

The effect of social distancing measures on the incidence of COVID-19 in Brazil: A multisectoral analysis

Lucas Emanuel de Oliveira Silva¹ , Thiago José Matos Rocha¹ , Dalson Britto Figueiredo Filho² 

ABSTRACT

Objective: This article estimates the impact of social distancing measures on the incidence of COVID-19 from a multisectoral perspective. **Methods:** The research design uses a panel regression model to analyze the relationship between mobility restrictions in different economic sectors and the longitudinal dynamics of the infection across Brazilian states. **Results:** The main results indicate that only the coefficients for the restaurant (p-value < 0.05), shopping (p-value < 0.05), and transport sectors (p-value < 0.001) reached statistical significance. In particular, transport ($\beta = -0.674$) is the variable with the strongest impact on the variation in the number of COVID-19 cases. **Conclusions:** The evidence reported in this research can assist the decision-making process of government managers regarding the effectiveness of non-pharmacological interventions as a tool to reduce the spread of COVID-19.

Keywords: SARS-CoV-2, COVID-19, Distanciamento social, Modelos lineares.

1. Universidade Estadual de Ciências da Saúde de Alagoas (UNCISAL), Curso de Medicina, Maceió, (AL), Brazil.
2. Universidade Federal de Pernambuco (UFPE), Departamento de Ciência Política, Recife, (PE), Brazil.



INTRODUCTION

COVID-19 is the greatest global public health threat of the 21st century¹. There is consensus in the literature that vaccines are the most effective strategy to flatten the spread curve and reduce disease mortality². However, in view of the high demand for immunizers on the international scene and the operational and logistical difficulties faced by countries, mass vaccination is still a challenge for several nations³.

Although Brazil is one of the countries that applies more vaccine doses in the world, vaccination campaigns have been attacked in political-ideological speeches by members of the Executive branch. This has caused a phenomenon of vaccine hesitation in the population⁵, transforming the country into a large repository of SARS-CoV-2 and its variants⁶.

This scenario points to a long way to go to meet vaccination goals. Therefore, non-pharmacological interventions, especially social distancing measures, are still an important tool for containing SARS-CoV-2 transmission¹.

As time goes by and the epidemiological scenario changes, social and economic pressures often make governments face calls for more restrictive or flexible measures⁷. In addition, various social sectors claim priority to resume activities⁸. Fearing electoral consequences, public managers are often led to make political decisions to the detriment of the existing scientific recommendations⁹.

The aim of this paper is to analyze the relationship between social distance measures on the incidence of COVID-19 in Brazilian states from a multi-sectoral perspective. Specifically, it aims to evaluate the impact of mobility restrictions in different economic sectors on the dynamic of the infection in Brazilian states.

METHODS

Data

Data on legal measures of social distancing (Social Distancing Index – IDS in Portuguese) were obtained through the project Measures of Physical Distancing in Brazil, by the Institute for Applied Economic Research (IPEA)¹⁰. Information on the incidence of COVID-19 was extracted from the repository elaborated by Cota¹¹. For each sector, the distance measures values were coded using qualitative analysis of government decrees and assumed the following categories: “non-existent”, “partial”, or “total”. Table 1 summarizes this information.

The database is organized by state with epidemiological information collected daily between March 20, 2020 and December 31, 2020. The analysis period is justified for two reasons: a) to avoid possible confounding effects that may be associated with the start of vaccination in 2021 and b) information on the adoption of social distancing measures is only partially available for 2021 (the series was interrupted on April 11, 2021).

Statistical Analysis

A regression model panel is employed to estimate the effect of restriction measures in economic sectors on the incidence of COVID-19 cases in states. The objective of this technique is to estimate the degree of association between the dependent and independent variables over time across different units of analysis¹²⁻¹⁴.

Table 1. Description of variables.

Variable	Description	Values
events	Suspension of events and activities by cultural, sports, or religious establishments	
restaurants	Suspension of activities in bars, restaurants, and similar establishments	
commerce	Suspension of activities by other commercial and service establishments, except essential ones	0 = Nonexistent; 1 = Partial; 2 = Total
industry	Suspension of industrial establishments activities, except essential ones	
education	Suspension of classes	
transport	Restrictions on transporting passengers by land, waterway, or sea	

Source: Moraes¹⁰.

In general, the classical notation of the linear regression model is defined as follows:

$$Y_i = \alpha + \beta X_i + \epsilon_i \quad (1)$$

Where Y corresponds to the dependent variable. In turn, α is the model's intercept, i.e., it is equivalent to the value of the dependent variable in the absence of independent variables. β is the regression coefficient and represents the observed effect in Y associated with an increase of one unit in the independent variable (X). The subscript *ii* indicates that the observations are indexed by case. The ϵ represents the stochastic term, equivalent to the inherent error in predicting Y from X.

The panel regression model is an extension of the linear model and assumes the following annotation:

$$Y_{it} = \alpha + \beta X_{it} + \epsilon_{it} \quad (2)$$

The interpretation is the same; the difference consists in the presence of two subscripts: *i* and *t*. They indicate that the observations are indexed by case and time, respectively. With this, the model becomes more explanatory, as it accumulates information about the relationship between the variables of interest for various states and months.

The dependent variable of the model is the incidence rate of COVID-19. The independent variables are the indices of legal measures of social distancing described in Table 1. Originally, this information was arranged temporally by day. However, many values were repeated due to the independent variables' degree of measurement. For this reason, it was decided to use the monthly average instead of the daily registered value.

Given this, the regression model developed is defined algebraically as follows:

$$Y_{incidence_{it}} = \alpha + \beta X_{events_{it}} + \beta X_{restaurants_{it}} + \beta X_{commerce_{it}} + \beta X_{industry_{it}} + \beta X_{education_{it}} + \beta X_{transport_{it}} + \epsilon_{it} \quad (3)$$

In this way, it is possible to estimate the effect that the sectoral restriction produced on the number of daily cases. Next, it will be possible to analyze which type of economic activity had the greatest impact on reducing the rate of infection in the state.

Computational Tools

The data were analyzed using R Statistical Software 4.0.5. All significance tests were two-sided, considering p-value < 0.05. Materials for replication, including raw data and computational scripts, are available at: < <https://osf.io/cwtda/>>.

RESULTS

Table 1 describes the average of the IDS indicators recorded in the states between March and December 2020. The education sector suffered the highest level of restrictive sanctions during the period ($\bar{X} = 1.67$). Next comes the events sector ($\bar{X} = 1.17$). Restaurants ($\bar{X} = 0.86$), shopping ($\bar{X} = 0.66$), and transportation ($\bar{X} = 0.58$) follow the list. The industrial sector presented the lowest level of restriction ($\bar{X} = 0.08$).

Figure 1 illustrates the variation in the IDS over the period analyzed among the states, allowing the observation of similarities and differences regarding the restriction profiles adopted among the states. Piauí ($\bar{X} = 1.16$), Ceará ($\bar{X} = 1.09$), and Rio Grande do Sul ($\bar{X} = 1.06$) were the ones adopting the strongest restrictions, on average, during the period. Tocantins ($\bar{X} = 0.55$), Paraná ($\bar{X} = 0.52$), and Mato Grosso do Sul ($\bar{X} = 0.35$) were the least restrictive.

The restriction of educational activities and the liberalization of the industrial sector are present in almost all states. Another common feature is an increase in restrictions in the initial months (March and April) and some easing in the final months (October, November, and December).

Finally, Table 2 shows the coefficients of the regression model. A random effects model was estimated on a cross-section dominant panel of 270 observations, where $n = 27$ (total states) and $T = 10$ (months analyzed). The r^2 of 0.36 indicates that the model explains 36% of the variance in the dependent variable.

The coefficients assumed the theoretically expected sign, except for the education variable. In principle, the restrictions would exert a negative effect on the incidence of cases of COVID-19 because the lower the level of movement of people in the economic sectors, the lower the spread of cases of the disease in society.

Table 1. Average of IDS indicators from March to December 2020.

Categories	Months										Overall average
	Mar 2020	Apr 2020	Mai 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	
events	1.05	1.67	1.53	1.39	1.08	1.00	1.00	1.00	1.00	1.00	1.17
restaurants	0.75	1.50	1.37	1.29	0.94	0.66	0.58	0.51	0.48	0.50	0.86
commerce	0.67	1.23	1.08	0.93	0.73	0.58	0.43	0.31	0.28	0.31	0.66
industry	0.11	0.20	0.16	0.10	0.09	0.07	0.03	0.01	0.00	0.00	0.08
education	1.18	1.93	1.93	1.93	1.89	1.85	1.78	1.56	1.36	1.30	1.67
transport	0.45	0.94	0.99	0.87	0.69	0.57	0.45	0.32	0.26	0.26	0.58

Source: Elaborated by the authors.

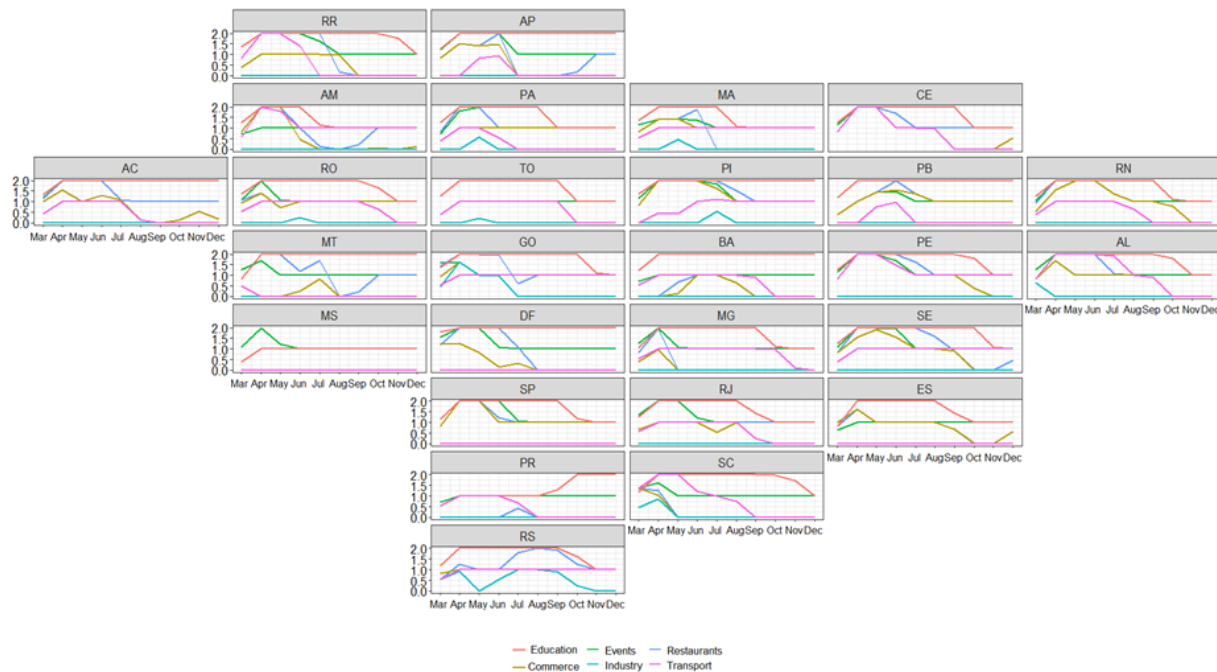


Figure 1. Variation in the IDS among federal units.

The fact that the coefficient of the education variable takes on a positive sign does not necessarily indicate that the restrictions in this sector are related to an increase in incidence. This analysis needs to be done with caution since we are dealing with data aggregated and categorized from content analysis. Measurement problems can be directly linked to the behavior of this variable. In addition, because of Brazilian federalism and local characteristics, the

implementation of restrictions in this sector may be the responsibility of municipalities and not the state, which is not captured by the indicator.

Another point of analysis concerns statistical significance. Although the directions were the ones theoretically expected in almost all variables analyzed, only the restaurant (p-value < 0.05), shopping (p-value < 0.05), and transportation sectors (p-value < 0.001) obtained significance. In particular,

Table 2. Coefficients of the regression model.

	Model 1
(Intercept)	3646.86 *** (506.55)
mean_events	-625.99 (374.29)
mean_restaurants	-655.04 * (255.50)
mean_commerce	-630.10 * (291.37)
mean_industry	-81.39 (412.16)
mean_education	293.41 (245.97)
mean_transport	-933.05 *** (229.98)
nobs	270
r.squared	0.36
adj.r.squared	0.34

*** p < 0.001; ** p < 0.01; * p < 0.05.

Source: Elaborated by the authors.

the transportation coefficient had the largest effect on the dependent variable ($\beta_{std} = -0.674$), being the variable that had the most impact on reducing the incidence of COVID-19.

DISCUSSION

The effect of social distancing measures has been demonstrated by the literature since the first wave of Covid-19 infection in Brazil. Cruz¹⁵ points out that distancing strategies had a significant impact on the reduction of the number of deaths in the state of São Paulo. Silva et al.¹⁶ found a statistically significant reduction in new cases in Recife, Fortaleza, São Luís, and Belém. In addition, they also detected a reversal in the trend of daily deaths. Figueiredo Filho and Silva¹⁷ identified that distancing measures also reduced the curve of cases in Araraquara, a city in São Paulo that had an abrupt increase in cases in early 2021 due to the presence of the P1 variant.

However, the studies that measure the effect of these policies analyze the most rigid degree of social distancing, lockdowns. These measures have a series of negative externalities, and for this reason, they must be used carefully, with a clear justification and a reasonable expectation of net benefit in population health¹⁸. For this reason, this measure also has a short timeframe, which causes its effects to be null in the medium and short term.

Most governments only adopt lockdown policies as a last resort in the fight against the pandemic. In this sense, social distancing measures do not assume a dichotomous character (open or close everything), but vary in a continuum, where restrictions assume levels and can vary according to the functioning of each social sector. The indicator used in this analysis (IDS) captures this dynamic.

Under this perspective, Silva et al.¹⁹ initially analyzed the social distancing measures for coping with COVID-19 in Brazilian states in the first month of the pandemic. They observed that the policies were adopted by almost all states before or at the early stage of the exponential growth curve of cases and deaths.

More recently, Moraes²⁰ used the IDS to compare the distancing policies adopted by the states during the 1st and 2nd waves. Initially, the states tried to anticipate a possible scenario of the collapse of the health system and adopted the measures on a large scale. Contrary to what they had done in the beginning, the governors were slow to adopt more rigid measures in the second wave, something that only came about with the pressure imposed on the health system. A behavioral change in the population in relation to the pandemic was also observed between the outbreak of the two waves of infection²⁰.

Economic activities are the areas directly affected by the adoption of social distancing measures, from the mildest to the strictest given that companies rely heavily on face-to-face communication or physical proximity to produce a product or provide a service²¹. Although all sectors registered retractions, some managed to adapt to the new scenario imposed by the disease and minimized the damage.

The reduction in service hours and service capacity of establishments has led retail and restaurant entrepreneurs to use e-commerce as the main sales platform²². Delivery apps have seen an increase in demand for delivery since the beginning of the pandemic²³.

However, the same phenomenon cannot be observed in the events sector. The control of agglomerations caused by events having to be canceled or rescheduled caused great losses to their organizers²⁴. On the other hand, this sector is a critical point in the control of the dissemination of cases, since it encourages the grouping of people in inadequate conditions of air circulation.

In turn, the effect observed in the industrial sector can be justified by the fact that almost all sectors were classified as essential services, as they involve raw material transformation activities directly linked to supply and support activities²⁵.

The transportation sector was initially affected by restrictions on flights and ground travel²⁶. The virus takes hold in large cities by air. It then spreads to the countryside by land travel²⁷. Despite being severely impacted at first, travel generally resumed with the adoption of health protocols²⁸. The biggest problem in the sector is public transportation, which is responsible for the daily displacement of millions of people in large urban centers²⁹.

Although the restrictions on the education sector try to help reduce the incidence of new cases, the damage to the learning process can already be seen. Worldwide, the closure of educational institutions has affected more than 1.6 billion students³⁰. This has resulted in the traditional pedagogical approach being forcibly replaced by remote learning³¹. In addition to further highlighting educational inequalities, this context can also lead to a reduction in student achievement, especially in early childhood³².

Despite the model's predictive limitations, this paper seeks to contribute to the literature examining the relationship between measures of social distance and COVID-19 by incorporating a new type of approach.

CONCLUSIONS

The theoretically expected effect was observed in almost all the variables analyzed. However, only the restaurant, shopping, and transportation sectors obtained statistical significance. In particular, the latter had the greatest effect on the dependent variable. By analyzing restrictions at the sector level, the article hopes to collaborate in the decision-making process of government managers regarding the adoption of restriction measures and relaxation of distancing. The findings reinforce the importance of social distancing as an important tool for controlling the incidence of COVID-19.

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Contributions

Lucas Silva: Study conception and design; data interpretation and statistical analysis; manuscript writing;

Thiago Matos: Study conception and design; revision of the manuscript;

Dalson Figueiredo Filho: Statistical analysis; writing and revision of the manuscript.

Funding Information

CNPQ.

Corresponding Author:

Lucas Emanuel de Oliveira Silva

lucas.silva@academico.uncisal.edu.br

Editor:

Prof. Dr. Felipe Villela Gomes

Received: feb 16, 2022

Approved: may 30, 2022
