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ORIGINAL ARTICLE

Trends in COVID-19 mortality and case-fatality rate in the State of Paraná, South Brazil: spatiotemporal analysis over one year of the Pandemic

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Abstract

Introduction: By late 2019, China notified a new disease rising, and with the agent's identification, it was called COVID-19. Despite the efforts of the World Health Organization (WHO) and worldwide countries, the disease spread out of control; on March 11, WHO declared the pandemic state. Brazil is the biggest country in South America, demarcated into 26 states with different economic, cultural, and social aspects. Paraná is one of the Brazilian federative units, it is the sixth more economically important and ranks second in Education. Its first COVID-19 case was confirmed on March 12, 2020, and the first death was on March 27, two weeks after the first death in Brazil.

Objective: This study objective is to determine the mortality and case-fatality rates of COVID-19 in the State of Paraná, Brazil, from March 1, 2020, to March 31, 2021.

Methods: It is an ecological time-series study, using all cases (854,326) and deaths (17,229 deaths) of COVID-19 reported in public and official database of the State of Paraná Health Department. Case fatality and mortality rates were stratified by sex and age. For trend analysis, the period was divided into a first "wave" (March to November 2020) and a second "wave" (December 2020 to March 2021). The Prais-Winsten regression model for population mortality and case-fatality rates allowed classifying whether it increased, decreased, or was flat.

Results: Women were more affected by the number of cases, with 454,056 cases (53.15%) confirmed and 7,257 fatalities (42.12%). A total of 400,270 men (46.85%) were infected and 9,972(57.87%) died. For the first year of COVID-19, in the State of Paraná, the incidence was calculated as 7404.12/100,000 inhabitants, the mortality was 149.32/100,000 inhabitants, and the case-fatality rate was 2.02%. We saw a tendency for decreasing the case-fatality rate (DPC = -0,18; p<0,001). The mortality and incidence showed an increasing trend (DPC=1,13, p<0,001; DPC=1,58, p<0,001, respectively).

Conclusion: The level and variability of transmission during this first year of pandemic suggest that the disease in the State of Paraná was never under control.

Keywords: COVID-19, mortality, case-fatality, SARS-CoV-2, Epidemiology.

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Authors summary

Why was this study done?
This study was carried out in response to the critical state of the country's health system in the fight against the COVID-19 pandemic. The lack of epidemiological data to strategically deal with the situation, especially in the state of Paraná, increases the risk of uncontrolled pandemics and consequently, increases the number of deaths.

What did the researchers do and find?
This study aims to determine the mortality and case-fatality rates of COVID-19 in the State of Paraná, Brazil, from March 1, 2020, to March 31, 2021. It is an ecological time-series study, using all the cases and deaths of COVID-19 reported in public and official database of the State of Paraná Health Department, Brazil. The effective reproduction number (Rt), the incidence, mortality, and lethality were estimated, then the trend analysis according to the wave period was classified as increased, decreased, or flat/stationary. We found that from May to August, the Rt was always above 1,0, after that period from August to mid-October, a number below 1,0.

What do these findings mean?
This study was essential to elucidate the status of the high mortality rate and confirm the lack of pandemic control in addition to the emerging need of the population of the state of Paraná to adhere to non-pharmacological measures as well as the advance of vaccination to control the COVID-19 pandemic.

INTRODUCTION

At the end of 2019, Chinese public health authorities reported a new viral respiratory disease surge to the world. On January 10, 2020, the country identified the etiological agent causing the severe acute respiratory syndrome (SARS), the coronavirus named SARS-CoV-2. Lately, the World Health Organization (WHO) announced the new coronavirus disease 2019 (COVID-19) and declared the pandemic state on March 11, 2020, despite the global efforts to contain the spread of the disease[1].

In Brazil, the first COVID-19 case was confirmed on February 26, 2020. A 61 years old man who had traveled to Italy and returned to his home in São Paulo. The first death was a 57 years old woman from São Paulo, which occurred on March 11, 2020. Since then, COVID-19 has uncontrollably disseminated through all sociodemographic regions of the country, leading to an unprecedented socioeconomic crisis and health system collapse. By July 13, 2021, Brazil had 19.151.993 accumulated cases and 535.838 deaths, with an incidence of 9113.6 new cases by 100,000 inhabitants, mortality of 255.0 deaths by 100,000 inhabitants, and lethality of 2.8%[2] being ranked as the second nation in the global death toll due to COVID-19[3].

Brazil is the largest country in South America, with an estimated population of 210,147,125 inhabitants and an extensive territory (8,510,345,538 km²) divided into 26 states and 1 Federal District. According to economic, cultural, and social aspects, the national territory is demarcated into five geographic regions (North, Northeast, Central-West, Southeast, and South), indicating a situation of disparities and inequalities permanently confronted by consecutive governments[4].

In 1988 Brazil approved a new Constitution, which included a basic definition for health as a universal right and a governmental responsibility. The new Constitution also implemented universal and decentralized health coverage by creating the Unified Health System (Sistema Único de Saúde or SUS), responsible for providing public health care services since 1990[5]. During the past three decades, despite all issues and challenges to cover over 200 million people living in a vast territory and socially unequal country, the SUS is well-known to have a robust primary care provision through the Family Health Strategy (Estratégia de Saúde da Família or ESF) program. Remarkably, the SUS vaccination program is a worldwide example of success[6]. The COVID-19 pandemic overwhelmed this system, increasing the demand for Intensive Care Unit (ICU) beds and advanced health care services, which evidenced the frailty of the Brazilian preparedness plan in response to public health emergencies[7].

Suppose this sociodemographic condition, by itself, could be a tremendous challenge for the country to fight against a pandemic. In that case, a political situation leaves the country without the federal government's central organization to struggle with the problem. As an example, Brazil changed the Minister of Health four times during the first year of the pandemic.

So, the States had to deal with the pandemic independently, managing their treatment protocols, diagnostic tests, the negotiation of mechanical ventilators, supplies such as personal protective equipment, the training of health workers, and hospital resources like ICU beds. Everything had to be done respecting each state's context. It potentially led to different outcomes and, using the words of WHO's General Director, Mr. Teodros Adhanom Ghebreyesus, "Equity is critical. It applies to information, innovation, essential medical equipment, and supplies, as well as medicines, vaccines, and diagnostic"[8].

Paraná is one of the Brazilian federative units located in the South Region. Together with the Southeast, they are the two more prosperous and developed regions of the country. Paraná is the sixth most crucial Brazilian state in terms of Economy and ranks second in Education. The State shares borders with Paraguay, and the port of Paranaguá, on the coast, is an essential route for international business. The airport of Curitiba, the capital State, is a critical gateway to other countries[9]. The first COVID-19 case of Paraná was confirmed on March 12, 2020, and the first death on March 27, almost two weeks after the first death in Brazil. As a similarity, all patients aforementioned were linked to recent international travel[10].

To understand the COVID-19 risks and severity to better determine health programs and interventions, it is critical to know indicators like the incidence, mortality, and case-fatality rates. It can also be used to compare the outcomes of different Brazilian States, how they have managed COVID-19, and give insights regarding

the expected inequalities that could arise during the fight against the disease.

Under these circumstances, this study objective is to determine the mortality and case-fatality rates of COVID-19 in the State of Paraná, Brazil, from March 1, 2020, to March 31, 2021.

METHODS

Study Design

It is an ecological time-series study, using all the cases and deaths of COVID-19 reported in public and official database of the State of Paraná Health Department, Brazil, available on the website https://www.saude.pr.gov.br/Pagina/Coronavirus-COVID-19. This study is part of a population-based umbrella project, where each state of Brazil was analyzed separately, following a standard protocol for ecological time-series studies as described by Abreu, Elmusharaf and Siqueira[11].

Study Location and Period

The database was updated on June 1, 2021, considering information about cases and deaths of COVID-19 in residents of the state of Paraná, southern Brazil, from March 2020 to March 2021.

Study Population and Eligibility Criteria

Were included in the study all the cases and deaths by COVID-19 that occurred in Paraná and were reported by the municipalities (854,326 cases and 17,229 deaths) from March 2020 to March 2021.

All notifications of cases and deaths referred to COVID-19 were considered, using the International Classification of Diseases, 10th edition (ICD-10) of "U07.1 COVID-19, "identified virus" or "U07.2 COVID-19, virus not identified"[12], associated with the diagnosis of the disease, according to with clinical, laboratory or epidemiological confirmation of disease. Cases and deaths were classified according to the date of diagnosis and death, respectively.

Data Collection

Two researchers independently extracted the data to minimize collection bias and guarantee the quality and reliability of the data obtained. The collected data were organized into spreadsheet software Microsoft® Excel 2016.

Population data were obtained using the Projection of the Federation Units Population by gender and age groups for the year 2020[13].

Data from cases and deaths of COVID-19 were collected and stratified by sex (male and female) and age groups (0-19 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years, 60-69 years, 70-79 years, 80 or more years). The variables analyzed were sex (male and female), age groups, date of data de diagnosis, date of death, municipality of residence of the patient, and the number of daily and monthly cases and deaths.

Data Analysis

The effective reproduction number (Rt) was estimated using R studio software EpiEstim package[14], version 2.2.4, a previously time-varying reproduction number for epidemics model, developed by Thompson and colleagues[15]. Our model used a mean serial interval of 2.97 days with an average standard deviation of 3.29 days, as described in previous studies[16,17].

The incidence (1) and mortality rates (2) by 100,000 inhabitants and the case-fatality (3) (%) were calculated according to the equations:

$$(1)\ \text{Incidence} = \frac{\text{(number of cases)}}{\text{population}} \times 100.000$$

$$(2)\ \text{Mortality} = \frac{\text{(number of deaths)}}{\text{population}} \times 100.000$$

$$(3)\ \text{Case-fatality} = \frac{\text{(number of deaths)}}{\text{(number of cases)}} \times 100$$

Mortality rates were also calculated and stratified by sex and age for the same period. According to the population projection of Federation Units for the year 2020, the State of Paraná had 11,538,518 inhabitants[13].

For trend analysis, the period was divided into the first wave (1st Wave - March to October 2020) and second wave (2nd Wave – November 2020 to June 2021) to define the end of the first wave, the month with the lowest mortality rate was considered, which suggested the end of a first wave in the curve.

The trends were analyzed according to the methodological guidelines by Antunes and Cardoso18, the Prais-Winsten regression model for population mortality rates was used to build time series, series as well as to determine the incidence, case fatality, and mortality trends. Were estimated the probability (p), and Daily Percent Change (DPC), considering a 95% level significance, according to equations (1), (2), and (3):

$$(1)\ DPC = (10^{\beta} - 1) \times 100\%$$

$$(2)\ (IC95\%)_{ul} = (10^{\beta\_max} - 1) \times 100\%$$

$$(3)\ (IC95\%)_{u} = (10^{\beta\_min} - 1) \times 100\%)$$

In these equations, we considered β as the angular coefficient from the linear regression, the indexes ul as the upper limit, and ll as the lower limit of the confidence level.

The case-fatality, mortality, and incidence trends were classified as increased, decreased, or flat. Flat trends were considered when the p-value was not significant ($p<0.05$).

Statistical analyses were performed using the STATA 14.0 software (College Station, TX, U.S. 2013).

Ethical and Legal Aspects of the Research

It is a secondary data analysis with no identification of the individuals in the database, and therefore no ethics committee approval was necessary.

RESULTS

The population of residents in the State of Paraná was taken from the projection of Federation Units for 2020[13], distributed by age and gender (table 1). Table 2

shows essential sociodemographic characteristics of the State of Paraná. The total population estimated for the State of Paraná in 2020 was 11,538,518 inhabitants.

Table 1: Estimated population of residents in the state of Paraná, distributed according to age and sex

Age (years old)	Number of inhabitants of State of Paraná, Brazil		Total
	Male	Female	
0 – 19	1,596,030	1,529,193	3,125,223
20 – 29	918,879	898,334	1,817,213
30 – 39	909,586	908,372	1,817,958
40 – 49	792,390	819,364	1,611,754
50 – 59	681,802	738,840	1,420,642
60 – 69	460,619	525,347	985,966
70 – 79	232,176	287,673	519,849
80 or more	97,423	142,490	239,913
Total	5,688,905	5,849,613	11,538,518

Source: Projection of the Federation Units Population by gender and age groups: 2000-2030 - DATASUS, 2021.

Table 2: Sociodemographic characteristics of the state of Paraná, Brazil

Characteristic	Description
Region*	South
Number of municipalities*	399 municipalities
State's capital*	Curitiba
Territorial extension* (2020)	199,298.982 km²
Demographic density* according to the last census, 2010*	52.40 inhabitants/km²
Monthly household income per capita*	1,508 Reais
Human Development Index (HDI), last census, 2010*	0.749
Average number of people per household***(2019)	2.8 people
Number of basic health units****	1,966 units
Total Hospital Beds*****(June 2021)	hospital beds
Number of clinical Beds (SUS) - Adults	6654 clinical beds
Number of clinical Beds (SUS) - Pediatrics	1654 clinical beds
Number of beds in the Intensive Care Unit (SUS)- Adults	938 ICU beds
Number of beds in the Intensive Care Unit (SUS)- Pediatrics	175 ICU beds
Number of clinical COVID beds – Adults	2,842 clinical beds
Number of clinical COVID beds – Pediatric	34 clinical beds
Number of COVID ICU beds – Adults	1980 ICU beds
Number of COVID ICU beds – Pediatric	34 ICU beds

Source: *Brazilian Institute of Geography and Statistics (IBGE, 2021); **DATASUS - Projection of the Federation Units Population by sex and age groups: 2000-2030; ***Sistema IBGE de Recuperação Automática – SIDRA; ****Cadastro Nacional de Estabelecimentos de Saúde (CNESNet); *****State of Paraná Health Department.

According to the official database of the State of Paraná Health Department, from March 1, 2020, to March 31, 2021, there were 854,326 confirmed cases of COVID-19, and 17,229 people died from the disease. The distribution of cases and deaths by municipalities is illustrated in Figure 1.

For the first year of COVID-19 in the State of Paraná, the incidence was calculated as 7404,12/100,000 inhabitants, the mortality was 149,32/100,000 inhabitants, and the case-fatality rate was 2,02%.

Women were more affected by the number of cases, with 454,056 cases (53,15%) confirmed and 7,257 fatalities (42,12%). A total of 400,270 men (46,85%) were infected and 9,972 (57,87%) died. The highest number of confirmed cases was seen in 30-39 years women (99,952), and the deaths were higher in 70-79 years older men (2665) (Table 3).

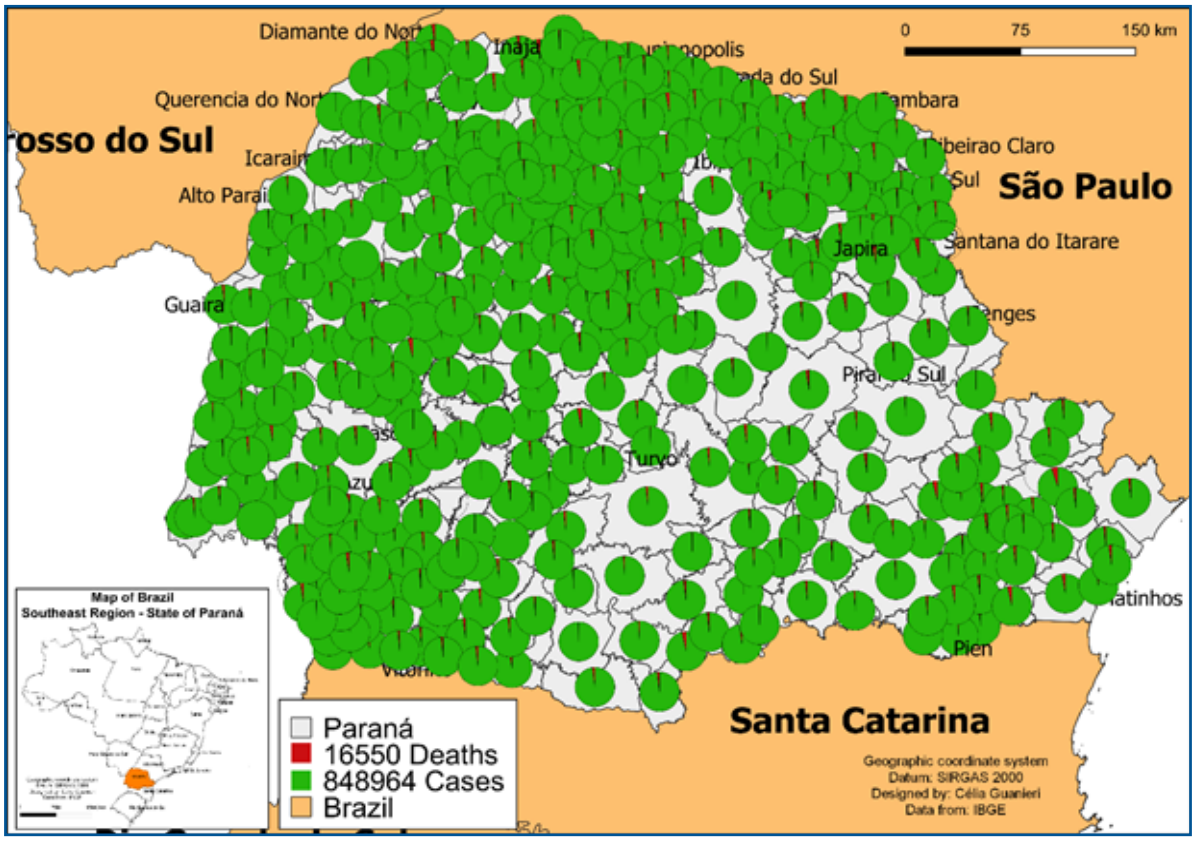


Figure 1: Distribution of COVID-19 cases and deaths among municipalities of the State of Paraná from March 2020 to March 21.
Source: Cases, deaths, and population were obtained from the Secretary of Health of Paraná State, Brazil. (N = 848,964 cases and 16,550 deaths were residents in the state of Paraná, 5,362 cases and 679 deaths notified by the state of Paraná, but residing in another state or information ignored, were excluded).

Table 3: Number of cases and deaths, distributed by age and gender, in Paraná State, from March 2020 to March 2021. Source: State of Paraná Health Department.

Age group (years old)	Cases			Deaths		
	Male	Female	Total	Male	Female	Total
0-19	42321	45941	88262	18	28	46
20-29	83409	94478	177887	103	69	172
30-39	89176	99952	189128	344	208	552
40-49	72865	84965	157830	766	444	1210
50-59	56576	65596	122172	1490	955	2445
60-69	33145	37286	70431	2536	1722	4258
70-79	16148	17383	33531	2665	1937	4602
80-more	6630	8455	15085	2050	1894	3944
Total	400270	454056	854326	9972	7257	17229

The more economically active population, ranging from 20 to 59 years of age, was more infected than the older population (60 or more years) and the youngers (0-19 years), with an incidence of 5,607, 1,031, and 764 per 100,000 inhabitants, respectively. By the other side, mortality and case-fatality rate were higher in people older than 60, compared to the ranges of 20-59 and 0-19 years old (mortality = 110.97; 37.95; 0.40/100,000 inhabitants, and case-fatality = 10.76%; 0.67%; 0.05%, respectively). Figure 2 shows the proportions of cases (A), the proportion of deaths (B), the case-fatality (%) (C), and the mortality rate (per 100,000 inhabitants) of COVID-19 distributed by gender and age in the state of Paraná from March 2020 to March 2021.

According to new cases distributed by day, the effective reproductive number Rt was estimated from March 2020 to March 2021. In the beginning, there was a higher variability, with April having numbers as high as almost 1.7 and low below 0.8. After this, with a few days of variations, from May to August, the Rt was always above 1.0. Only from August to mid-October, a number below 1.0, with a decreasing trend in transmissibility rates, could be seen. After these two and a half months of hope, the levels arose again, with peaks of 1.27 at the beginning of

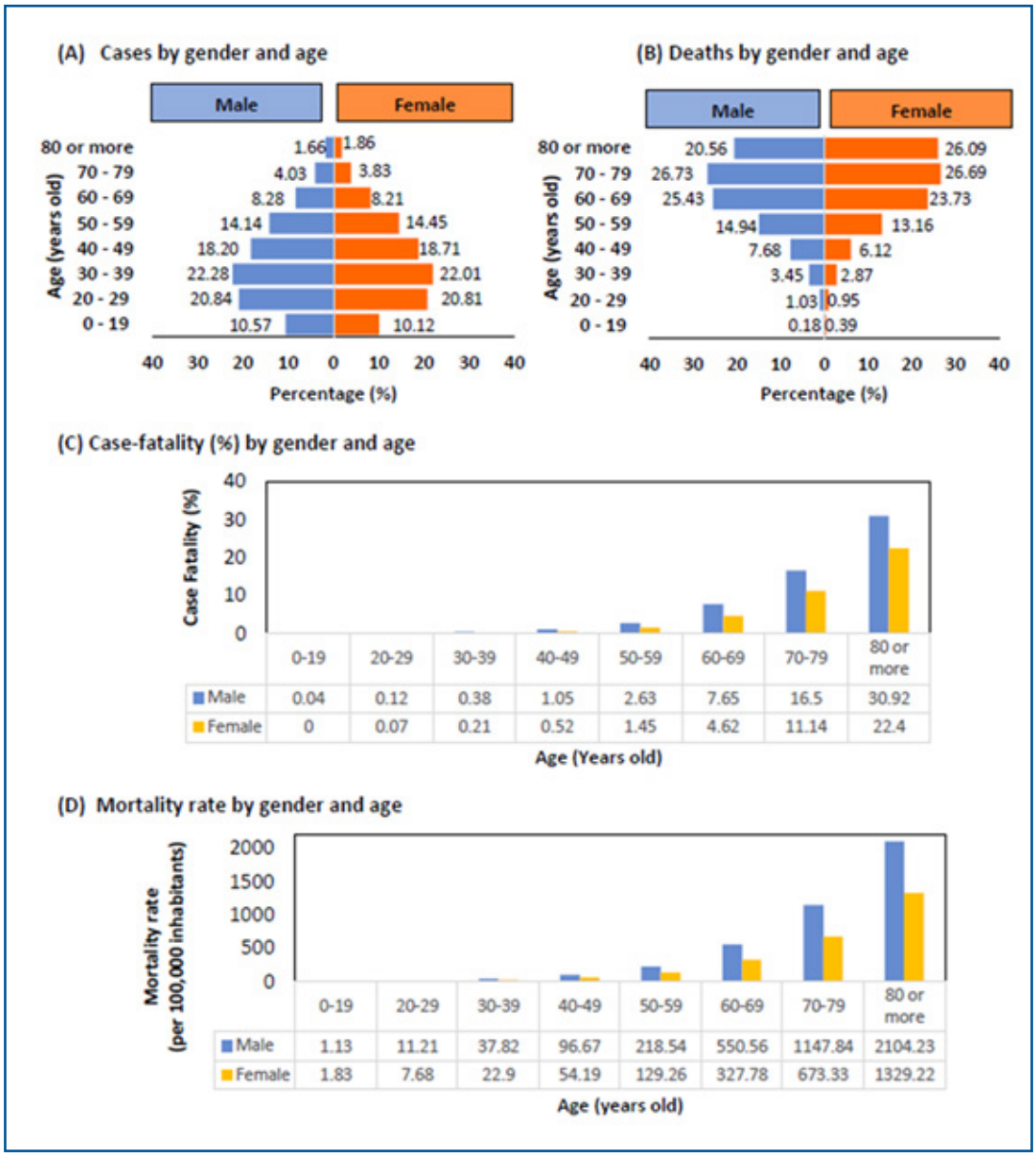


Figure 2: Proportion of cases (A), the proportion of deaths (B), case-fatality (%) (C), and mortality rate (per 100,000 inhabitants) of COVID-19 distributed by gender and age in the state of Paraná from March 2020 to March 2021.

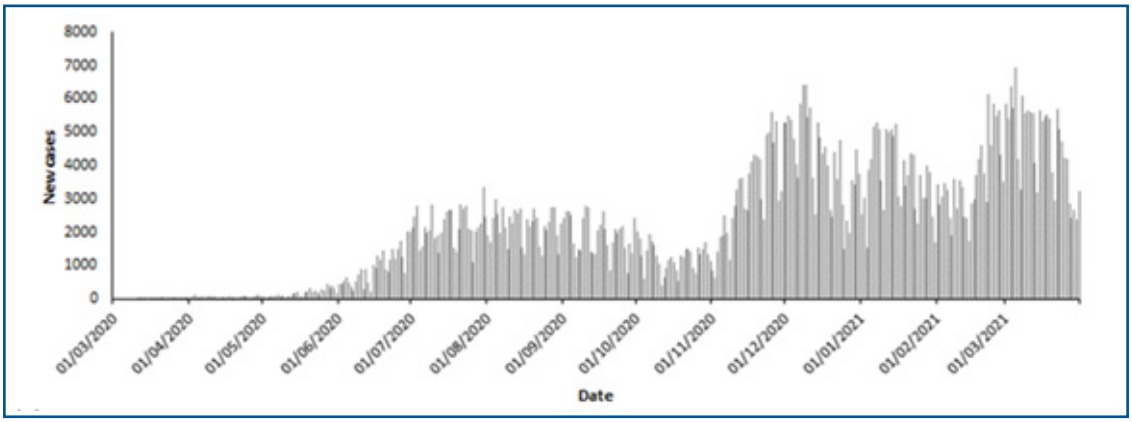
Source: Cases and deaths data were obtained from the Health Department of the State of Paraná, Brazil.

November, 1.16 just after Christmas and New Year's Eve in January, and then 1.22 in the last days of February. Thus, the level and variability of transmission during this first year of pandemic suggest that the disease in the State of Paraná was never under control.

Figure 3 shows the distribution of new cases and the Rt during this period.

To define the periods for trend analysis or "waves," the end of each period must be the one with the lowest level of mortality happening after a peak and then constant

(A)



(B)

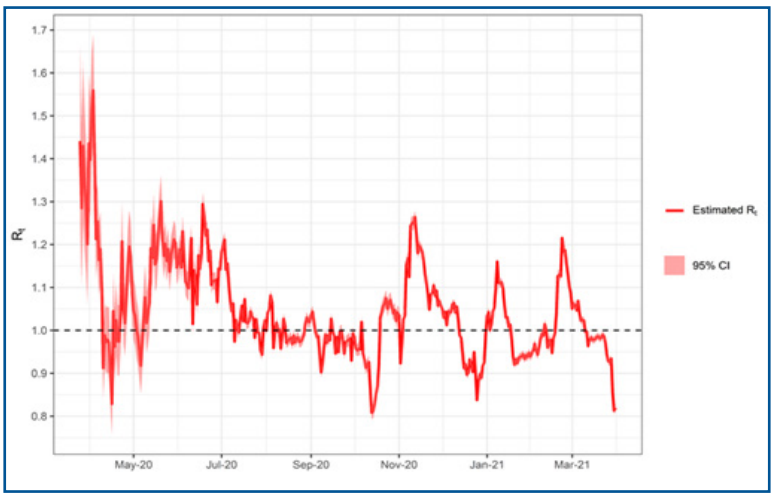


Figure 3: Incidence (per day) (A) and the estimated reproductive number (Rt) (B) of COVID -19 in the state of Paraná in the period from March 2020 to March 2021.
CI = Confidence Interval. Rt estimated during 2020, March 18 to 2021, March 31 period to the state of Paraná.
Source: Cases data were obtained from the Secretary of Health - State of Paraná, Brazil

dropping in numbers for more than two months. Looking at data, the bottom tier after the first peak descendent was October 2020, with mortality of 7.01/100,000 inhabitants. It gave us a division in the entire period of March 2020 to March 2021 in two waves. The first one was from March 2020 to October 2020, and the second wave was from November 2020 to March 2021 (Figure 4b). We could see mortality as high as 13.63/100,000 inhabitants in August 2020, the peak of the first wave, and much higher mortality, 40.50/100,000 inhabitants, in March 2021.

The case-fatality rate was high in April (4.96%), when there still was a lot of uncertainty about the best way to treat the disease and had the bottom level in November 2020 (1.05%). After this, in March, probably related to the appearance of new variants, the rate rose again to 3.22%.

Figure 4 shows the percentual case-fatality (A), the mortality rate (B), and the incidence rate (C) per 100,000 inhabitants of COVID-19 in the State of Paraná, according to the 1st (March to October 2020) and 2nd (November 2020 to March 2021) waves.

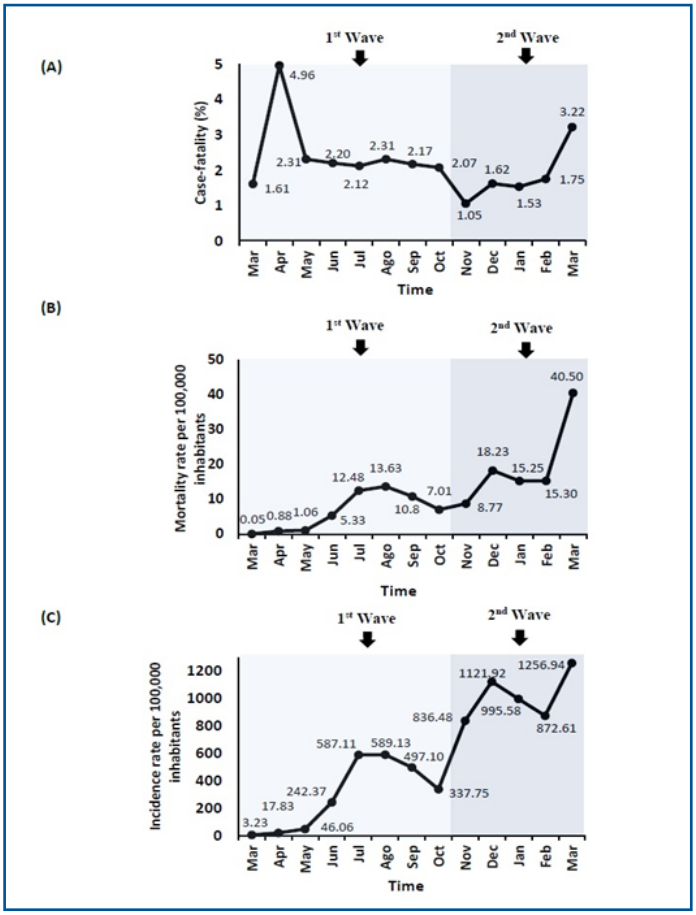


Figure 4: Case-fatality (%) (A), mortality (per 100,000 inhabitants) (B) and incidence (per 100,000 inhabitants) (C) rates of COVID-19 in the State of Paraná, during the 1st (March to October 2020) and the 2nd (November 2020 to March 2021) waves.

The Prais-Winsten regression model for population mortality and case-fatality rates were used to build time series, assessing whether it increased, decreased, or was flat. From March 2020 to March 2021 we saw a tendency for decreasing the case-fatality rate with a daily reduction rate of 0.18% (DPC = -0.18%; p<0.05), maybe because of the better knowledge about the disease and how to treat it. However, the mortality and incidence showed an increasing trend (p<0.001) (Table 4).

The first wave had a tendency of a decreasing case-fatality (DPC= -0.34; p<0.001), and an increasing mortality (DPC= 1.69; p<0.001) and incidence (DPC=2.57; p<0.001). The second wave, maybe influenced by the explosion of cases and deaths caused by the new variant P1, had an increasing trend of fatalities (DPC= 0.73; p<0.001) and mortality (DPC=1.02; p<0.001) (Table 4).

Table 4: Prais-Winsten regression estimative and Daily Percent Change (DPC) of case-fatality (%), mortality (per 100,000 inhabitants), and incidence (per 100,000 inhabitants) rates due to COVID-19 in the State of Paraná, during the 1st (March to October 2020) and the 2nd (November 2020 to March 2021) waves.

Period	**DPC (CI 95%) Fatality**	**p**	**Fatality Trends**
total	-0.18 (-0.27 : -0.08)	<0.001*	Decreasing
1° wave	-0.34 (-0.51 : -0.18)	<0.001*	Decreasing
2°wave	0.73 (0.49 : 0.97)	<0.001*	Increasing
Period	**DPC (CI 95%) Mortality**	**p**	**Mortality Trend**
total	1.13 (0.88 : 1.37)	<0.001	Increasing
1° wave	1.69 (1.20 : 2.19)	<0.001	Increasing
2° wave	1.02 (0.70 : 1.34)	<0.001	Increasing
Period	**DPC (IC 95%) Incidence**	**p**	**Incidence Trends**
total	1.58 (1.13 : 2.03)	<0.001*	Increasing
1°wave	2.57 (1.80 : 3.35)	<0.001*	Increasing
2°wave	0.30 (-0.02 : 0.61)	0.063	Flat

Source: cases and deaths were obtained from the Health Department of the State of Paraná, Brazil.
DPC-Daily Percent Change (%); CI 95%-Confidence Interval 95%; p-value – probability of statistical significance - *p<0,05 – Prais-Winsten regression test; Total – Period from march 2020 to march 2021; 1°W – First Wave: Period from March to October 2020; 2°W – Second Wave: Period from November 2020 to March 2021.

DISCUSSION

The first year of the COVID-19 pandemic in the State of Paraná, Brazil, had an incidence of 7404.12 new cases by 100,000 inhabitants, the mortality was 149.32 deaths by 100,000 inhabitants, and the case-fatality rate was 2.02%.

In our results, women are more affected by the disease than men, although men died more than women. The range of 30 to 39 years old had more confirmed cases, both in men and women. However, the number of deaths was higher in 70 to 79 years old, both in men and women. In a wide range of ages, the more economically active population, between 20 to 59 years, had the higher incidence of the disease. The more elderly, with 60 or more, had a higher case-fatality rate. These results could be explained by the more economically active population having to work to earn their money for the family. Even with the risk of being infected, they are more prominent not to follow public health advisory of social distancing or lockdowns. It is especially true in low-income countries. Regarding age, since the beginning of the pandemic and mainly when Italy was brutally hit by it, older adults (60> or older) were identified as a significant risk factor for COVID-19 severity, which may be related to their higher frequency of comorbidities compared to the general population.

COVID-19 transmissibility in Paraná, during the first year of the pandemic, looks out of control most of the time. The estimated Rt was higher than 1.0, with peaks in April, the second month of the pandemic in Brazil, and the months of November, early days of January, and the end of February, possibly related to the Christmas and New Year's Eve and the appearance, in the city of Manaus, of the P1 variant, more contagious and aggressive[19]. Except for some slight days variation, from mid-August to mid-October was the only period when the estimated Rt was below 1.0. It could be explained by the results of the measures taken by states and municipalities to control the transmission (social distancing measures, obligatory use of masks, borders control, closure of schools, bars, restaurants, and stores). Maybe, after this short period, without political support, the population, tired of being at home and needed to restart working, did not see more periods of the low transmission rate.

Following the periods defined for trend analysis or waves, the first wave (March to October 2020) showed a peak of incidence and mortality in August (589.13 and 13.63/100,000 inhabitants, respectively), and the end of the curve at the lowest level showed an incidence of 337.75/100,000 inhabitants and mortality of 7.01/100,000 inhabitants. Because of the reasons mentioned above, the case-fatality rate had a peak in April (4.96%) and the lowest level in November (1.05%). The second wave (October 2020 to March 2021) has not ended by the data collection date. We established our study's scope as the first year of the pandemic, so further studies are needed to know the curve's

behavior. The incidence, mortality, and case-fatality were rising at the end of March (1256.94/100,000 inhabitants, 40.56/100,000 inhabitants, and 3.22%, respectively).

This was a critical period, the pandemic caused by the COVID-19 has battered the healthcare infrastructure all around the globe, reverberating in the health care workers' tiredness as a reason, and expect that mass vaccination reduces these numbers[20]. The vaccination program started in Brazil on January 2021[21].

The Prais-Winsten regression estimates showed a statistically significant tendency ($p<0.001$) of an overall increasing incidence and mortality, indicating that the pandemic was still out of control. The decreasing trend in the fatality-case rate during the first wave and during the entire period could be explained by better knowledge and treatment protocols, and the increasing tendency during the second wave could be influenced by the appearance of new variants, problems with supplies like oxygen and the tiredness of health workers. These factors must be better studied. The lack of diagnostics and underreporting can influence the results of the incidence in the second wave.

Looking at the results around the world, Brazil is still not going well[7]. Besides the fact that it is difficult to compare the effects of countries and regions with different sociodemographic characteristics, health systems capacities, and amount of diagnostic tests done, by July 27, 2021, the country was the second in the number of deaths (550,586) and the third in cumulative cases (19,707,662), only behind the USA (611,010) and the USA and India (34,536,402 and 31,440,951), respectively[22]. During the first year, the incidence of COVID-19 in Brazil was 5974,41/100,000 inhabitants, the mortality was 150.67/100,000 inhabitants, and the case-fatality rate was 2.52%.

The State of Paraná had a similar result. Nevertheless, compared to the other two states from South Region, Santa Catarina, and the Rio Grande do Sul, with very similar sociodemographic characteristics, Paraná had the worst indicators[23]. The study of Marinho *et al.,* [24], using another source of database (COVID-19 Data Hub project - https://covid19datahub.io/) and looking for the rates of mortality and lethality in Brazil until October 2020, showed a slight variation in lethality (2.89%) but drew the attention to the fact that these indicators had potentially bias because the low number of reliable diagnostic tests. They also ranked among the ten worst Brazilian states according to the severity of the disease, although Paraná was not.

There are a lot of factors that are important to be accessed in a respiratory tract viral pandemic. The agent, the host, the environment, the health workforce, Primary Health Care (PHC) programs and hospital structures and supplies, the political situation, and leadership. In their review article, Lippi, Sanchis-Gomar, and Henry[25] used the expression "the perfect storm" to define the Covid-19 pandemic. They pointed that SARS-CoV-2 structure and peculiar biology of infection, high risk of inter-human transmission, long incubation time combined with early and sustained viral load, the existence of asymptomatic or mildly-symptomatic carriers, viral shedding for days after symptom relief, unfavorable progression towards respiratory distress and death in up to 5–10% of patients thus causing dramatic healthcare challenges, as well as environmental contamination", were factors that contribute to the magnitude of the pandemic.

We found that more men died in Paraná, and the elderly are more at risk too. Analyzes of the mortality risk factors in Brazil, using the SIVEP-Gripe, Brazilian Ministry of Health database of 162,045 patients (March to August 2020), showed that elder age, male gender with comorbidities are at higher risk of death[26]. The same result was found in the first 500 patients hospitalized in a major tertiary hospital in São Paulo. Age (older than 60 years old, gender (male), pulmonary CT scan findings, and troponin are variables that influence the outcome of death[27].

Sociodemographic aspects and their relationship with the incidence and mortality of COVID-19 were analyzed in a prospective geospatial study between February and July 2020. The authors suggested that the incidence was influenced by houses where two or more people sleep in the same room and cities where the index of social vulnerability (SVI) and the municipality human development index (MHDI) were low. Mortality was also affected by low numbers in both indexes[28].

Paraná is the 6th most populated state in the country, and besides this higher demographic density (52.4 inhab./km^2), it is ranked five in the Human Development Index (HDI)[9]. Paraná also has a good health infrastructure. In January 2020, the number of ICU beds was 6559 in the South region, representing an average of 2.2/10,000 inhabitants. The area with the best index is the Southeast with 2.7/10,000 inhabitants, and the worst is the North with 0.9/10,000 inhabitants. The recommended number by the Brazilian Ministry of Health and WHO is 1 to 3/10,000 inhabitants[29]. On March 31, 2021, there was a higher occupation of 95% of ICU beds[10]. Whether there were cases of patients who died waiting for a bed or without assistance requires further investigations.

Our study did not evaluate the transmissibility of the virus, influenced by environmental factors such as the weather or season[30,31]. Paraná is part of the South region of Brazil, with subtropical weather and temperatures with a mean approximate of 19ºC. Curitiba is the coldest state capital of Brazil[32]. The estimated Rt found in our study, during the winter in Paraná, was the lowest of the entire period, and the mortality also was in a descending curve. According to another study made in Pará, a North region State, where the spread of the virus didn't give up even in a tropical climate and much higher temperatures[33].

The transmissibility and, consequently, the incidence are also influenced by social isolation or distancing measures[34]. Chen and colleagues[35] examined coronavirus transmission and associated factors in six countries (China, Korea, Japan, Italy, the USA, and Brazil). In a qualitative analysis, they compared mitigation measures like border control, isolation and lockdowns, tracking of contaminated patients and their contacts, and the disease severity, measured by the number of cases and deaths. They concluded that China and Korea had taken high mitigation measures and had low severity of the disease. The USA and Brazil had insufficient mitigation and high severity. Another analytic, comparative study

tried to see the correlation between social isolation in the states of Paraná and Santa Catarina and mortality. The level of social isolation in Paraná was never above 54%, with a mean of 37%, and the author saw no correlation between this factor and the variability of cases and deaths[36].

We still need to investigate more about the consequences of Brazilian political leaders' influence on the disease behavior in the country. According to Ortega and Orsini[37] Paraná is governed by a federal government ally who has been criticized for defending the Economy at the expense of health. Denemark[38] in his article covering the historical perspective of past pandemics like the Spanish Flu and the Black Death, pointed that the best way to control a pandemic is to attack the problem as a public health challenge, and more than the type of government, authoritarian or democratic, is the leader positioning taking rapid scientific, informed decisions that will have the trust of the citizens and reach the best results. He also emphasized the low number of deaths in 12 countries led by women and needs further investigation.

> *"This pandemic reminds us that we have a shared destiny.*
> *None of us, our health systems, and our economies operate in a vacuum.*
> *We are interdependent. We cannot win without solidarity.*
> *As long as COVID-19 persists in one country, it is a threat to all of us."*
> *Mr. Teodros Adhanom Ghebreyesus – WHO's General Director (WHO, 2020).*

Limitations

The current study used a secondary database. Although the database is from an official government department and collected on a large scale, secondary data will always have the limitation of reliability of data. In this particular case, the underreporting of COVID-19 in Brazil is recognized as a significant problem. The number of tests is deficient in the country. It directly impacts the case-fatality rate since many non-fatal cases have not been tested.

Another limitation is that the pandemic has not ended in Paraná, Brazil. The study comprised only the first year period. Otherwise, the number of cases and deaths revealed a continuous increase by March 2021. So, it was not possible to analyze until the end of the second established wave. It will be necessary to continuously investigate the numbers after the pandemic ends to have the final mortality and case-fatality rate results in the state.

CONCLUSION

During the first year of the COVID-19 pandemic in Paraná, Brazil, there were 854,326 confirmed cases of COVID-19, and 17,229 people died from the disease.

Even more than a year after the start of the Pandemic, Paraná registered a high concentration of new cases and deaths from COVID-19, factors that contributed to the second wave representing a more alarming scenario, with increasing trends in lethality (DPC= - 0.73 %) and mortality (DPC = 1.02%).

Author Contributions

Conceptualization, D.S.J., T.C.M., IP, M.P.E.C; B.E.G.D. and L.C.A.; methodology, D.S.J., T.C.M., L.C.J., R.D.R., K.E., C.E.S., and L.C.A.; software, T.C.M. L.C.J.; validation, L.C.J.; T.C.M., C.E.S., and L.C.A.; data curation, D.S.J., T.C.M., L.C.A.; writing-review and editing, all the authors; visualization, all the authors; supervision, K.E., C.E.S.; project administration, C.E.S., and L.C.A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The author declares that there is no conflict of interests related to this study.

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Resumo

Introdução: no final de 2019, a China notificou o surgimento de uma nova doença, com a identificação do agente, passou a chamar-se COVID-19. Apesar dos esforços da Organização Mundial da Saúde (OMS) e de países em todo o mundo, a doença se espalhou fora de controle; em 11 de março, a OMS declarou o estado de pandemia. O Brasil é o maior país da América do Sul, demarcado em 26 estados com diferentes aspectos econômicos, culturais e sociais. O Paraná é uma das unidades federativas brasileiras, é o sexto mais importante economicamente e o segundo em Educação. Seu primeiro caso de COVID-19 foi confirmado em 12 de março de 2020, e o primeiro óbito em 27 de março, duas semanas após o primeiro óbito no Brasil.

Objetivo: o objetivo deste estudo é determinar as taxas de mortalidade e letalidade da COVID-19 no Estado do Paraná, Brasil, de 1º de março de 2020 a 31 de março de 2021.

Método: trata-se de um estudo ecológico de série temporal que avaliou todos os casos (854.326) e óbitos (17.229 óbitos) da COVID-19 notificados em banco de dados público e oficial da Secretaria de Saúde do Estado do Paraná. As taxas de letalidade e mortalidade foram estratificadas por sexo e idade. Para análise de tendência, o período foi dividido em uma "primeira onda" (março a novembro de 2020) e uma "segunda onda" (dezembro de 2020 a março de 2021). O modelo de regressão de Prais-Winsten para taxas de mortalidade populacional e letalidade permitiu classificar as tendências em crescentes, decrescentes ou estacionárias.

Resultados: as mulheres foram as mais afetadas pelo número de casos, com 454.056 casos (53,15%) confirmados e 7.257 óbitos (42,12%). Um total de 400.270 homens (46,85%) foram infectados e 9.972 (57,87%) morreram. Para o primeiro ano da COVID-19, no Estado do Paraná a incidência foi calculada em 7.404,12/100.000 habitantes, a mortalidade foi de 149,32 / 100.000 habitantes e a letalidade foi de 2,02%. Observamos uma tendência de diminuição da taxa de letalidade (DPC= -0,18; p <0,001). A mortalidade e incidência apresentaram tendência crescentes (DPC=1,13, p <0,001; DPC= 1,58, p <0,001, respectivamente).

Conclusão: o nível e a variabilidade da transmissão durante este primeiro ano de pandemia sugerem que a doença no Estado do Paraná nunca esteve sob controle.

Palavras-chave: COVID-19, mortalidade, letalidade, SARS-CoV-2, Epidemiologia.