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ARTIGO ORIGINAL

COVID-19 in the municipalities of Botucatu and Serrana, São Paulo, Brazil, the effects of lethality and mortality

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Abstract

Introduction: In 2019, the proliferation of a virus identified as SARS-CoV-2 emerged in the city of Wuhan, a district in China, quickly spread throughout the world, gaining pandemic status and less than 1 year, its repercussions and magnitude caused scientists, governments and society to adopt severe measures to combat this disease.

Objective: To analyze mortality, incidence and mortality from COVID-19 in the municipalities of Botucatu and Serrana, São Paulo, Brazil.

Methods: This is an ecological study with a time series design with secondary data. All registered cases and deaths registered by COVID-19 from April 2020 to August 2021 in the municipalities of Botucatu and Serrana, São Paulo, Brazil were considered. The incidence, mortality and lethality rate were used. The monthly and/or weekly percentage variation and their respective 95% confidence intervals were estimated.

Results: It identified that 12.88% of the residents of the city of Botucatu were infected with COVID-19 and 8.61% of the population of the municipality of Serrana was infected. There was a stationary trend of mortality and incidence in the period between April 2020 and May 2021 and decreasing in both sexes in the mortality rate in the municipality of Serrana, in the city of Botucatu there was a trend of increasing mortality and incidence in the same period observed.

Conclusion: The mass vaccination strategy of citizens in the cities of Botucatu and Serrana present robust data to consider that immunization has a decreasing effect on the number of cases and deaths from COVID-19, which effectively contributes to fighting the pandemic and reduces the contamination and progression of the disease to more severe cases.

Keywords: COVID-19, SARS-CoV-2, Mortality, Lethality, Epidemiolog, Quarantine

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Authors summary

Why was this study done?
To report on the progress of the COVID-19 pandemic in the municipalities of Botucatu and Serrana.

What did they search and find?
An analysis of mortality and lethality indicators was carried out in the periods between April 2020 and August 2021, observing the disease evolution curves.

What do these findings mean?
it is observed that there was an important change in the number of deaths and in lethality indicators with the immunization intervention and social distancing measure applied.

INTRODUÇÃO

In the year 2019, a proliferation with the infection of a virus identified as SARS-CoV-2 began in the Wuhan region, a district in the region of China, quickly spread around the world, gaining pandemic status and less than 1 year[1].

SARS-CoV-2, when infected in the host, has a rapid replication in the cell nucleus, causing a disease that mainly affects the respiratory tract, commonly known as COVID-19[2]. As soon as the disease began to affect a significant number of the population, the scientific community quickly sought ways to identify the symptoms of the disease and so far it is a consensus that the main symptoms are identified between ten and fifteen days after the infection of the virus[2].

Currently, the infection by COVID-19 spreads with great speed, and measures to control and contain the disease are scarce, which leaves a number of deaths never seen in this magnitude[3]. Data regarding COVID-19 infection currently total about 148,859,866 registered cases and more than 3.1 million registered deaths worldwide[3].

In Brazil, there were more than 18 million registered cases of COVID-19 with more than 570 thousand deaths reported by the disease[3]. These indicators demonstrate the speed at which the infection has proliferated around the world with an indiscriminate reach in the population. In developing countries, the proliferation of the disease follows a speed never seen before, establishing the greatest challenge that the scientific community has witnessed, surpassing many other known viral diseases[4,5].

As discussed by the scientific community, so far there is no type of early treatment of infection and containment measures that can be adopted by the population regarding non-pharmacological actions.

Physical distancing, use of face masks, and constant hygiene, especially of the hands, are measures to contain the spread of COVID-19 infection, forming strategies that reduce the number of infected[6].

With the advance of the spread of contamination by SARS-CoV-2 and the respective infection by COVID-19 during the year 2020 until mid-May 2021, there was an increase in the number of cases in the Southeast Region of the country, especially in the State of São Paulo and important decisions to face the pandemic were necessary to avoid the collapse of the health system[7].

Amid a significant increase in the number of COVID-19 cases, especially among unvaccinated people, and facing one of the lowest vaccination rates in Western Europe, Austria resumed national confinement at the end of 2021, the first country on the European continent to reinstate it[8].

In June, Brazil received more than 1.5 million vaccines from the North American laboratory. Another 3 million doses of Janssen were distributed to Brazilian states after a donation made by the United States. Brazil applied 297.1 million vaccines against Covid-19. More than 157 million received the first dose, equivalent to approximately 90% of the target population, according to data from the Ministry of Health. "Already 127.9 million have completed the vaccination schedule, which corresponds to 72.3% of the main public"[9].

Younger generations trust scientists more and embrace international cooperation more easily than older groups, children and youth are 50% more likely to trust the world to improve than older people[10].

The city of Serrana, a municipality with around 45,000 inhabitants, was selected to be the first city to undergo mass vaccination; an action that started in mid-February 2021 and that was possible due to the partnership with the Butantã Institute, developer and manufacturer of the immunizing CORONAVAC® that provided the opportunity to implement Project S, a clinical study of effectiveness developed in partnership with the Health Department and the Municipality of Serrana with the aforementioned Institute, the immunizer already distributed and used in the population, but due to issues of availability of the active pharmaceutical ingredient, its production is still far from expected to meet the demand of the population[11,12].

The city of Botucatu is located 235 KM away from the Capital of São Paulo, the city has among its various economic activities, large companies in the industrial sector, commerce, and various services. The city was selected for a study that sought to evaluate the effectiveness of the immunizer produced by the manufacturer AstraZeneca in partnership with the University of Oxford and Fiocruz[13].

The monitoring of epidemiological data can have an important effect on the control of the disease in the country, therefore, decisions of the actors involved must be effective, clear, and planned, such relevance is important for the advancement in the capacity to combat the disease to reduce the threat faced by the disease. society.

Therefore, the objective of this study is to analyze the mortality, incidence, and lethality of COVID-19 in the municipalities of Serrana and Botucatu, São Paulo, Brazil.

METHODS

This is an ecological study with a time series design based on public data from the Information System of the Department of Informatics of the state of São Paulo, SP, Brazil.

Study population

The municipality of Serrana is in the northwest of the State of São Paulo, Brazil with a population of about 45 thousand inhabitants. This city is close to the metropolitan region of the city of Ribeirão Preto and is connected via highways to other cities such as Araraquara. The municipality of Botucatu is located in the northwest region of the state of São Paulo and has the neighboring cities of Pardinho, Itatinga, Avaré among others. With about 148,130 inhabitants according to 2020 data.

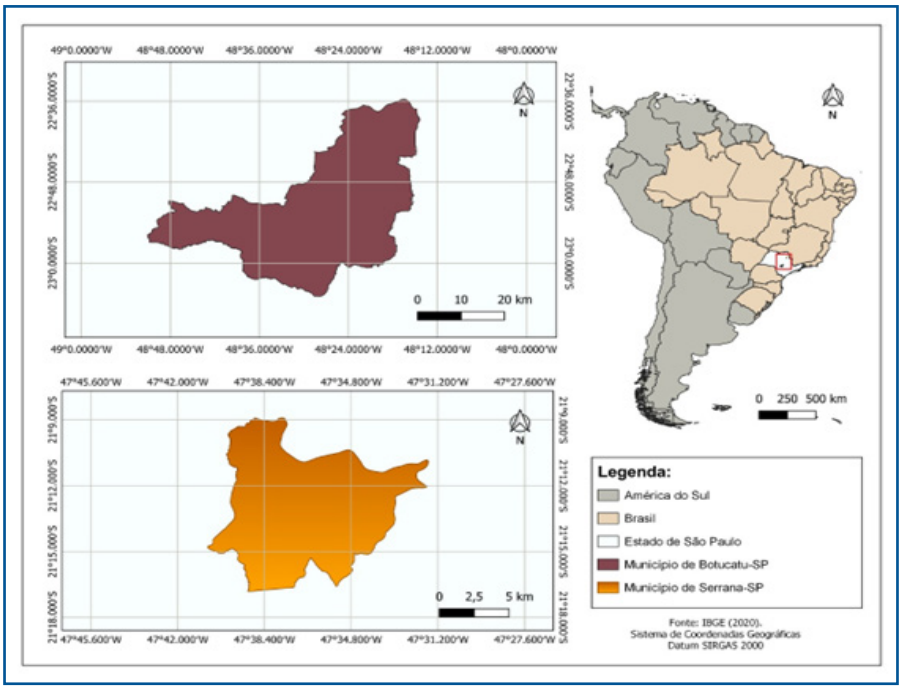

Figure 1: Map of the São Paulo state with the identification of the municipality of Serrana and Botucatu.
Source: ArcGiz

All cases and deaths recorded by COVID-19 in the period from April 2020 to August 2021 in individuals residing in the municipality of Serrana and Botucatu, São Paulo, Brazil were considered.

Data collection

Data collection was carried out using data available at the Department of Informatics of the state government of São Paulo (https://www.saopaulo.sp.gov.br/coronavirus/)[7], and ended on June 1, 2021. Data recorded on the number of confirmed cases and deaths of COVID-19 and available in this public database and epidemiological bulletins from the municipality of Serrana, São Paulo, Brazil were used. Data were combined between the analysis by epidemiological week in the period of 2021 and monthly in the period of 2020.

Population data were obtained through estimates made by the State Data Analysis System (SEADE Foundation – State System for Data Analysis of the State of São Paulo), for the inter census years; and by the 2010 census, by the Brazilian Institute of Geography and Statistics (IBGE)[14].

This information was collected by two independent researchers to identify possible discrepancies. Given the specific record of data referring to COVID-19 infection, only the record of deaths reported by the disease in the municipalities of Serrana was selected for this study. Deaths from other causes not considered or unrelated to Covid-19 infection were excluded.

The variables used were sex (male and female), the age group from 1 year of age with intervals of 5 in 5 years up to 80 years of age and over, presented as follows (1-4 years, 5-9 years, 10-14 years, 15-19 years, 20-24 years, 25-29 years up to 80 years).

Statiscal analyses

The descriptive analysis of the data was according to the deaths and number of cases of COVID-19, in absolute and relative frequencies.

Crude incidence and mortality rates were calculated according to sex and age group. The incidence rate was calculated by the number of confirmed cases of COVID-19 divided by the resident population of Serrana and Botucatu, São Paulo per 100 inhabitants. The mortality rate is the number of deaths from COVID-19 per resident population per 1,000 inhabitants.

The case fatality rate is the number of deaths from COVID-19 divided by the number of confirmed cases by 100 which is represented as a percentage.

For the analysis of time trends, the weekly and monthly rates of incidence, mortality, and lethality by COVID-19. Linear regression was used, as the variables were normally distributed.

The Prais-Winsten regression model was used to calculate the time series construction rates. This method allows first-order autocorrelation corrections to be performed on the values, organized by time15. Thus, the values of the angular coefficient (β) and respective probability (p) were estimated, considering a 95% confidence interval significance level (95% CI). The data modeling process included the transformation rates (dependent variable = Y value) in a logarithmic function of base 10. The independent variable (X value) was the months of the historical series.

The results of the logarithmic rates (β) of the Prais-Winsten regression allowed estimating the percentage change in monthly or weekly change (Monthly Percent Change – MPC or Weekly Percent Change – WPC) in the municipality. The regression model used is described by Kleinnbaum:

$$y = \beta 0 + \beta 1 * t,$$

On what:
y = mortality from COVID-19 per 1,000 inhabitants;
y = COVID-19 lethality per 1000;
y = incidence per 100
t = calendar months (from April 2020 to May 2021);
β0 = intercept; when x is equal to 0.
B1 = average monthly and weekly change in mortality, lethality, or incidence of COVID-19.

The trend was considered present when zero was within the 95% confidence interval of the MPC and WPC, and $p<0.05$ being: ascending when positive and decreasing when negative. In the absence of a statistically significant difference, the trend was termed stationary. All analyzes were performed using the statistical program Stata (Data Analysis and Statistical Software) version 14.0.

Time trend analyzes were performed in 2 periods: the total period (April 2020 to August 2021) in which the MPC was calculated; and the period from January to May 2021 in which the WPC was calculated.

Ethical and Legal Aspects of Research

Due to the use of public domain data, there was no need to submit the work to the National Research Ethics Commission (CONEP) and to analyze the Research Ethics Committee (CEP) system.

RESULTS

The total number of confirmed cases of COVID-19 in the municipality of Serrana in the studied period was 3,931, which represents 8.61% of the total infected population from April 2020 to August 2021. Of this total, 2,179 (55.43%) are female with an incidence rate of 9.61 per 100 inhabitants. The age groups with the highest incidence rate were between 35 to 39 years old (12.03%), 50 to 54 years old (12.06%), and 75 to 79 years old (12.15%), and the lowest incidence rate was between 5 and 9 years (1.28%) (Table 1)

Table 1: Frequency of the number of confirmed COVID-19 cases and incidence rate from April 2020 to May 2021 in the municipality of Serrana, São Paulo, Brazil.

Characteristics	Number of Confirmed Cases	%	Population	Incidence Rate*Per 100 inhab.
Sex				
Male	1.752	44,57	22.969	7,63
Female	2.179	55,43	22.675	9,61
Age group				
0 a 4 years	52	1,32	3.610	1,44
5 a 9 years	45	1,14	3.515	1,28
10 a 14 years	82	2,09	3.412	2,40
15 a 19 years	220	5,60	3.554	6,19
20 a 24 years	400	10,18	3.857	10,37
25 a 29 years	383	9,74	3.870	9,90
30 a 34 years	464	11,80	4.020	11,54
35 a 39 years	464	11,80	3.856	12,03
40 a 44 years	366	9,31	3.239	11,30
45 a 49 years	337	8,57	2.881	11,70
50 a 54 years	316	8,04	2.620	12,06
55 a 59 years	248	6,31	2.195	11,30
60 a 64 years	168	4,27	1.722	9,76
65 a 69 years	150	3,82	1.244	12,06
70 a 74 years	98	2,49	855	11,46
75 a 79 years	66	1,68	543	12,15
80 + years	72	1,83	651	11,06
Total	3.931	100,00	45.644	8,61

Data source: Health Department of the State of São Paulo. *Incidence rate is the number of confirmed cases of COVID-19 among the population residing in Serrana/SP per 100 inhabitants; hab - inhabitants.

Table 2 shows the frequency of the number of deaths, with a total of 82 deaths from COVID-19, from April 2020 to May 2021. Of this total, 43 (52.44%) were more frequent in males. The mortality rate during the study period is 1.8 per 1,000 inhabitants and the age group with the highest mortality rate was individuals aged 80 years or older (29.19%), while in the age groups of 1 and 4 years, 5 to 9 years old, 15 to 19 years old, 20 to 24 years old and 25 to 29 years old there were no reported deaths.

It can be seen that there is a predominance of the male fatality rate of 2.45%, while the highest lethality rate in the age groups of 80 years and over is 26.38% (Table 3).

Table 2: Frequency of the number of deaths from COVID-19 and mortality rate from April 2020 to May 2021 in the municipality of Serrana, São Paulo, Brazil

Characteristics	Number of deaths	%	Population	Mortality Rate* per 1000 inhab.
Sex				
Male	43	52,44	22.969	1,87
Female	39	47,56	22.675	1,71
Age group				
0 a 4 years	0	0,00	3.610	0,00
5 a 9 years	0	0,00	3.515	0,00
10 a 14 years	1	1,22	3.412	0,29
15 a 19 years	0	0,00	3.554	0,00
20 a 24 years	0	0,00	3.857	0,00
25 a 29 years	0	0,00	3.870	0,00
30 a 34 years	3	3,66	4.020	0,75
35 a 39 years	2	2,44	3.856	0,52
40 a 44 years	3	3,66	3.239	0,93
45 a 49 years	8	9,76	2.881	2,78
50 a 54 years	1	1,22	2.620	0,38
55 a 59 years	4	4,88	2.195	1,82
60 a 64 years	7	8,54	1.722	4,07
65 a 69 years	12	14,63	1.244	9,65
70 a 74 years	12	14,63	855	14,04
75 a 79 years	10	12,20	543	18,42
80 + years	19	23,17	651	29,19
Total	82	100	45.644	1,80

Data source: Health Department of the State of São Paulo. * Mortality rate is the number of confirmed cases of COVID-19 in the resident population in Serrana/SP per 1000 inhabitants; hab. - population

Table 3: Frequency of the number of deaths and confirmed cases of COVID-19 and case fatality rate from April 2020 to May 2021 in the municipality of Serrana, São Paulo, Brazil.

Characteristics	Number of deaths	%	Number of confirmed cases	Case-fatality rate*
Sex				
Male	43	44,57	1.752	2,45
Female	39	55,43	2.179	1,78
Age group				
0 a 4 years	0	1,32	52	0
5 a 9 years	0	1,14	45	0
10 a 14 years	1	2,09	82	1,21
15 a 19 years	0	5,60	220	0
20 a 24 years	0	10,18	400	0
25 a 29 years	0	9,74	383	0

Continuation - Table 3: Frequency of the number of deaths and confirmed cases of COVID-19 and case fatality rate from April 2020 to May 2021 in the municipality of Serrana, São Paulo, Brazil.

Characteristics	Number of deaths	%	Number of confirmed cases	Case-fatality rate*
30 a 34 years	3	11,80	464	0,64
35 a 39 years	2	11,80	464	0,43
40 a 44 years	3	9,31	366	0,81
45 a 49 years	8	8,57	337	2,37
50 a 54 years	1	8,04	316	0,31
55 a 59 years	4	6,31	248	1,61
60 a 64 years	7	4,27	168	4,16
65 a 69 years	12	3,82	150	8
70 a 74 years	12	2,49	98	12,24
75 a 79 years	10	1,68	66	15,15
80 + years	19	1,83	72	26,38
Total	82	100,00	3.931	2,08

Data source: Health Department of the State of São Paulo. *Lethality rate (%) is the number of deaths from COVID-19 out of 100 confirmed cases

Figure 2 shows the behavior of lethality and mortality cases during the entire period analyzed.

The temporal analysis of lethality trends in the period from April 2020 to May 2021 is decreasing in males and in general. And the mortality and incidence rates remained stationary, as shown in table 4.

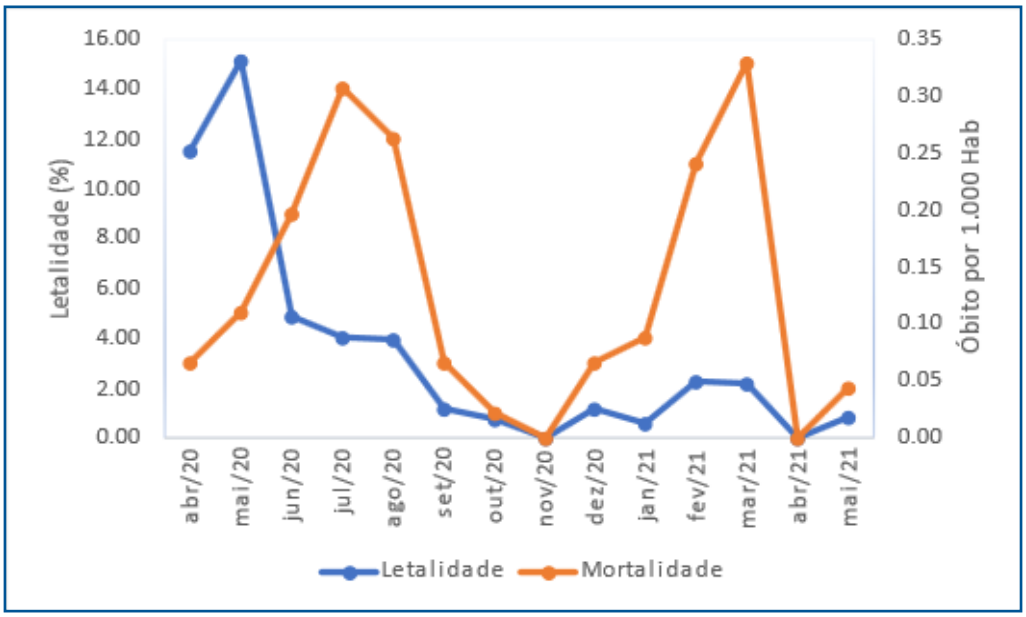

Figure 2: Analysis of lethality and mortality in the full period observed, between April 2020 and May 2021.
Data source: Health Department of the State of São Paulo. * Mortality rate is the number of deaths from COVID-19 over the population residing in Serrana/SP per 1,000 inhabitants. The case fatality rate is the number of deaths over the number of recorded cases.

Table 4: Estimates from the Prais-Winsten regression and the Weekly Percent Change (WPC) of incidence rates per 100 inhabitants, mortality per 1000 inhabitants and percentage fatality of COVID-19, from April 2020 to May 2021 in the municipality of Serrana, São Paulo Brazil

Sex	MPC (IC 95%) Lethality	p	Lethality trend	MPC (IC 95%) Mortality	p	Mortality trend	MPC (IC95%) Incedence	p	Incedence trend
Both Sex	-16.35 (-28:-3)	0,021	Decreasing	0.73 (-20:28)	0,947	Stationary	16.23 (-3:39)	0,088	Stationary
Male	-16.05 (-25:-6)	0,007	Decreasing	0.07 (-24:32)	0,996	Stationary	17.99 (-7:49)	0,149	Stationary
Female	-11.57 (-25:4)	0,127	Decreasing	-2.52 (-25:26)	0,826	Stationary	10.88 (-9:35)	0,284	Stationary

LET- Lethality; MORT – Mortality; INC – Incidence; T LET – Lethality Trend; T MORT – Mortality trend; T INC – Incidence Trend; MPC – Monthly Week Percent Change (%); CI 95% – Confidence Interval 95%; p – p-value: the probability of statistical significance. * Means statistical difference – Prais-Winsten regression test, p <0.05. Source: Cases, Deaths, and Population extracted from the Health Department of the State of São Paulo.

Table 5 shows that the lethality and mortality rate in both sexes remained stationary from February 2021 to May 2021 and the incidence rate in both sexes and in females was decreasing.

Table 6 in the period from January to May 2021, the lethality and mortality rate is increasing in males, although the incidence rate is decreasing in both sexes.

Table 5: Estimates of the Prais-Winsten regression and the Weekly Percent Change (MPC) of incidence rates per 100 inhabitants, mortality per 1000 inhabitants and percentage fatality of COVID-19, from February 2021 to May 2021 in the municipality from Serrana, Sao Paulo, Brazil

Sex	WPC (IC 95%) LET	p	T LET	WPC (IC 95%) MORT	p	T MORT	WPC (IC 95%) INC	p	T INC
Both Sex	-6.46 (-19: 8)	0.304	Stationary	-4.89 (-19: 12)	0.485	Stationary	-10.35 (-19: -1)	0.030	Decreasing
Male	0.96 (-22: 31)	0.929	Stationary	-1.29 (-20: 22)	0.882	Stationary	-7.76 (-15: 0.35)	0.059	Stationary
Female	-5.72 (-29: 25)	0.597	Stationary	-4.12 (-19: 13)	0.519	Stationary	-12.83 (-22: -3)	0.020	Decreasing

LET- Lethality; MORT – Mortality; INC – Incidence; T LET – Lethality Trend; T MORT – Mortality trend; T INC – Incidence Trend; WPC – Weekly Percent Change (%); CI 95% – Confidence Interval 95%; p – p value: the probability of statistical significance. * Means statistical difference – Prais-Winsten regression test, p <0.05.Fonte: Casos, Óbitos e População extraídos da Secretaria de Saúde do Estado de São Paulo.

Table 6: Estimates of the Prais-Winsten regression and the Weekly Percent Change (MPC) of incidence rates per 100 inhabitants, mortality per 1000 inhabitants, and percentage fatality of COVID-19, from January 2021 to May 2021 in the municipality of Serrana, São Paulo Brazil.

Sex	WPC (IC 95%) LET	p	T LET	WPC (IC 95%) MORT	p	T MORT	WPC (IC 95%) INC	p	T INC
Both Sex	0.04 (-8: 9)	0.992	Stationary	-2.84 (-10: 5)	0.438	Stationary	-9.68 (-16: -3)	0.007	Decreasing
Male	15.93 (6: 26)	0.005	Increasing	12.09 (4: 21)	0.011	Increasing	-10.67 (-16: -5)	0.001	Decreasing
Female	2.70 (-4: 10)	0.42	Stationary	-1.43 (-8: 5)	0.638	Stationary	-14.53 (-22: -7)	0.001	Decreasing

LET- Lethality; MORT – Mortality; INC – Incidence; T LET – Lethality Trend; T MORT – Mortality trend; T INC – Incidence Trend; WPC – Weekly Percent Change (%); CI 95% – Confidence Interval 95%; p – p value: probability of statistical significance. * Means statistical difference – Prais-Winsten regression test, p <0.05. Source: Cases, Deaths, and Population extracted from the Health Department of the State of São Paulo.

Data from the epidemiological bulletins of the city of Botucatu recorded 18,599 confirmed cases of COVID-19 until the 40th week of the year 2021, which represents 12.5% of the city's population, its incidence rate of contamination by COVID-19 until the observed period was 12.88%[16].

In the city of Botucatu, the distribution of cases and deaths was observed in the period from April 2020 to August 2021, according to the table of total data on cases by COVID-19, there was an increase in the number of cases between the age group of 25 to 44 years. Although it also has a high number of cases in adolescents, in the age group between 15 to 24 years, and adults in the age group between 50 to 59 years. Regarding gender, it is observed that there were more cases in females, with a total of 9920 in women and 8679 in men.

Following the same table, we have the number of total deaths by COVID-19. In it, we see that the age group most affected are elderly people aged 80 years or more. Although the other table informs that more cases occur in women, according to the table the number of deaths is higher in men, being 169 to 147 in women.

Table 7: Frequency of the number of confirmed COVID-19 cases and deaths, distributed by age group and sex, from April 2020 to August 2021 in the municipality of Botucatu, São Paulo, Brazil.

Cases				Deaths			
Age group	General	Male	Female	Age group	General	Male	Female
0-4 years	808	400	408	0-4 years	0	0	0
5-9 years	824	419	405	5-9 years	0	0	0
10-14 years	886	474	412	10-14 years	1	1	0
15-19 years	1234	570	664	15-19 years	0	0	0
20-24 years	1451	642	809	20-24 years	2	1	1
25-29 years	1774	828	946	25-29 years	3	1	2
30-34 years	1884	853	1031	30-34 years	1	1	0
35-39 years	1979	927	1052	35-39 years	8	4	4
40-44 years	1732	780	952	40-44 years	17	11	6

Continuation - Table 7: Frequency of the number of confirmed COVID-19 cases and deaths, distributed by age group and sex, from April 2020 to August 2021 in the municipality of Botucatu, São Paulo, Brazil.

	Cases				Deaths		
Age group	**General**	**Male**	**Female**	**Age group**	**General**	**Male**	**Female**
45-49 years	1420	690	730	45-49 years	18	11	7
50-54 years	1209	534	675	50-54 years	17	11	6
55-59 years	1086	515	571	55-59 years	30	17	13
60-64 years	789	378	411	60-64 years	33	19	14
65-69 years	563	258	305	65-69 years	48	25	23
70-74 years	386	194	192	70-74 years	37	24	13
75-79 years	239	96	143	75-79 years	32	15	17
80+ years	335	121	214	80+ years	69	28	41
Total	18599	8679	9920	Total	316	169	147

In the period between May and August 2021, the effects of mass vaccination of the citizens of the city of Botucatu are observed, in the age groups from the youngest age to the age group between 25 and 29 years old, there was a drop in the number of cases and deaths, among adults aged 30 to 59 years, the downward trend followed, however, there is a greater occurrence of cases in females.

The number of confirmed deaths followed the downward trend, especially in individuals aged over 65 years, in individuals aged 80 years and over there were 25 deaths in 3 months. Women have the highest number of cases with 51 deaths.

Table 8: Frequency of the number of confirmed COVID-19 cases and deaths, distributed by age group and sex, from May 2021 to August 2021 in the municipality of Botucatu, São Paulo, Brazil.

	Cases				Deaths		
Age group	**General**	**Male**	**Female**	**Age group**	**General**	**Male**	**Female**
0-4 years	327	160	167	0-4 years	0	0	0
5-9 years	344	176	168	5-9 years	0	0	0
10-14 years	369	205	164	10-14 years	0	0	0
15-19 years	500	229	271	15-19 years	0	0	0
20-24 years	510	242	268	20-24 years	0	0	0
25-29 years	570	279	291	25-29 years	1	0	1
30-34 years	621	263	358	30-34 years	0	0	0
35-39 years	685	319	366	35-39 years	2	1	1
40-44 years	625	271	354	40-44 years	7	5	2
45-49 years	513	267	246	45-49 years	3	2	1
50-54 years	442	206	236	50-54 years	7	6	1
55-59 years	384	196	188	55-59 years	12	5	7
60-64 years	287	136	151	60-64 years	10	4	6
65-69 years	176	81	95	65-69 years	13	7	6
70-74 years	130	61	69	70-74 years	12	6	6
75-79 years	66	24	42	75-79 years	4	2	2
80+ years	116	41	75	80+ years	25	7	18
Total	6665	3156	3509	Total	96	45	51

The following table shows the distribution by sex and age of cases and deaths recorded in the city of Botucatu, from May 2021 to August 2021, a period that comprises the mass immunization process carried out in the city.

It was observed in the temporal analysis of the daily trend of mortality, lethality and difficulty in the city of Botucatu, in the period of 2020 the tendency of increasing lethality presented itself of increasing, in the year of 2021 it presented itself increasing, the mortality for the periods of 2020 and periods of 2020 2021 remained stationary and a probability trend in 2020 was increasing and in the period of 2021 it follows an increasing trend, as shown in the following table.

Table 9: Estimates of the Prais-Winsten regression and the Weekly Percent Change (DPC) of incidence rates per 100 inhabitants, mortality per 1000 inhabitants, and percentage fatality of COVID-19, in the years 2020 and 2021 in the city of Botucatu, São Paulo, Brazil.

Period	WPC (IC 95%) Lethality	p	T LET	WPC (IC 95%) Morthality	p	T MORT	WPC (IC 95%) Incidence	p	T INC
Total Period	-0.40 (-0.51 : -0.29)	<0.001	Decreasing	0.07 (0.01 : 0.14)	0.026	Increasing	0.69 (0.55 : 0.84)	<0.001	Increasing
2020	-0.69 (-1.03 : -0.35)	<0.001	Decreasing	0.00 (-0.13 : 0.13)	0.987	Stationary	0.98 (0.77 : 1.19)	<0.001	Increasing
2021	0.26 (0.03 : 0.49)	0.027	Increasing	-0.10 (-0.28 : 0.08)	0.269	Stationary	-0.52 (-0.79 : -0.24)	<0.001	Decreasing

LET- Lethality; MORT – Mortality; INC – Incidence; T LET – Lethality Trend; T MORT – Mortality trend; T INC – Incidence Trend; WPC – Weekly Percent Change (%); CI 95% – Confidence Interval 95%; p – p-value: the probability of statistical significance. * Means statistical difference – Prais-Winsten regression test, p <0.05. Source: Cases, Deaths, and Population extracted from the Health Department of the State of São Paulo.

DISCUSSION

According to the World Health Organization (WHO), until 07/23/2021, there were 190,671,330 confirmed cases of COVID-19 in the world, of which 4,098,758 died. In the Americas, more than 80 million cases have been confirmed and more than 2 million deaths from the disease[1,3].

In Brazil, the Ministry of Health (MOH) reports that the situation of cases in the national territory: is 19,523,711 confirmed cases, of which 547,016 died[16].

Cases in the Southeast region total 7,446,464, with 255,666 deaths. The situation in the State of São Paulo between the first confirmation and the end of Epidemiological Week 29 of 2021 (07/18/2021), was confirmed, considering the different case definitions used in the period, 3,979,102 cases 136,466 (3.43%) died[7].

From the first confirmation until the end of Epidemiological Week 22 of 2021 (06/02/2021), 4013 cases of COVID-19 were confirmed, of which 90 (2.2%) evolved to death. It was identified that in the full period observed, 8.61% of the population of the municipality of Serrana was infected with COVID-19; of these, females were more affected than males, with 9.61% and 7.65% respectively.

In the same period, individuals aged 75-79 years (12.15%) had a higher incidence of infection by the disease, but these values are very similar in different age groups, between 30 and 59 years.

Regarding the observed full-time mortality, it is noted that the mortality rate of males was slightly higher than females, 1.87 and 1.71 respectively.

From the analysis of mortality and lethality in the full period, it is identified that there was a significant reduction in the period that includes mass immunization in the city. In the MPC statistical analysis, a stationary trend of mortality and incidence is observed in the full period between April 2020 and May 2021; there was a decreasing trend in both sexes in the lethality variable. The incidence rate for the period from January 2021 to May 2021 showed a decreasing trend.

In order to reduce the number of deaths and the high rates of contamination and evolution of the disease, according to the results indicated, inducing immune responses can prevent or limit the disease after the subsequent natural infection, and it is known that according to the World Health Organization (2019))[17], vaccination is one of the most effective means of preventing infectious diseases, and mass immunization is the best way to respond.

The search for a vaccine against SARS-CoV-2 was the main topic of research in the world to help stability[18], with the development of immunizations in the world, in a very short time.

The CoronaVac vaccine (Sinovac Life Sciences, Beijing, China), is an inactivated virus vaccine, which, through the application of two doses, can induce a humoral response against Sars-Cov-2, in addition to having low intolerability[19].

When considering that in the period studied there was a reduction in the incidence rate of COVID-19, the results suggest that the effects of mass immunization of the population promoted a protective effect, which confirms reports by researchers[20] who claim in a study on the outcomes of the pandemic that the Deployment of effective vaccines against SARS-CoV-2 can prevent disease and transmission, resulting in community protection.

The mass immunization of the inhabitants of the city of Botucatu had the effects of a significant reduction in the number of COVID-19 cases by 80% and a drop of 86.7% in the number of hospitalizations for the disease, these drop indicators were observed after the application of the first dose of the immunizer13.

Another measure that is advancing rapidly in the fight against the pandemic is vaccines, a fundamental instrument for the control of infectious diseases for decades[21,22]. Brazil has a structured and efficient health system for the distribution of vaccines, recognized worldwide as a model of health and vaccination management[23,24].

With the advancement of the development of vaccines to reduce the severity of the disease in humans, when available in adequate amounts, it can have an important effect on the control of the disease in the country, therefore, decisions of the actors involved in the development of strategies to combat it effectively, clear and planned[25].

In the municipality understudy, concomitantly with the implementation of the S immunization Project, non-pharmacological measures such as the use of masks and distancing were strongly implemented, which potentiated the control of the transmission of COVID-19. However, until the moment observed in the study, there are not enough immunizations available to meet the population's needs, and effective measures by governments and actors involved in the purchase and distribution must be pragmatic to resolve this issue[11].

Therefore, good guidance to the population on the

severity of the disease and how to avoid contagion, adopting measures to contain the circulation and agglomeration of people, and non-pharmacological measures, will hardly have a favorable outcome for the population and, consequently, maintain There will be coexistence with the actions of physical distancing and the number of deaths increasing for longer[12,26-30].

Thus, the continuing need for public health practices with face protection mask use and social distancing[4] will continue to be particularly important until a sufficient proportion of the population is immunized[20]. In this context, even with the positive results of COVID-19 control in the municipality, these practices must continue, which highlights the importance of health education actions as an instrument for empowering the population at a time when everyone must be co-responsible for their health[31].

These preliminary results demonstrate the importance of indicators for monitoring the behavior of the pandemic despite constant change. Thus, it is emphasized that efforts continue to be necessary to contain the spread of the disease in all the analyzed municipalities until the disease does not represent a threat to Public Health, for which the data presented in this work may be useful.

Although the incidence rate is a fundamental concept in the epidemiology of infectious diseases, given that it describes the frequency of new cases of the disease in a given period, it suffers direct limitations due to the number of tests to detect the infection[32]. However, although the number of data for statistical analysis is small, the effect on data manipulation suffers great impacts regarding the confidence interval, however, when observing the weekly data, there is no record of new deaths, thus supporting the hypothesis that the protective effect of the immunization was efficient[32-36].

Fiocruz's InfoGripe Bulletin indicates a scenario of stability in the incidence of Severe Acute Respiratory Syndrome (SARS) in Brazil, with small fluctuations in most age groups[37]. The only exception remains children. For the group aged between zero and 9 years, there is again a sign of growth, with around 1,500 cases per week, a number higher than that recorded in July 2020 (1,282 cases in Epidemiological Week 29)[37].

However, laboratory results continue to indicate a greater volume of other viruses, with a predominance of the respiratory syncytial virus. The analysis refers to Epidemiological Week 45, from the 7th to the 13th of November 2021. This increase in SARS cases associated with other respiratory viruses in children is observed in several states of the country, a direct consequence of the greater exposure of this population in the last months[37].

These findings indicate the epidemiological pattern of the number of new cases and mortality in the municipality studied. However, even with the optimistic perspective of immunization efficiency, it is far from being effective for the population of the country, which once again highlights non-pharmacological measures as important for reducing the number of cases and deaths[38,39].

The city of Serrana, a municipality with around 45,000 inhabitants, was selected to be the first city to undergo mass vaccination; an action that started in mid-February 2021 and that was possible due to the partnership with the Butantã Institute, developer and manufacturer of the immunizing CORONAVAC® that provided the opportunity to implement Project S, a clinical study of effectiveness developed in partnership with the Health Department and the Municipality of Serrana with the aforementioned Institute, the immunizing agent already distributed and used in the population, but due to issues of availability of the active pharmaceutical ingredient, its production is still far from what was expected to meet the demand of the population[11,12].

It is noteworthy that in the aforementioned municipality of Serrana, located in the interior of the state of São Paulo, it was selected to participate in the first project to analyze the effects of immunization with the vaccine developed by the Butantã Institute from the S project, it was the first city in country to undergo mass vaccination of the entire adult population[11].

Considering, therefore, the importance of Project S as a provider of information that will guide Public Policies, in order to guarantee the right to prevention and health for the Brazilian population and control the spread of infection by SARS-CoV-2, despite the preliminary effects of epidemiological investigations may be important to prove the effectiveness of the immunization process.

Despite the chronic underinvestment that has made the Americas vulnerable to COVID-19, according to the Pan American Health Organization, it is essential that countries remain vigilant and prioritize public health spending to recover and save lives[40].

With the return of restrictive measures in several places in Europe and with the increase in the number of cases and deaths, especially in places where vaccination coverage has not been progressing, in Brazil, so far the monitored data[16] point to the maintenance of downward trends in indicators (cases, deaths and bed occupancy rates) related to the transmission of Sars-Cov-2[16].

The current situation in European countries, which has been called the "pandemic of the unvaccinated", has served as a warning to the issue of the advancement of vaccination in these nations where portions of the unvaccinated population have been presenting a high number of cases of COVID-19[19,41].

Brazil currently has about 60% of the population with a complete vaccination schedule[9], with an estimated 1.15 deaths per million inhabitants, according to data available from Our World In Data[41]. However, countries such as Austria, Lithuania, and Germany, with higher percentages of the vaccinated population (63.7%, 65.2%, and 67% respectively) are not only facing a large increase in hospitalizations, especially among the unvaccinated but also in the indicator of deaths per million inhabitants, which is at 2.23 for Germany, 4.00 for Austria and 10.62 for Lithuania[3,41].

Rondônia is the only state in the intermediate alert zone3,9,16. The other 26 units are outside the alert zone: Acre (4%), Amazonas (27%), Roraima (29%), Pará (54%), Amapá (18%), Tocantins (15%), Maranhão (24%), Piauí (58%), Ceará (42%), Rio Grande do Norte (49%), Paraíba (24%), Pernambuco (52%), Alagoas (30%), Sergipe (17%), Bahia (35%), Minas Gerais (16%), Espírito Santo (53%) Rio de Janeiro (27%), São Paulo (23%), Paraná (31%),

Santa Catarina (38%), Rio Grande do Sul (54%), Mato Grosso do Sul (30%), Mato Grosso (34%), Goiás (29%) and Federal District (58%)[3,9,16,41].

It was observed that in the period of severe contamination, there is higher mortality between mid-June 2020 and September of the same year, as the first wave of infections and deaths by COVID-19, after a period of decrease in the number of cases and deaths, observed. if the second wave comprises the period between mid-February 2021 and the month of May 2021, with increased mortality and lethality, with stationary trends in relation to the observed period.

The mortality, lethality, and incidence rate in the population of the municipality of Serrana in São Paulo from April 2020 to May 2021 follows a stationary pattern for COVID-19. of covid-19 and 293 deaths resulting from complications associated with the disease[7,42]. 11.5 million booster doses were applied. In total, 360.6 million doses were distributed to states and municipalities, of which 349,941 were delivered.

In the city of Botucatu in 2020, there was an increase in the number of cases and deaths, observed in the first wave of COVID-19, with effects on the incidence, lethality, and mortality rates that followed increasing trends, in the period 2021, with vaccination and strategies of mass immunization of the citizens of this city, it was observed a steady trend in relation to mortality, with a tendency of incidence in a decreasing pattern.

CONCLUSION

The mass vaccination strategy of citizens in the cities of Botucatu and Serrana presents robust data to consider that immunization has the effect of reducing the number of cases and deaths by COVID-19, which effectively contributes to combating the pandemic and reduces contamination and progression of the disease to more severe cases.

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Resumo

Introdução: em 2019, surgiu na cidade de Wuhan, um distrito na região da China a proliferação com a infecção de um vírus identificado como SARS-CoV-2, rapidamente espalhou-se pelo mundo ganhando status de pandemia em menos de 1 ano, suas repercussões e magnitude fizeram que os cientistas, governos e sociedade adotarem medidas severas para o combate a esta enfermidade.

Objetivo: analisar a mortalidade, incidência e letalidade por COVID-19 nos municípios de Botucatu e Serrana, São Paulo, Brasil.

Método: trata-se de um estudo ecológico com delineamento de série temporal com dados secundários. Foram consideradas todos os casos registrados e óbitos registrados por COVID-19 no período de abril de 2020 a agosto de 2021, nos municípios de Botucatu e Serrana, São Paulo, Brasil. Foi utilizado a taxa de incidência, mortalidade e letalidade. Estimou-se a variação percentual mensal e/ou semanal e seus respectivos intervalos de 95% de confiança.

Resultados: identificou que e 12,88% dos munícipes da cidade de Botucatu foram infectados com COVID-19 e 8,61% da população do município de Serrana foi infectada. Observou-se uma tendência estacionária de mortalidade e incidência no período entre abril 2020 a maio 2021 e decrescente em ambos os sexos na taxa de letalidade no município de Serrana, na cidade de Botucatu houve tendência de mortalidade e incidência crescentes no mesmo período observado.

Conclusão: a estratégia de vacinação em massa dos munícipes das cidades de Botucatu e Serrana apresentam dados robustos para considerar que a imunização tem efeito de queda no número de casos e óbitos por COVID-19, o que contribui efetivamente no combate a pandemia e reduz a contaminação e evolução da doença para casos mais graves.

Palavras-chave: COVID-19; SARs-CoV2; Mortalidade; Letalidade; Epidemiologia; Quarentena.