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**COVID -19 - BEHAVIOR OF CASES AND DEATHS ANALYZED  
ACCORDING SANITATION SYSTEM WASTEWATER AND WATER IN  
THE MUNICIPALITIES OF 4 BRAZILIAN STATES: SÃO PAULO,  
CEARÁ, PARANÁ AND AMAZONAS**

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**ABSTRACT**

According to WHO, hand washing with soap and water and surface hygiene are essential in the prevention of COVID-19. Studies have shown the permanence of viral components in feces of individuals cured of the disease, presence of the virus in wastewater in several countries, evidencing the importance of basic sanitation in the fight against the disease. Objective: to analyze the relationship between the sanitation system of municipalities in four Brazilian states and the evolution of cases and deaths by COVID-19. Demographic data were obtained from

IBGE 2018, health data from SNIS 2018 and the dynamics of COVID-19 cases from the state health departments. Data were analyzed in an Excel table. The period analyzed was from February 25th to May 22nd, 2020. Brazil presented in the period 330,709 cases and 21,117 deaths, with a lethality rate of 6.4%. States of Amazonas and Ceará present rates of COVID-19 cases higher in municipalities operated by non-state operators. Ceará, São Paulo and Paraná show a higher death rate per 100,000 in municipalities with the performance of state sanitation operators. In the Amazon, the proportion of cases and deaths is high, and it is concentrated in areas of model care privatized sanitation, as happens in Manaus, with lethality rate 8.69%. Municipalities in need of basic sanitation are more vulnerable to the dissemination of SARS-CoV-2. Conclusion: analyses of COVID-19 cases by sanitation models may contribute to the adoption of preventive measures in municipalities.

**Keywords:** COVID-19, sanitation, water, surveillance, sewers.

## 1. Introduction

Identified at the end of 2019 in China, Acute Respiratory Syndrome by the new subtype of Coronaviridae virus (SARS-CoV-2) was named Coronavirus Disease (COVID-19)<sup>1</sup>. On February 25<sup>th</sup>, 2020, the first case in Brazil was documented<sup>2</sup>. The main route of transmission is aerial and droplets, and the prevention of contagion is made by social distancing, household isolation from confirmed cases, use of masks by the entire population in public places and hygiene of hands and objects with alcohol or soap and water<sup>3</sup>.

Although the main clinical picture of the disease is respiratory, 10% of the cases of COVID-19 may develop gastrointestinal symptoms such as nausea, vomiting, abdominal pain and diarrhea<sup>4</sup>. Research has indicated the permanence of viral RNA of the coronaviridae family in feces of individuals contaminated within 30 days after contagion<sup>5</sup>. Recently, a Chinese study detected fecal release of SARS-CoV-2 at 5 weeks after PCR negative in respiratory swab<sup>6</sup>. A study done in Amsterdam collected untreated wastewater at the city's airport for viral analysis, which positive PCR after 4 days of the first confirmed Dutch case<sup>7</sup>. Thus, fecal-oral transmission of SARS-CoV-2 was theorized<sup>8</sup>.

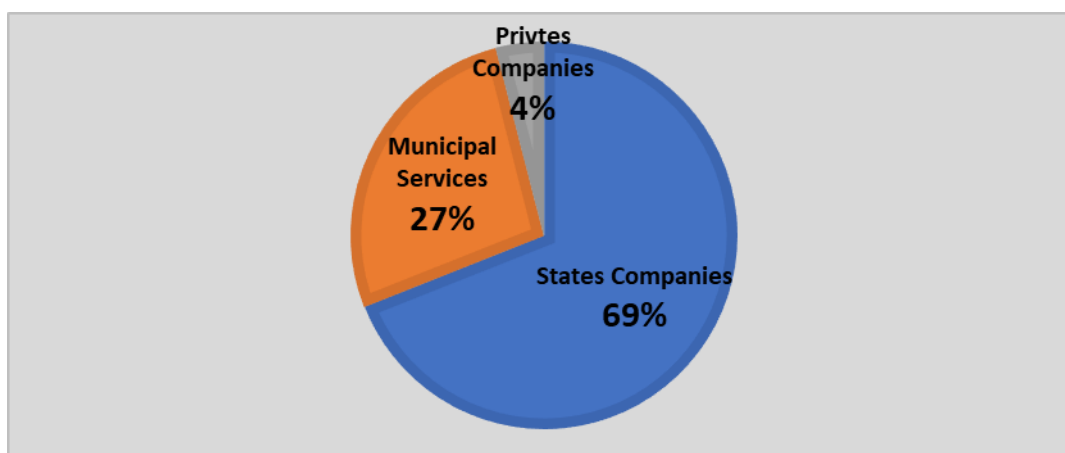
Brazil is a country with a population of 211 million inhabitants, with 27 states and 1 federal district. According to Trata Brazil in its Sanitation Ranking published in 2020, Brazil is a heterogeneous country in health issue. While there are regions with access to treated water and sewage collection in almost the entire population, there are also localities without any sanitation support. The water transfer service and its distribution to the population, as well as the collection and treatment of sewage in Brazil can be carried out by a state, municipal or private company, and the decision is taken by the municipality<sup>9</sup>. According to data from the BRAZIL Atlas of the National Water Agency - ANA, 69% of municipalities have activities developed by state providers<sup>10</sup>.

National Sanitation Information System (SNIS), an agency of the federal government, provides a Sanitation Information Panel and consists of an interactive platform in which it is possible for the user to view the information generated by SNIS in a dynamic and didactic environment. In this

platform, technical information, international operations and quality control are available for most municipalities in Brazil<sup>11</sup>.

Some states have a different dynamic. The state of São Paulo is the Brazilian epicenter of the disease, covering most reported cases and deaths by the end of April. Paraná has a small portion of the cases and has a differentiated sanitation system in the country. Two other states with many confirmed and deaths are Amazonas and Ceará, which have reached the total capacity of care of the public health system.

Fig. I: Distribution according to sanitation service providers in relation to Brazilian municipalities.



*Source: Data Agency National Water.*

## 2. Objectives

To analyze the relationship between the dynamics of cases and deaths by COVID-19 and the sanitation system in different municipalities of four Brazilian states: Amazonas, Ceará, Paraná and São Paulo.

## 3. Methodology

Ecological and exploratory study, which was initiated by bibliographic survey, data collection and later creation of a platform for information. Data in relation to COVID-19 were collected from the information service of the Ministry of Health of DATASUS<sup>12</sup> and the State Health Secretariats<sup>13,14,15,16</sup>, which disclosed the number of confirmed cases and deaths through their daily epidemiological bulletins, from February 25<sup>th</sup>, 2020 to May 22<sup>nd</sup>, 2020. For the data related to the demography of the cities and states studied, we used a 2018 Census of Brazilian Institute of Geography and Statistics (IBGE)<sup>17</sup> data on the basic sanitation of each state and municipality was obtained by SNIS - 2018. Another database used was BRAZIL. IO (<http://brazil.io/>)<sup>18</sup>, section DATASET - COVID, a collaborative and free site with information from official sources of the Ministry of Health. Subsequently, tables were prepared in Excel with information on

suspected cases, confirmed cases and deaths, population of municipalities and state, basic sanitation operators that provide care in each locality and percentage of drinking water supply and sewage collection. Statistical analyses were performed using Excel.

#### 4. Results

The results are initially displayed by state.

##### 4.1 SÃO PAULO st

There are 645 cities on the State of São Paulo (SP) and has 45,919,049 inhabitants. Basic Sanitation Company of the State of São Paulo (SABESP) is the company responsible for water and sewage treatment, operating in 371 municipalities in São Paulo and covering 67% of the population of São Paulo. As reported in SNIS 2018, approximately 3.8% of the inhabitants do not have access to treated water and 10.2% of the inhabitants of the state are not assisted in sewage collection.

Health Department of the State of São Paulo identified, until May 22<sup>nd</sup> of this year, 76,815 cases of COVID-19 and 5,773 deaths from the disease, a lethality rate of 7.5%. According to Graph 1, confirmed cases and deaths in cities that are not operated by SABESP total 9,339 with a mortality rate of 5.4%, representing 12% of the total cases in the state.

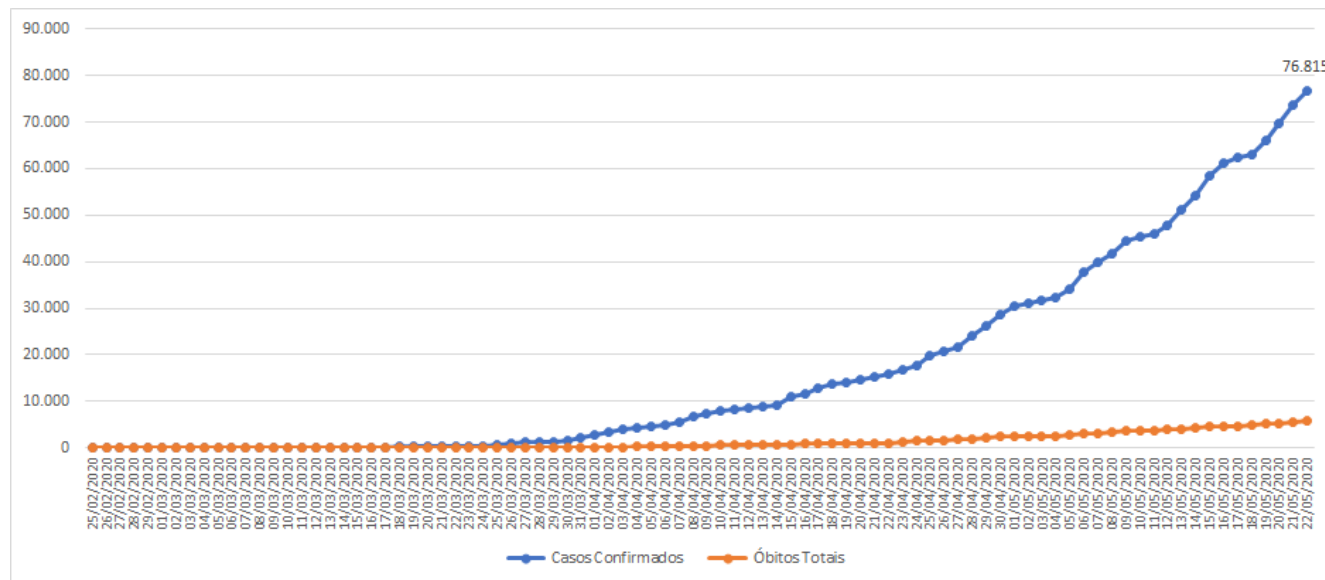
Graph 1: Cases and Deaths due to COVID -19 in municipalities operated by the SABESP and other companies. SP State



Source: Ministry of Health and SES data.

Confirmed cases and deaths per day (still increasing) are shown in Graph 2.

Graph 2: Daily Evolution Cases and Deaths by COVID -19 in the state of SP.02/25-05/22/2020



Source: SES/SP

#### 4.2 PARANÁ st

The State of Paraná (PR) encompasses 399 independent municipalities and it has population of 11,433,957. Paraná Sanitation Company (SANEPAR) is the state company responsible for water supply and sewage collection and serves 370 cities in Paraná. The other 54 municipalities manage these services by municipal and private agencies and total 662,939 individuals (6% of the population of Paraná). According to SNIS 2018, approximately 5.6% of the population does not have access to water and 12.4% have irregular access. Also, 28.6% of the population does not have adequate sewage collection and the rate of sewage treatment by treated water is 73.2%.

According to Health Department of Paraná, until May 22<sup>nd</sup>, 2020, confirmed cases of COVID-19 in the state total 2,938 and the number of deaths reaches 146, with a lethality rate of 5.0%. 206 municipalities confirmed cases of the disease and 98% of confirmed cases are in municipalities operated by SANEPAR. 2% (54 cases) of the total number of confirmed cases are outside the company's coverage area. Deaths occurred in a total of 56 cities. 95% of them are operated by SANEPAR and 5% by others, with a total of 3 deaths. (Graph 3).

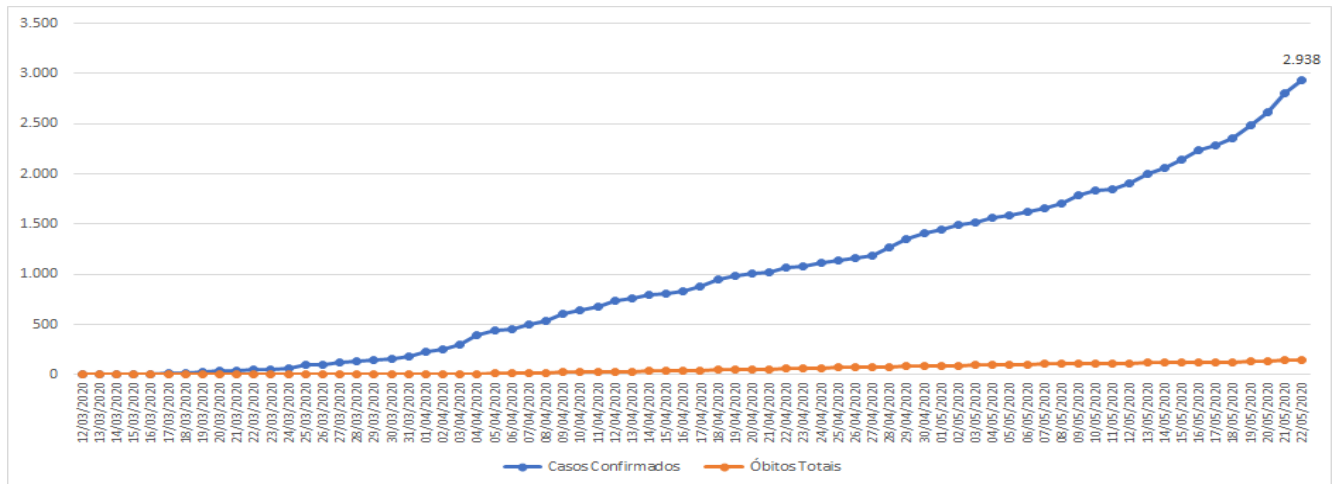
Graph 3: Cases and Deaths due to COVID 19 in municipalities operated by SANEPAR and others.



Source: Ministry of Health and SES data.

The daily evolution of confirmed cases and deaths from COVID-19 in the state of PARANÁ is in Graph 4.

Graph 4: Daily Evolution Cases and Deaths by COVID-19 in the state of PR.02/25-05/22/2020



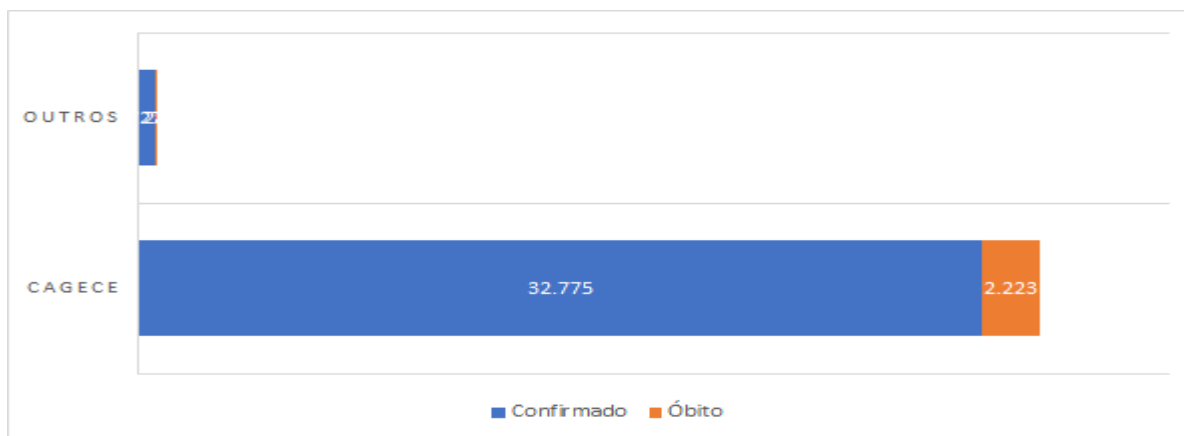
Source: SES/PR.

### 4.3 CEARÁ st

The State of Ceará (CE) has 184 municipalities and its population is 9,132,078 inhabitants. CAGECE (Water and Sewage Company of the State of Ceará) serves 98% (179) of these municipalities and the remaining 2% are operated by autonomous service networks. According to SNIS 2018, about 41% of the population was not served by a water supply network and 74.5% of people do not have a sewage collection network. According to Health Department of Ceará,

the confirmed cases of COVID-19 by May 22<sup>nd</sup>, 2020 totaled 33,502 and reached 184 municipalities in the state. The number of deaths in the same period was 2,261 with a lethality rate of 6.8%. 2% (1,524 cases) of the total number of confirmed cases and 79 deaths were confirmed in residents of other municipalities not attended by CAGECE (Graph 5).

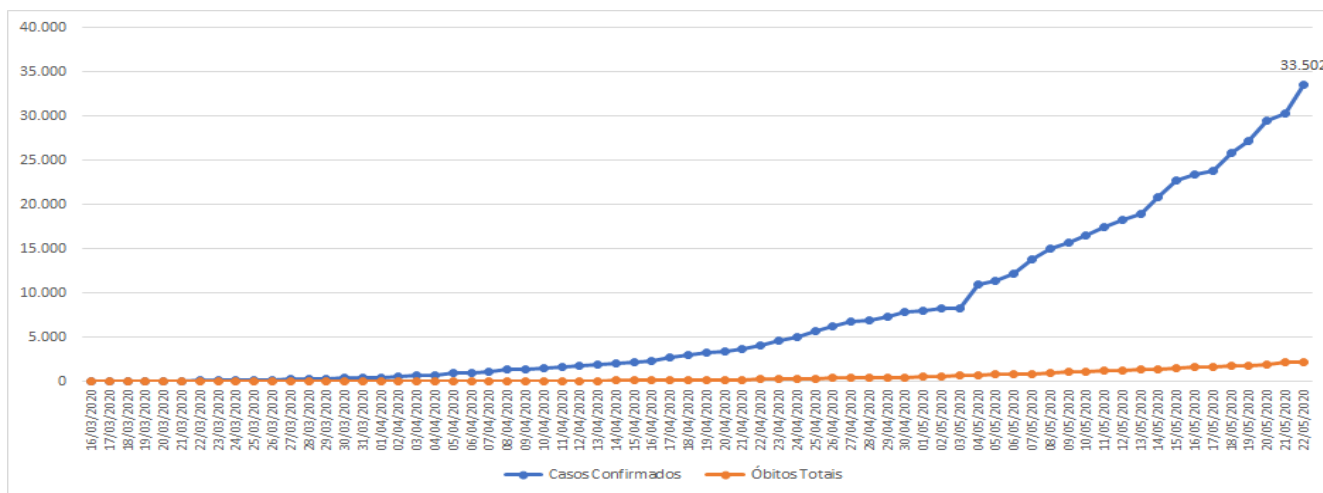
Graph 5: Cases and Deaths by COVID 19 in municipalities operated by the state company CAGECE and others.



Source: Ministry of Health and SES data.

The evolution of confirmed cases and daily deaths by COVID - 19 in the state of Ceará points to an important evolution in the first days of May and they are shown in graph 6.

Graph 6: Daily Evolution Cases and Deaths by COVID-19 in the state of CE 02/25-05/22/2020



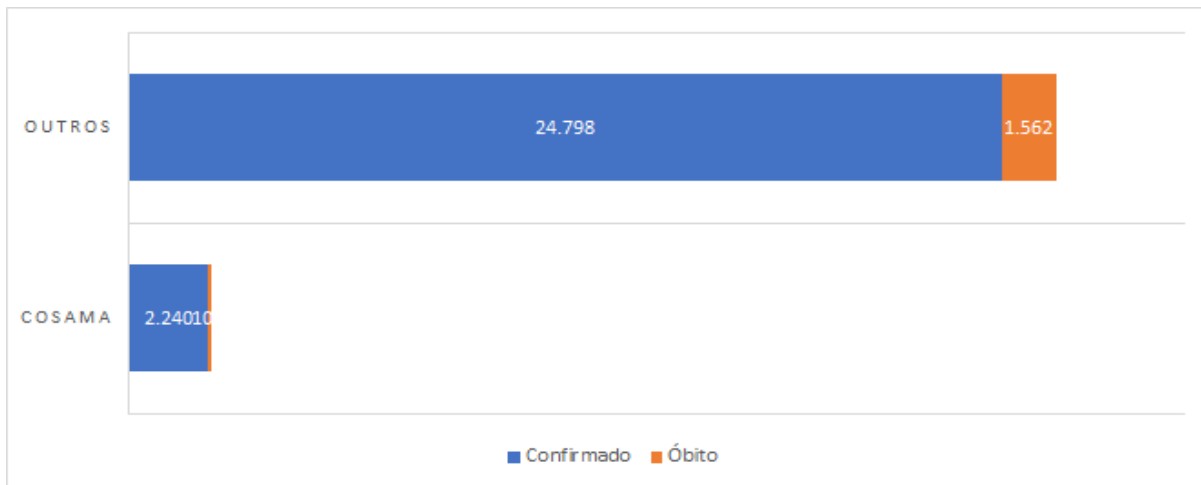
Source: SES/CE

#### 4.4 AMAZONAS st

According to IBGE, in 2018, the state of Amazonas (AM) had 62 municipalities and a population of 4,080,611. According to SNIS2018, 89.3% of the state's urban population has water service and 11.2% is provided with sewage network. Amazonas Sanitation Company (COSAMA) is the state-owned mixed capital company responsible for water supply, collection, and sewage treatment in the state. It operates in 12 municipalities, with a coverage of 3% of the Amazonian population. In these municipalities, water and sewage indexes are below the national average. The capital Manaus has privatized water service (Manaus Waters) and is not served by COSAMA. The responsible company covers only 12% of the population with the sewage service.

According to Amazonas Health Surveillance Foundation, the state recorded until May 22<sup>nd</sup>, 2020, 27,038 confirmed cases and 1,669 deaths due to COVID-19, lethality 6.1%. Manaus leads the ranking of cases with 48% of confirmed from all over the state and it presented 12,967 confirmed cases, 1,127 deaths (67% of all deaths in the state) with lethality 8.69% and 51.63 cases / 100,000 inhabitants. Graph 7 shows that the municipalities who have COSAMA's performance are responsible for only 650 cases.

Graph 7: Cases and Deaths by COVID -19 in municipalities operated by COSAMA and others.

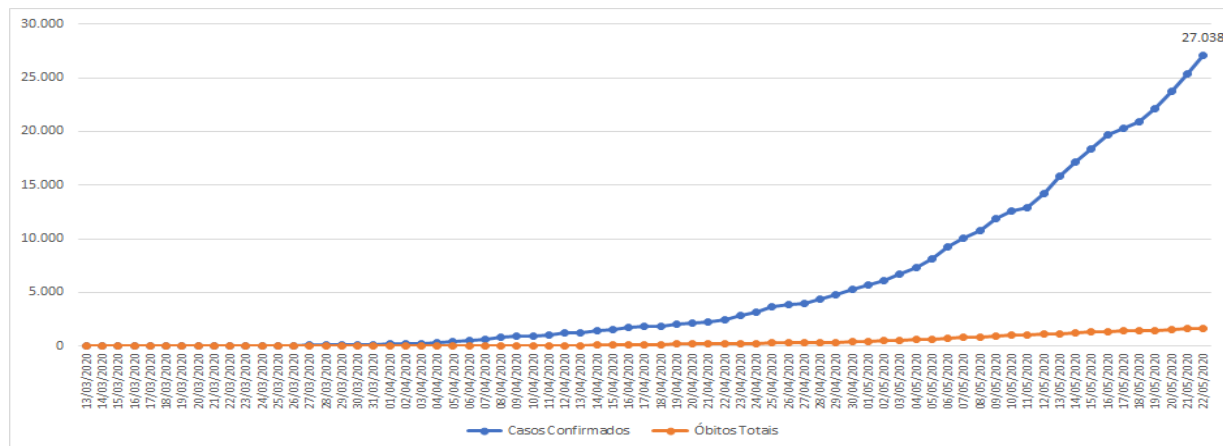


Source: Ministry of Health and SES data.

Graph 8 shows the daily evolution of confirmed cases and obits in the state.



Graph 8: Cases and Deaths by COVID 19 in municipalities operated by the state company and others. AM state. Period 02/25-05/22/2020



Source: SES/AM

Results of the rates of confirmed cases and deaths by COVID-19 are presented by the set of municipalities by each state according to the state operator standard or not. (Table 1). In the same table are also presented the position of the state capital on the Sanitation Ranking<sup>11</sup> of the 100 Brazilian cities facing better sanitation issues, in the years 2019 and 2020. Overall, the rate of confirmed cases (per 100,000 inhabitants) is higher in the set of municipalities by other operators (not interstate) in the states of Ceará and Amazonas, in relation to the municipalities of state operators in these states. In the other two states the rates are higher in those operated by the state. The death rate (per 100,000 inhabitants) is higher in the group of municipalities operated by the state. The capitals that are in the worst classifications in the Sanitation Ranking also have higher rates of confirmed cases in the group of municipalities.

Table 1: Rate of cases (confirmed and deaths) per 100,000 inhabitants from 02/25-05/22/2020, by set of municipalities by state and other operators. Position of the capital in the Sanitation Ranking.

States	Confirmed		Deaths		POSITION OF THE CAPITAL IN THE RANKING SANITATION (year)	
	TX cases (per 100k inhabitants) State Operating Municipalities	TX cases (per 100k inhabitants) Other Operators	TX cases (per 100k inhabitants) State Operating Municipalities	TX cases (per 100k inhabitants) Other Operators	2020	2019
SP	218	63	17	3	19	16
PR	27	8	1	0	17	12
CE	367	379	25	15	73	76
AM	599	669	29	42	96	98

Source: Project and Treats Brazil data

The lethality for each state analyzed is presented in table 2, at the same time that the percentage of the population served by the state companies of each state and the position of the capital of each state in the Sanitation Ranking in 2020 are presented, for an overview.

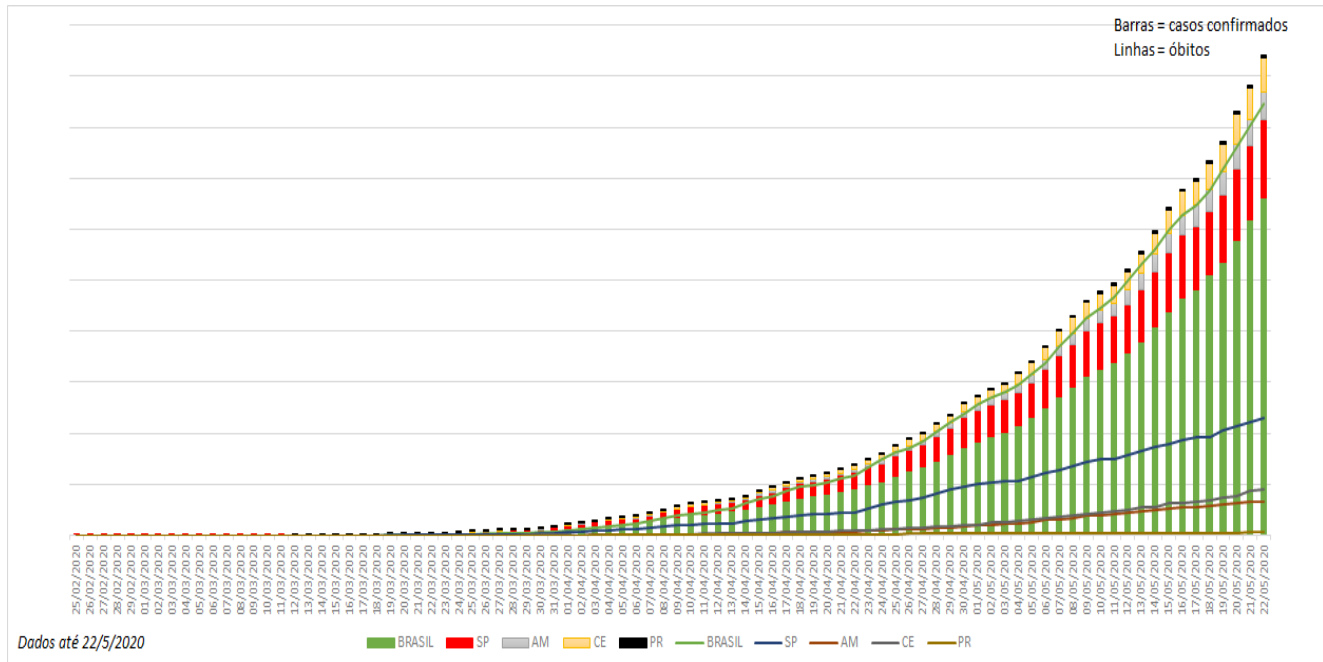
Table 2: position of the capital in the ranking with 5 of the population served by state operators and lethality rate by COVID-19

State	Position of the state capital in the sanitation ranking 2020	% population served by state-owned company	Tx lethality by COVID-19 in the state
SP	19	67%	7.5 %
PR	17	94%	5.0 %
CE	73	98%	6.7 %
AM	96	3%	6.2%

Source: SNIS data, TRATA BRAZIL, MS

The confirmed cases and deaths by Covid 19 in the 4 states analyzed and in Brazil are at Graph 9.

Graph 9: Confirmed cases and deaths in the states of SP, PR, CE, AM and total of Brazil.



Source: MS - SES

### 5. Discussion

Our study presented, in analyzed states, a variation of the population served with access to water of 96% in SP, 94% in Paraná, 89% in Amazonas and 59% in Ceará. According to the recommendations of World Health Organization (WHO) to combat the spread of the SARS-CoV-2 virus, also adopted by the Ministry of Health, hand hygiene through soap and water is fundamental<sup>19</sup>. Therefore, it is expected that regions with irregular access to treated water are more vulnerable to transmission of the virus, most often areas in the peripheries of large centers or isolated within the states, have lower social investments. Studies pointing to the permanence of the SARS-CoV-2 virus in feces of asymptomatic or cured individuals and even in wastewater indicate that fecal-oral transmission may be possible and regions without access to sewage collection and treated water would be more vulnerable to this type of transmission. Waste contaminated objects are recognized as key vehicles for the spread of other infectious human viruses (e.g., norovirus) during outbreaks<sup>20</sup>. According to SNIS<sup>12</sup>, more than half of Brazilian municipalities (55%) have poor water supply system. 16% of those reported problems related to the quantity and quality of water in the springs. In the North region, the highest availability of drinking water for consumption is concentrated, while in the Southeast are the highest demands of the country<sup>11</sup>. As reported in the study by Bombardi<sup>21</sup>, it was possible to establish a

relationship between the number of cases and deaths due to COVID-19 and the sanitation of Brazilian municipalities. Several groups, notably in Australia, the Netherlands, Sweden, and the USA, have already reported the detection of traces of SARS-CoV-2 in wastewater<sup>22,23</sup>.

The present study identified that in the state of São Paulo, operated by SABESP in most municipalities, the cases are concentrated in the capital and metropolitan region until May 22<sup>nd</sup>, already with an expansion to municipalities in the interior. The state and its capital are expected to maintain high rates of transmission of the virus by high population density. The capital of the state of São Paulo occupied in the Ranking of Sanitation of Trata Brasil<sup>10</sup> in 2019 the position 19 and in 2020 the position 16.

In the state of Amazonas, the state company COSAMA serves only 12 cities and provides water supply and sewage collection below the national average. 97% of deaths and 94% of cases were concentrated in municipalities that have a privatized or municipal water supply system. The focus is Manaus, a city where sanitation services are privatized. The company *Águas de Manaus* provides treated water to 88% of the population but performs sewage collection of only 12%. Analyses indicate metropolitan regions in Brazil with higher population and higher population density do not have as large proportion of cases and deaths as Manaus<sup>21</sup>. Contrary to those who advocate the privatization of sanitation, it is observed that among the 100 largest municipality in Brazil, Manaus occupies the position 96 in 2020 and position 98 in the year 2019<sup>10</sup>.

Data from the state of Ceará also present many notifications of COVID-19 even with lower population density compared to the main metropolises of Brazil. It can also be related to Manaus, the low coverage of water supply by the company. Although CAGECE covers sanitation in most of the state, services are below the national average. According to company data<sup>24</sup>, the low volume of water in the springs is a factor that directly interferes with the supply of the population. Case rates per 100,000 inhabitants in municipalities operated by other non-state models are 3.5% higher. The capital of Ceará, Fortaleza, occupies position 73 in 2020 in the Sanitation Ranking<sup>10</sup> and, in 2019, position 76.

The state of Paraná reported mostly cases and deaths in municipalities that serve SANEPAR and the company serves 96% of Paraná population. However, it has a lower number of patients and deaths from the disease compared to the other states studied. Paraná is more populous than Ceará and Amazonas, with higher population density and still has less impact by COVID-19. Sanepar's management model and its coverage in almost the entire state, with quality indicators above the national average, can contribute to this panorama. Curitiba, state capital, occupies the position 17 in 2020 among the 100 largest cities, being the 12th position in the year 2019, in the ranking of Trata Brasil<sup>10</sup>.

We observed that there is a difference between cases of COVID-19 in cities that are operated by state-owned enterprises and those that are not. São Paulo presented 217 cases per 100,000 inhabitants in municipalities operated by the state company and 63 cases in the municipalities of other operators. Paraná showed 17 cases/100,000 in the set of municipalities operated by the state and 3 in the non-operated ones. Ceará presented 367/100,000 in the set of municipalities

operated by the state and 380 in those not operated. Amazonas showed 88 cases in the set of municipalities operated by the state and 723 cases per 100,000 inhabitants in those not operated. The states that present capitals in better positions of the Sanitation Ranking have better rates per 100,000 cases and deaths due to COVID 19.

Since water is essential in the prevention of COVID-19, studies<sup>25</sup> point out that the involvement of public policymakers is urgently necessary to ensure efficient and equitable allocation of water both in response to COVID-19 and in the future, to sustainably manage water use and ensure access to those who need it most. Regular hand washing is highly recommended to fight the disease and requires access to sufficient and safe water, in addition to what is necessary for cooking, moisturizing and general sanitation. Universal and equitable access to water, sanitation and hygiene is a critical health issue. However, more than 50% of the global population does not have access to adequate sanitation and 75% of low-income families and middle-income countries cannot wash with soap and water<sup>25</sup>.

In the states analyzed in 3 of them, most of the population is assisted by state sanitation companies, indicating that it is important that these companies/sectors also adopt measures to promote factors related to COVID-19.

The approach considering characteristics of sanitation services is important in the global context. The Center for Studies in Democracy and Sustainability of the Transnational Institute (TNI)<sup>26</sup>, based in the Netherlands, mapped privatized services that were returned to public control around the world between the years 2000 and 2017. Most of them are essential services such as water distribution, energy, public transportation and garbage collection. According to the institute, the renationalization process occurred because private companies prioritized profit and services were expensive and bad. In this study, almost 300 sanitation services were returned to public control.

Studies indicate that the ability to detect SARS-CoV-2 in wastewater offers an ideal opportunity for information as a source<sup>27</sup>. Some biases of the present study should be highlighted. The underreporting of cases due to the unavailability of diagnostic tests interferes in the attempt to bring our statistics closer to reality<sup>28</sup>. Also, because it is an ecological study, it is subject to ecological bias.

## **6. Conclusion**

Due to the rapid demographic evolution of the disease due to its high transmissibility and lethality, the data continue to transition. Further studies should be based on epidemiological reports that are published by the state health departments to verify a real relationship between sanitation and COVID-19 series and expand the knowledge of the data highlighted in this research. A special look should be made for the most deprived areas in water supply and sewage collection, to evaluate characteristics of the performance of the operators to which the services are granted. The analysis of COVID-19 data regarding characteristics of sanitation services is an important parameter and can contribute to the search for more appropriate preventive measures, in by sanitation service operators.

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