of the vaccine's efficacy and the possible achievement of herd immunity in the town [121].

At present, potentially more lethal lineages of SARS-CoV-2 are circulating around the world and other lineages can appear as the virus undergoes continuous mutations. Massive vaccination is therefore important, not only for individual protection, but also for collective protection, in order to halt the circulation of the virus. Still, vaccines are not supposed to completely sweep an infection out. They rather reduce the odds of getting severely ill due to the infection. This can be shown by Israel's example, where nearly 60% of its population and observing was vaccinated and a sharp decrease in the death and hospitalization rates followed [24]. This is the path Brazil, and all other countries, must follow in order to prevent further health care collapse and to turn COVID-19 into one more endemic disease. In the meantime, stringent social isolation measures are needed, even as vaccination progresses worldwide.

Nevertheless, a positive Spearman correlation was found between vaccination dosages and COVID-19 markers such as COVID-19 cases, number of deaths due COVID-19, number of SARS-CoV-2 RT-PCR tests, and lethality in a statistical analysis from 112 countries or territories. The same occurred between vaccination per 100 people and COVID-19 cases or deaths due COVID-19 per one million inhabitants. Unfortunately, a negative correlation was found between vaccination per 100 people and SAR-CoV-2 RT-PCR tests per one million of inhabitants with lethality, which leads to the belief that vaccination per 100 people and number of SARS-CoV-2 RT-PCR tests per one million inhabitants is lower in regions with higher lethality rate ([Table 5](#)).

## 4. HIGHLIGHTS

- One year after COVID-19 was declared a pandemic, Brazil had the second higher number of cases and deaths, and the highest number of daily deaths due to the disease.
- Lack of massive testing, non-stringent and ineffective collective health policies, poor management of the public health care system, and political instability were the main drivers of the country's flawed management of the COVID-19 advancement.
- Due to previous governmental negligence, massive vaccination in Brazil will be a challenge.
- Anti-science and sabotaging actions by government had a pivotal role in the country's current situation.
- Brazil has a large territory and is marked by social contrasts among different regions and states, which showed contrasting data regarding the impact caused by COVID-19.
- COVID-19 databases and data sharing are important to provide an overview of epidemiological aspects of the disease; however, Brazil lacks standardization in these datasets.

## 5. LIMITATIONS

Our study has limitations. First, the number of SARS-CoV-2 RT-PCR tests performed in Brazil is not fully clear, as there is limited access to these data in the official channels. Lack of official data availability is also an issue for number of new ICU beds and for the amount paid for mechanical ventilators and laboratory and hospital supplies. The disclosure of COVID-19 data was assigned to states and to the Federal District, which makes data normalization difficult. Also, many of our sources included preprints, which have not been peer-reviewed, and press articles, which, although

## 6. CONCLUSIONS

After one year of COVID-19, Brazil certainly failed to manage the disease's spread. In the present article, we explored several factors associated with this failure, such as the low availability of SARS-CoV-2 RT-PCR tests, lack of efficient health policies, political instability (especially in the Ministry of Health), use of knowingly inefficient treatment approaches, lack of special attention for the most susceptible populations, lack of accessibility to health care facilities, high treatment costs, and, most important, the sabotaging attitudes by President Jair Messias Bolsonaro during the pandemic, which are not at all expected from an authority and to which an important part in the country's current situation can be credited. Unfortunately, Brazil is maybe the best example of what not to do during a pandemic and indicates a need for a suitable government that can base its health policies on science and not personal political issues or guesswork.

## ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Supplement 1.** Description of the Indigenous Health Special Districts in Brazil. DOI: <https://doi.org/10.5334/aogh.3182.s1>
- **Supplement 2.** Number of Vaccination's dosages, SARS-CoV-2 RT-PCR, confirmed COVID-19 cases, deaths due COVID-19 and lethality for the data retrieved from 112 countries and territories. DOI: <https://doi.org/10.5334/aogh.3182.s2>

## COMPETING INTERESTS

The authors have no competing interests to declare.

## AUTHOR CONTRIBUTIONS

Matheus Negri Boschiero, Camila Vantini Capasso Palamim and Fernando Augusto Lima Marson contributed equally to this study.

All authors have approved the manuscript and agreed with its submission to the journal. Also, all authors wrote and revised the manuscript.

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