Effects of lockdown on COVID-19 incidence in the health emergency phase of the pandemic

Efeitos do *lockdown* na incidência da COVID-19 na fase de emergência sanitária da pandemia

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ABSTRACT

Objective: to assess the effects of lockdown on the incidence of COVID-19 during the health emergency phase of the pandemic. **Methods:** this is a cross-sectional ecological study. Data was collected from the websites of the State Data Analysis System Foundation and Araraquara City Hall. To analyze the incidence of COVID-19, cases reported in the municipality were considered. A regression model with a negative binomial distribution and a logarithmic link function was used to compare the periods in terms of daily cases. **Results:** for all age groups except those under 20, there was a statistical difference in the incidence coefficients. For females, the decline in the incidence of the disease was more significant. Considering both sexes and all age groups, there was a 49% reduction in the incidence of cases. **Conclusion:** there was a significant reduction in the incidence of the disease in the general population of the municipality. **Contributions to practice:** the availability and adoption of traditional public health measures, such as lockdown, proved essential to reducing cases and deaths from emerging respiratory virus diseases without treatment or vaccine.

Descriptors: COVID-19; Quarantine; Physical Distancing; Incidence.

RESUMO

Objetivo: avaliar os efeitos do *lockdown* na incidência da COVID-19 na fase de emergência sanitária da pandemia. **Métodos**: trata-se de um estudo ecológico transversal. Os dados foram coletados nas páginas da Fundação Sistema Estadual de Análise de Dados e da Prefeitura Municipal de Araraquara. Para analisar a incidência da COVID-19 foram considerados os casos notificados no referido município. Para comparar os períodos em relação aos casos diários, foi utilizado o modelo de regressão com distribuição binomial-negativa com função de ligação logarítmica. **Resultados**: para todas as faixas etárias, com exceção de menores de 20 anos, verificou-se diferença estatística nos coeficientes de incidência. Para o sexo feminino o declínio na incidência da doença foi mais expressivo. Considerando ambos os sexos e todas as faixas etárias, observou-se uma redução de 49% na incidência de casos. **Conclusão**: houve uma redução significativa na incidência da doença considerando a população geral do município. **Contribuições para a prática**: a disponibilidade e adoção de medidas tradicionais de saúde pública, como o *lockdown*, mostraram-se essenciais para reduzir casos e óbitos de doenças de vírus respiratórios emergentes sem tratamento e vacina.

Descritores: COVID-19; Quarentena; Distanciamento Físico; Incidência.

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Introduction

The COVID-19 pandemic has resulted in high morbidity and mortality worldwide, as well as economic and public health crises. In the initial phase of the pandemic, non-pharmacological measures such as frequent hand hygiene, use of masks, isolation of cases, quarantine of contacts and large-scale physical distancing were adopted to reduce the spread of the virus causing the disease, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)[1].

In 2020, in the first year of the pandemic, when there was still no vaccine or specific treatment, physical distancing was recommended for all ages to slow the spread of the disease and prevent the collapse of health systems. Hubei province in China was identified as the first epicenter of COVID-19, recording the first cases of the new coronavirus at the end of December 2019. And after the implementation of physical distancing measures in the territory in January 2020, there was a reduction in the spread of the disease. Thus, throughout the pandemic, studies have shown that physical isolation and lockdown measures adopted in several countries have been effective in controlling the spread of the virus[1-2].

In this context, countries and even municipalities in the same country have adopted different restrictive measures. To this end, the most restrictive isolation measure has become widely known as lockdown, understood as a strict quarantine recommended when the pandemic is out of control to minimize the burden on health services by flattening the epidemic curve of the disease[3].

In Brazil, in December 2020, the incidence of COVID-19 cases began to grow exponentially; later, in early 2021, the circulation of the Gama variant (P.1) was confirmed in Manaus, characterized by being 2.5 times more transmissible than the variant of the first wave[4]. The Gamma variant was associated with the second wave, characterized by an increase in cases among younger people and overall mortality when compared to the first wave. This new variant emerged against the backdrop of the beginning of vaccination against the disease, and during this period the country experienced a critical situation due to the collapse of the health system in some regions, resulting from the high rate of contamination and mortality[5].

In this context, the municipality of Araraquara, in the interior of São Paulo, faced a scenario of a high increase in the incidence of cases and hospitalizations, resulting in the occupation of 100% of the public and private wards and Intensive Care Unit (ICU) beds made available for patients infected with SARS-CoV-2. Due to the collapse of the city's health system, record numbers of deaths, and the circulation of the Gamma variant, a ten-day lockdown was declared in Araraquara on February 21, 2021, extending from February 21 to March 2, 2021[6].

Thus, due to the adoption of the lockdown in Araraquara, the municipality gained prominence throughout the country since strict and highly restrictive measures had not been applied in any other Brazilian municipality. It is noteworthy that, one week after the end of the restriction measures, there was a reduction in the number of COVID-19 cases and in the occupancy rates of ward and ICU beds from 100% to 79 and 91%, respectively; and, one month after the end of the measure, these rates remained at 76 and 92%[6].

Although studies show the impact of mobility restriction measures on reducing the incidence of the disease in the most critical period of the pandemic, corresponding to the first months of 2021, due to the high incidence and mortality from the virus, there are still few studies that evaluate and correlate the incidence coefficient of COVID-19 before and after the adoption of the lockdown implemented in a territory, considering the sociodemographic variables of age and sex[1-3]. Thus, this study was guided by the following research question: What is the influence of lockdown on the incidence of COVID-19 in the population in a scenario of a high number of cases and deaths from the disease?

The aim of this study was to assess the effects

of lockdown on the incidence of COVID-19 during the health emergency phase of the pandemic.

Methods

This is a cross-sectional ecological study analyzing secondary health data. The municipality of Araraquara was chosen because it was the first Brazilian municipality with more than 100,000 inhabitants to declare a continuous lockdown during the most critical phase of the pandemic. During this period, commercial establishments and services that were not considered essential were suspended; in addition, leaving the home was only allowed for the purchase of medicines, the need for medical care or urgency for people or animals, and unavoidable needs, such as going to the supermarket and other food stores[6-7].

In this study, cases reported 32 days before the start of the lockdown, in force from February 21 to March 2, 2021, and 32 days after the implementation of the measure were considered. Thus, the study covered the period from January 21 to April 2, 2021. The analysis of 32 days before and after the lockdown was justified by the need to understand the short-term effects after the implementation of the most restrictive measure imposed to control the pandemic[6].

The data were collected in December 2021, obtained by consulting the website of the State Data Analysis System Foundation (SEADE), available at the São Paulo State Government website, and information regarding the population structure was collected from the official website of the Araraquara City Hall, considering the same number of inhabitants for the years 2020 and 2021[8].

This study analyzed sociodemographic variables (age and gender) and epidemiological variables (confirmed COVID-19 case and outcome). The inclusion criteria were the completeness of notifications regarding sociodemographic and epidemiological variables and the exclusion of notifications before or after the period defined for data collection.

To this end, the date of the confirmed case of COVID-19 notification is considered the date of the onset of symptoms reported by the patient when taking the test. To estimate and compare the incidence coefficients one month before and one month after the start of the lockdown, the age groups under 20, 20 to 39, 40 to 59 and 60 and over were considered.

Initially, a descriptive analysis of the incidence of COVID-19 in the study period and area was carried out, considering sociodemographic variables. To compare the periods before and after the lockdown in relation to the number of daily cases of the disease, the regression model with a negative binomial distribution with a logarithmic link function was used, given that the response was a count with over-dispersion (variance greater than the mean)[9]. A parameter offset from the log (population/10,000) was used to estimate an incidence coefficient.

To estimate the number of cases avoided, simulations were carried out based on the forecast number of cases if the intervention had not taken place. From the estimated number of cases predicted, the number of total cases observed in the period after the intervention was subtracted. In the simulations, 10,000 replications were carried out using the bootstrap method. Subsequently, the simulated samples were summarized by median and percentiles (2.5; 97.5). A 5% significance level was used for the analyses. All the statistical analyses and graphs presented were carried out using R software, version 4.0.4.

As this was a study using secondary data that is publicly accessible and in the public domain, it did not need to be examined by the Research Ethics Committee.

Results

During the study period, 5,442 cases of COVID-19 were reported, considering the date of onset of symptoms reported by the patient who tested positive for the disease in the municipality, of which 32 days before the lockdown, 3,247 cases were confirmed; during the lockdown period, between February 21 and March 2, 2021, 482 cases; and 32 days later, 1,713 cases (Table 1).

Table 1 – COVID-19 cases observed before, during and after the lockdown. São Carlos, SP, Brazil, 2023

Characteristics	Before	Lockdown	After	Total
	n (%)	n (%)	n (%)	n (%)
Age group (years)				
< 20	245 (7.5)	84 (17.4)	195 (11.4)	524 (9.6)
20 - 39	1,350 (41.6)	170 (35.3)	734 (42.8)	2,254 (41.4)
40 - 59	1,150 (35.4)	149 (30.9)	544 (31.8)	1,843 (33.9)
> 60	502 (15.5)	79 (16.4)	240 (14.0)	821 (15.1)
Gender				
Female	1,726 (53.2)	259 (53.7)	670 (39.1)	2,655 (48.8)
Male	1,521 (46.8)	223 (46.3)	1,043 (60.9)	2,787 (51.2)
Total	3,247	482	1,713	5,442

When evaluating the number of daily COVID-19 cases in Araraquara between the sexes, it was found that the trend before the lockdown was an increase in the number of daily cases among females and males; and afterward, the trend became almost constant among women (Figure 1A) and fell slightly among men (Figure 1B).

Regarding the distribution of cases by age group, there was no trend before and after the lockdown among people under 20 (Figure 2A). However, for the other age groups: 20 to 39 years old (Figure 2B), 40 to 59 years old (Figure 2C) and people aged 60 and over (Figure 2D), there was a variation in the trend of COVID-19 cases, with a reduction in daily cases after the measure in the 20 to 39 and 60 and over age groups (Figure 2).
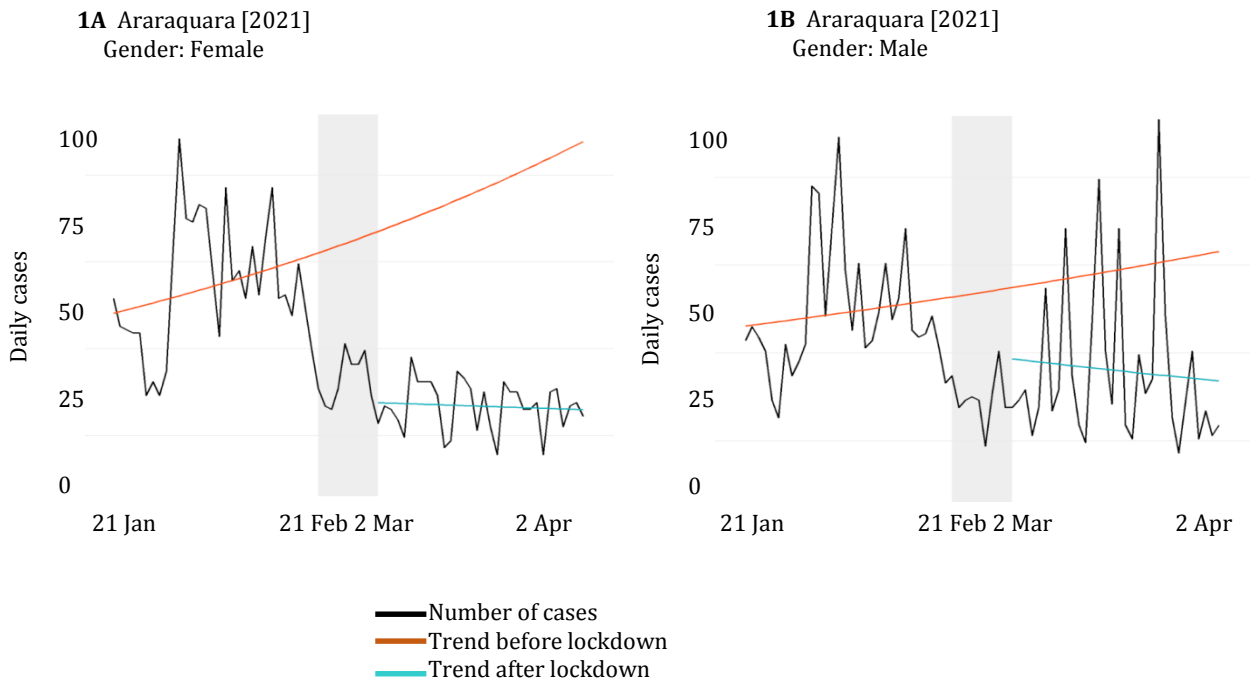
1A Araraquara [2021]
Gender: Female

1B Araraquara [2021]
Gender: Male

Number of cases
Trend before lockdown
Trend after lockdown

Figure 1 – Daily COVID-19 cases for males and females. São Carlos, SP, Brazil, 2023

2A Araraquara [2021]
Age group: < 20 years

2B Araraquara [2021]
Age group: 20 to39 years

2C Araraquara [2021]
Age group: 40 to 59 years

2D Araraquara [2021]
Age group: 60 and over years

Number of cases
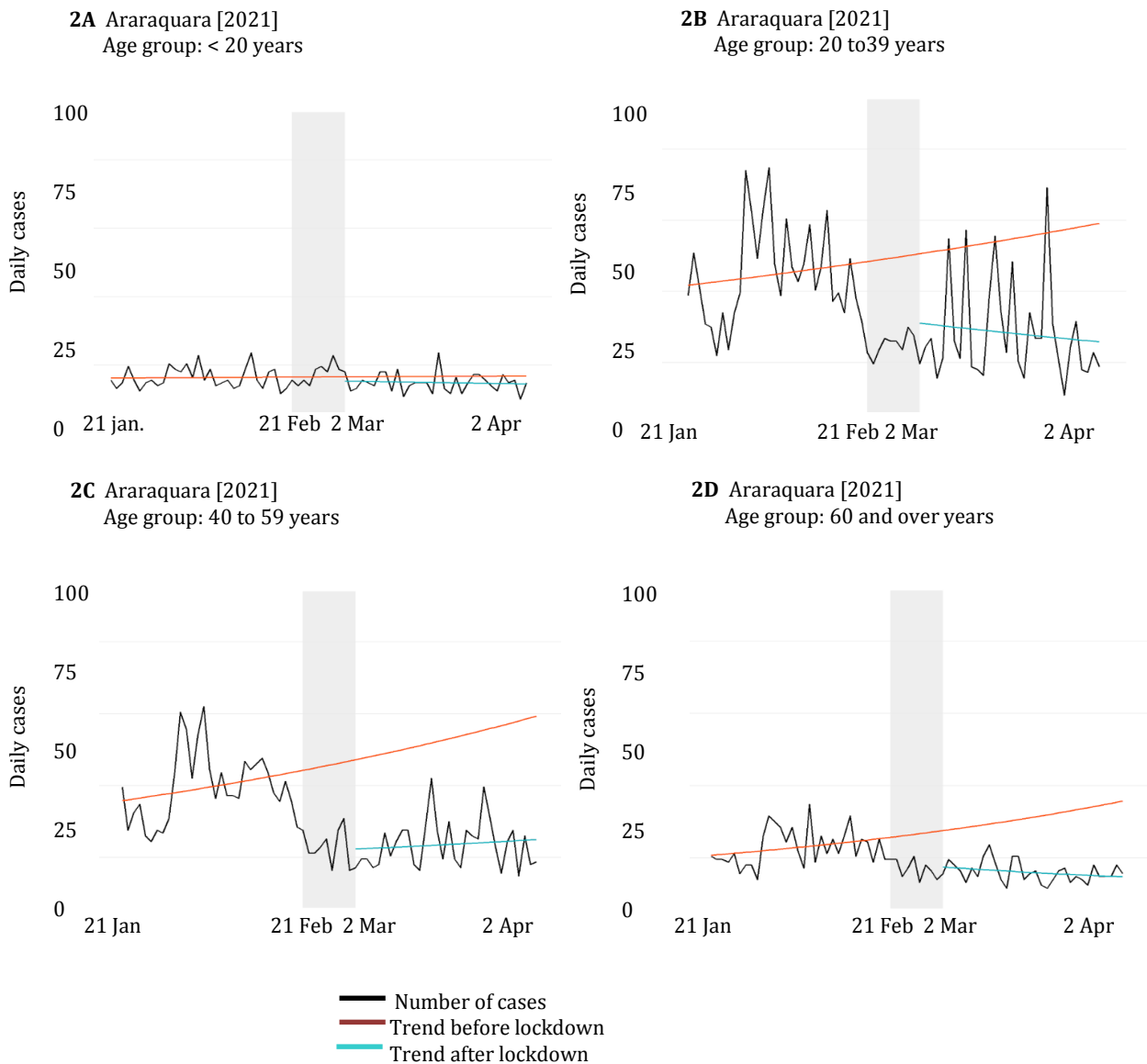Trend before lockdown
Trend after lockdown

Figure 2 – Daily COVID-19 cases by age group. São Carlos, SP, Brazil, 2023

There was no difference between the trends before and after the lockdown in any of the age groups (p>0.05). However, considering the entire population of the municipality, thus covering all age groups, there was an impact on the incidence coefficient. Regarding the analysis by sex, there was a greater decline in incidence in females than in males; however, there was no trend before and after the lockdown in either sex (Table 2).

Table 2 – Results of the regression model for the incidence of COVID-19 cases per 10,000 inhabitants. São Carlos, SP, Brazil, 2023

Variables	Before		After	
	Coefficient	*CI 95%	Coefficient	CI 95%
Age group (years)				
< 20	1.276	1.057–1.541	0.984	0.807–1.198
20 - 39	5.831	5.017–6.775	3.068	2.625–3.586
40 - 59	6.795	5.838–7.91	3.106	2.642–3.653
> 60	5.420	4.592–6.396	2.501	2.072–3.019
Gender				
Female	5.021	4.331–5.82	1.891	1.615–2.213
Male	4.729	4.075–5.487	3.141	2.701–3.651
Total	4.880	4.225–5.638	2.495	2.156–2.888

*95% confidence interval

Note: Incidence coefficient per 10,000 inhabitants and 95% CI estimated by regression models with negative binomial distribution

The simulation of the regression model estimated a reduction, between March 2 and April 2, 2021, of around 27% of COVID-19 cases among individuals under the age of 20, 59% between the ages of 20 and 39, 68% between the ages of 40 and 59, and 72% for those aged 60 and over. In addition, there is an estimated 75% reduction in expected cases among women in the period corresponding to 32 days after the lockdown and 46% among men. Considering the general population, a 63% reduction in expected cases is estimated (Table 3).

Table 3 – Observed, predicted, and avoided COVID-19 cases one month after the lockdown. São Carlos, São Paulo, Brazil, 2023

COVID-19 cases*	Observed	Predicted	Avoided	
			Median	Percentiles (2.5% – 97.5%)
Age group (years)				
< 20	195	267	72	71 – 73
20 - 39	734	1,789	1.055	1.020 – 1.091
40 - 59	544	1,719	1.175	1.125 – 1.226
> 60	240	855	615	581 – 650
Gender				
Female	670	2,675	2.005	1.920 – 2.093
Male	1,043	1,956	913	879 – 948
Total	1,713	4,628	2.915	2.798 – 3.036

*In the period from Mar 2nd 2021 to Apr 2nd 2021

Discussion

This study indicated that the implementation of the lockdown in the municipality of Araraquara influenced the significant reduction in the incidence of daily COVID-19 cases during and after the end of the mobility restriction measure.

In terms of gender and the effects of the lockdown on the incidence of the disease, a different pattern was observed among women than among men. The higher reporting of cases among men may be associated with various factors, such as biological factors, the impact of the pandemic on working conditions, and behavioral factors, such as lower adherence to preventive measures like hand hygiene and mask use[10]. Resistance to wearing masks by part of the male population can be seen as a way for them to assert their gender identity to themselves and to people[11].

In addition, a lower capacity for the initial innate immune response in males and a greater susceptibility to infection among males have been described due to the greater expression of Angiotensin Converting Enzyme 2 (ACE2) receptors, which are the functional cell receptors used by SARS-CoV-2 to enter the host's cells, and the role of androgen receptors in facilitating the entry of the virus into cells[12].

In Canada, there was a higher incidence of cases among women than men. However, after excluding risk groups such as healthcare workers and residents of long-term care facilities, a lower incidence was observed among women than among men. A lower incidence of COVID-19 was also observed among women of reproductive age, aged between 20 and 49, when compared to men of the same age[13].

Women of reproductive age have a higher amount of circulating estrogen than men, thus suggesting that estrogen may play a fundamental role in reducing the incidence of the disease. Thus, estrogen plays an important role in immune modulation and non-immune mechanisms, acting to reduce the capacity for infection by modulating pro-inflammatory signaling pathways, conferring a protective effect in the context of SARS-CoV-2 infection[13-14].

Furthermore, the lower incidence rate of CO-VID-19 in females observed after the end of the lockdown altered the pattern of higher incidence in this sex observed in the periods before and during the measure and may be associated with greater acceptance and adoption of preventive measures after the end of the lockdown, such as the use of masks[15].

When considering the occurrence of COVID-19 and deaths by age group in Brazil, in the first six weeks after confirmation of the first death from the disease, 72% of deaths were recorded in individuals over 60 years of age, although most of the records of infected individuals were concentrated in the adult age group[16]. With the progress of the vaccination campaigns, there has been a change in the patterns of death from the disease, with an increased risk of death among younger, unvaccinated elderly people, no longer concentrated at the extremes of age[17].

The higher incidence of COVID-19 found in this study in individuals aged 20 and over can be explained by the fact that they are the most economically active population in the municipality. In the context of the pandemic, it should be noted that workers in services considered essential are at high risk of infection by SARS-CoV-2. Thus, considering 600 sectors of the country's economy, it was concluded that those most exposed to infection by the virus were health workers. Several sectors require physical proximity to operate, increasing the risk of contamination among these workers, such as the education sector and the retail trade[18-19].

In this context, an analysis pointed to the impacts on working conditions during the pandemic, especially for men in situations of social vulnerability, where the phenomenon known as the 'uberization' of work is rooted in vulnerability, which, in addition to the loss of individual and collective identities, is based on insecurity and the weakening of workers' organizations. This phenomenon was intensified during the pandemic since many labor categories did not allow remote working, exposing workers to a greater risk of contact with the virus, such as delivery workers, a job

mostly performed by men in the country, which could be one of the possible explanations for the increase in COVID-19 cases observed in this gender[20-21].

This study shows a higher incidence rate of the disease among economically active age groups, highlighting the risk of contamination among workers in essential sectors who are unable to work remotely. Professionals from different areas worked in close physical proximity to other workers, exposing themselves to the risk of SARS-CoV-2 infection[19]. On the other hand, the lower incidence of cases among those under the age of 20 is related to the greater physical distancing in this group due to the closure of schools and universities, as well as corresponding to the lowest percentages related to occupation. This reinforces the importance of physical distancing and mobility restriction measures to contain the spread of the virus.

It should be noted that in the initial phase of the pandemic, China was the first country to impose strict restrictions on people's mobility. After the lockdown was implemented, there was a significant drop in daily COVID-19 cases in the population, as opposed to the period before the intervention began, when the number of daily cases was increasing. When comparing the periods before and after the lockdown, there was a 69% reduction in the occurrence of daily cases in the country[22].

An analysis of 152 countries, considering four categories of social contact, found that well-timed lockdowns can segment the peak of hospitalizations into two smaller peaks and prolong the total duration of the pandemic, inhibiting the collapse of the health system[23]. In the state of São Paulo, it was observed that the adoption of relatively early isolation extended the duration of the first wave of the COVID-19 pandemic, delaying its peak[24].

In this context, in Italy in 2020, it was observed that a lockdown period of fourteen days would not be sufficient for most scenarios, requiring a longer duration to effectively interrupt the transmission of the virus. The period of implementation of the lockdown

measure in Italy took place during the initial period of the pandemic, when the capacity for dissemination and complications of COVID-19 were unknown, adding to the fact that health services were not prepared for the high demand. Also, to be considered is the country's demographic profile, which is characterized by an elderly population, an age group that is at greater risk of clinical complications from the disease[25].

The findings of this study demonstrate the effectiveness of a ten-day lockdown in reducing the COVID-19 incidence coefficient; however, it should be noted that the municipality, during the period when the measure was implemented, was experiencing a different phase of the pandemic when compared to Italy, since at the beginning of 2021 the Gama variant was circulating in Araraquara, with different dissemination and severity characteristics from the variant present in Italy in 2020[6]. Furthermore, the demographic profile of Araraquara differs from the advanced population aging profile found in Italy, with a younger population.

Internationally, countries that have implemented lockdowns have seen a reduction in the daily incidence of COVID-19 cases in the three-week period following the start of the measure. In general, there was a reduction in the incidence of the disease around fourteen days after the implementation of the measure. In the United States and Brazil, which had not implemented the measure nationwide, there was no significant reduction in the period[26].

Study limitations

Although this study analyzed sociodemographic and epidemiological variables, it may be subject to possible limitations due to the underreporting of COVID-19 cases during the period. It also shows that other events, in addition to the lockdown, may have been important in reducing the incidence in the municipality, such as the start of vaccination, which began in the state of São Paulo on January 17, 2021, and the adoption of preventive measures that include hand hygiene and the use of masks.

Contributions to practice

It is important to discuss and strengthen the literature on the effects of lockdown in the face of a health emergency, considering that, in the context of an emerging disease with a lack of vaccines and specific treatment, the adoption of traditional public health measures becomes fundamental. The adoption of lockdown measures predates the COVID-19 pandemic, with records dating back to the Spanish flu of successful implementations to reduce the contamination of people and flatten the curve.

When analyzing the history of humanity, it is known that the population is exposed to new pandemics, especially those caused by respiratory spread, so it is essential for managers to be knowledgeable and prepared to plan and implement restrictive measures such as lockdown.

Conclusion

This study made it possible to identify the positive impact of the lockdown implemented in the municipality of Araraquara, signaled by the significant reduction in the daily incidence coefficient of the disease in the city, as well as the different patterns of decline among different age groups and genders.

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Authors' contribution

Conception, planning, analysis, interpretation and writing of the work, final approval of the version to be published and responsibility for all aspects of the manuscript: Poli P, Uehara SCSA.

Interpretation and writing of the work, final approval of the version to be published and responsibility for all aspects of the manuscript: Ribeiro AC, Corrêa APV.

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