



# Effect of physical distancing on Covid-19 incidence in Brazil: does the strictness of mandatory rules matter?

Raphael Mendonça Guimarães<sup>1,\*</sup>, José Henrique Costa Monteiro da Silva<sup>2</sup>,  
Gustavo Pedroso de Lima Brusse<sup>3</sup> and Thalyta Cássia de Freitas Martins<sup>4</sup>

<sup>1</sup>Fiocruz' Observatory Covid-19, Oswaldo Cruz Foundation, Ministry of Health, Leopoldo Bulhões Street, 1480, 9th Floor, RJ 21041-960, Brazil

<sup>2</sup>CELADE, Population Division of the Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL), Avenue Dag Hammarskjöld 3477, Vitacura, Santiago de Chile 7630412, Chile

<sup>3</sup>University of Campinas (UNICAMP), Av. Albert Einstein, 1300, Cidade Universitária, Campinas, SP 13083-852, Brazil

<sup>4</sup>National School of Public Health, Oswaldo Cruz Foundation, Ministry of Health, Leopoldo Bulhões Street, 1480, 9th Floor, RJ 21041-960, Brazil

\*Corresponding author. Fundação Oswaldo Cruz, National School of Public Health, Department of Social Sciences, Leopoldo Bulhões Street, 1480, 9th Floor, RJ 21041-960, Brazil. E-mail: [raphael.guimaraes@fiocruz.br](mailto:raphael.guimaraes@fiocruz.br)

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## Abstract

This study aims to examine the association between physical distancing measures and coronavirus disease 2019 (COVID-19) incidence among Brazilian states. We divided the methodology into three steps. In the first step, we used nationwide global positioning system daily data to estimate country and state-level physical distancing and examined the association with COVID-19 incidence through a Generalized Additive Model. Secondly, using National Household Sample Survey COVID-19 data, a cluster analysis categorized the Brazilian states into different categories of physical distancing policies promoting adoption and political inclination of their governments. Finally, through a Poisson Regression Model, we examined the association of state physical distancing with variables related to the socio-economic situation, test coverage and early adoption of policies promoting physical distancing of each state. Physical distancing effects on reduction of COVID-19 spread are heterogeneous among states. Estimation of incidence rate ratio (IRR) suggests that in a scenario of 100% of social isolation incidence of COVID-19 will have reached approximately only 2.6% of the magnitude compared to when there is no social isolation for Brazil [95% confidence interval (CI) 0.8–8.3]. Only a 10% increase in Social Isolation Index in the country could have reflected in a 30.5% decrease in number of cases in 14 days. Adoption of physical distancing was associated with test coverage (IRR 0.976, 95% CI 0.973–0.979), home office (IRR 1.042, 95% CI 1.039–1.046), informal work proportion (IRR 0.961, 95% CI 0.958–0.965), political spectrum (IRR 0.961, 95% CI 0.958–0.965) and early moment of restrictive politics implementation (IRR 1.017, 95% CI 1.013–1.021). Physical distancing measures play a crucial role in mitigating the pandemic's spread. These analyses are crucial to support government decisions and improve the community's adherence to preventive measures.

**Keywords:** COVID-19, incidence, physical distancing, time series, Brazil

## Key messages

- In a scenario of 100% of social isolation, incidence of COVID-19 would have reached approximately only 1.9% of the current magnitude in Brazil.
- The geographic scale is an effect modifier in the association between social distance and the incidence of COVID-19 in Brazil.
- The pattern of social distancing measures and time of adopting them differs in Brazilian states.
- The political spectrum, the types of distance measures and the strictness of mandatory physical distancing rules are mediators of this association.

## Introduction

In March 2020, the World Health Organization (WHO) declared a coronavirus disease 2019 (COVID-19) pandemic state (Zhonghua *et al.*, 2020). At the end of 2020, Brazil

has more than 7.5 million registered cases and almost 200 thousand deaths due to COVID-19. The panorama of disease by states shows essential differences in the behaviour of the trend. In December 2020, 26% of the states had a drop in deaths. However, 40% of states tend towards stability, and 26% tend to have increase in cases (Brasil, 2020).

The large number of deaths caused by this disease has led several countries to adopt measures to contain it. Several countries adopted physical distancing to control the spread of COVID-19 (Prem *et al.*, 2020). One way to observe the effectiveness of physical distance is through the Social Isolation Index (SII). Despite its name, this index evaluates how populations adhere to physical distancing to mitigate virus dissemination. In Brazil, the highest SII was registered on 22 March 2020 (62.2%), and on 9 June, the country had an SII of 38.2% (Aquino *et al.*, 2020).

Brazil implemented measures of physical distancing in the initial phase of the exponential growth curve of cases and deaths from COVID-19 in most states (Silva *et al.*, 2020b).

The spread of the virus possibly happened before the interventions that started to reduce mobility within the Brazilian territory, including the closing of shops and schools, implemented mainly from mid-March 2020. Even so, right at the beginning of the pandemic, the physical distance, although adopted after the virus had spread, reduced the transmission rate from 3 to 1.6 contaminated per infected person (Candido *et al.*, 2020).

However, restriction and isolation measures were carried out in a decentralized manner in Brazil. In April 2020, the Supreme Court ruled that the government of states and municipalities would also have the power to define their isolation and quarantine measures in addition to the Federal Government. Since then, state governments have adopted several measures to contain the spread of the virus (Martins-Filho *et al.*, 2021). This decision reflected the significant political instability created in the country around the pandemic mitigation strategies. Since the beginning of the pandemic phase, Brazil has replaced the Minister of Health four times. Social distancing seems to have been effective until mid-November. The drop in the number of cases and deaths at the end of 2020 created the expectation that the pandemic was entering its final phase. Gradually, the population relaxed the physical distance measures. Even with the explosion of cases between the end of March and the month of April 2021, the resumption of distancing was not robust. In addition, the country has experienced demonstrations against social isolation and lockdown (Testa *et al.*, 2021). It is worth mentioning that the Federal Government, many times, exposed positions against the measure.

In fact, Brazil has a great diversity of socio-economic and human development contexts at the regional level. This heterogeneity resulted in a delay at the beginning of the incidence of COVID cases in the states. Besides, regional differences have been reflected in the population's adherence to physical distance measures (Natividade *et al.*, 2020). Also, the pattern of Brazilian federalism provided states with autonomy in defining a strategy to mitigate COVID-19 and the epidemiological moment for implementing measures (Brazilian Supreme Court, 2020). However, the effectiveness of these policy interventions on morbidity remains unknown. Thus, this study examined the association between physical distancing measures and COVID-19 incidence in Brazil and states.

## Methods

### Data source

We used daily information from COVID collected by the epidemiological surveillance of the Brazilian Ministry of Health.

The physical distancing measure was elaborated using smartphone geolocation data by the start-up InLoco™ and estimates the percentage of population respecting the physical distancing recommendations (InLoco, 2020). Monitoring consists of using data collected through apps in over 60 million smartphones in Brazil, producing data like Google Mobility Reports. The index has values expressed in percentages, in which 100% is a hypothetical situation in which the whole population stays at home for an entire day.

We obtained socio-economic, labour market and COVID-19 testing coverage data at the state level from the Brazilian Statistics Bureau during the National Household Sample Survey (PNAD) in its special issue COVID survey

(PNAD COVID19). PNAD COVID19 is pioneering because they constitute the first release of Experimental Statistics prepared in Brazil (Penna *et al.*, 2020).

Also, we collect information on physical distancing measures from decrees, laws, ordinances, technical notes and state deliberations to categorize measures of physical distance.

### Data analysis

We initially checked whether the time series that described the level of physical distance and the occurrence of cases with a time lag of 14 days were associated. The association was persistent for the country and the states, but its magnitude was quite variable. Therefore, we tried to characterize the states regarding the rigidity and temporality of adopting physical distance measures. This analysis allowed us to group the states into two groups. Finally, we use this classification of groups, together with other socio-demographic variables of the states (such as the participation of the population in the informal market, the level of activity in the home office and the coverage of COVID-19 diagnostic testing), to assess the extent to which these potential confounders explain the difference between states. Following a step-by-step description of methods employed.

### GAM

We fitted a Generalized Additive Model (GAM) with non-parametric smoothers to control seasonal patterns. We chose the Negative Binomial Regression Model instead of Poisson Regression Model due to over-dispersion of daily COVID-19 cases information. Formally:

$$E(Y_i) = \exp[\alpha + S_0(\gamma, i) + \beta * SII_t]$$

Where  $\beta$  is the coefficient (slope) for SII and  $S_0(\gamma, i)$  is the smooth function of date ( $i$ ).

To investigate the physical distancing–COVID-19 incidence relationship, we added a smooth function for physical distance to each model and the smoothed effect plotted. We conducted it for daily SII over 14 days previously to daily COVID-19 incidence (Lags 0–14) to assess effects delayed up to this duration. We evaluate each statistical model's goodness of fit from the model residuals, the dispersion-penalized AIC (Akaike Information Criterion) and the partial autocorrelation function to determine the degree of remaining autocorrelation (non-independence of adjacent days). We used Negative Binomial GAM regression to determine the relative risk (RR) of incidence associated with a 10% change in SII. We discussed results in terms of percentage changes, which we derived from the RR using the following formula:

$$\% \text{ change} = (RR - 1) * 100\% \text{ change} = (RR - 1) * 100$$

After adjusting for temporal variation as described above, no significant autocorrelation remained. We repeated the analysis for models with separate incidence counts for all Brazilian states and federal districts to explore the potential modification of physical distancing–COVID-19 incidence effects of area-level differences.

### Cluster analysis

From the characterization of the legal documents of isolation measures, we adopted the categorization criteria previously

defined by the study by [Silva et al. \(2020b\)](#) to assess the delay in taking distance measures: suspension of events, suspension of classes, quarantine of risk groups, economic paralysis (full or partial) and restriction of transport. We updated the documentary information collection to match the same period and reference of PNAD COVID19 for the incidence data of COVID-19 and the SII.

We categorized the epidemiological moment into five categories: did not present this measure; early measure (before the first case), an intermediate measure I (Case 1 to Case 10), and an intermediate measure II (Case 11 to Case 50); and a late measure (after Case 50).

Also, we classify state administrations according to the political inclination of their governments (right, left and central wing). We used these variables to characterize the Brazilian states and the federal district, performing state-level cluster analysis. After computing Gower's similarity coefficient, we performed a hierarchical clustering approach to construct an index for categorical data distance.

### Poisson model

Our analysis's final step was to estimate the association between specific strategies and physical distance among states.

We obtained the estimated count of people in the physical distance from the SII and the states' population in the reference period. We use a component (offset) responsible for controlling the number of people at a distance by each state's population.

Formally:

$$E(Y) = \frac{\mu^{Y_i} e^{-\mu}}{Y_i!}$$

Where  $E(Y)$  is the conditional expected value of the response variable  $Y$ ;  $\mu = e^{\beta_0 + \beta_i X_i}$  and  $\beta_i$  is the parameter of the variables included in the model.

To estimate the parameters, we used the maximum likelihood estimation method, based on the following postulate:

$$L(\beta) = \prod_{i=1}^n \frac{[\mu(X_i, \beta)]^{Y_i} \exp[-\mu(X_i, \beta)]}{Y_i!}$$

We used as covariates some indicators described in PNAD COVID: COVID-19 test coverage among the whole population, the proportion of employed people working from home and the proportion of workers employed in the informal sector. We divided the states into the indicators' distribution tertiles.

Finally, we include a variable that describes the state government's political spectrum, indicating whether it is a centre, left-wing or right-wing government. We chose to use this variable to assess whether the population's adherence to physical distance can be associated with the ruler's political spectrum. Over the past few months, right-wing governments have minimized the effects of the pandemic in Brazil ([The Lancet Editorial, 2020](#)).

We use Pearson's Chi-Square and its respective  $P$ -value to compare the frequency in each covariate category. We tested the explanatory variables individually and added them to the model whenever they showed statistical significance ( $P < 0.05$ ) using the forward method. We calculated each variable's crude

and adjusted prevalence ratios according to the best model obtained by the maximum likelihood statistics. We still estimate the confidence intervals (CIs) at a 95% significance level.

All statistical analyses were carried out using the statistical package R.

## Results

Brazil displays substantial internal heterogeneity in terms of its states' demographic and socio-economic characteristics. Therefore, the COVID-19 pandemic has spread through different profiles among states. [Figure 1](#) presents the evolution of daily cases between the country and the selected states and the fitted and smoothed fitted values by the GAM.

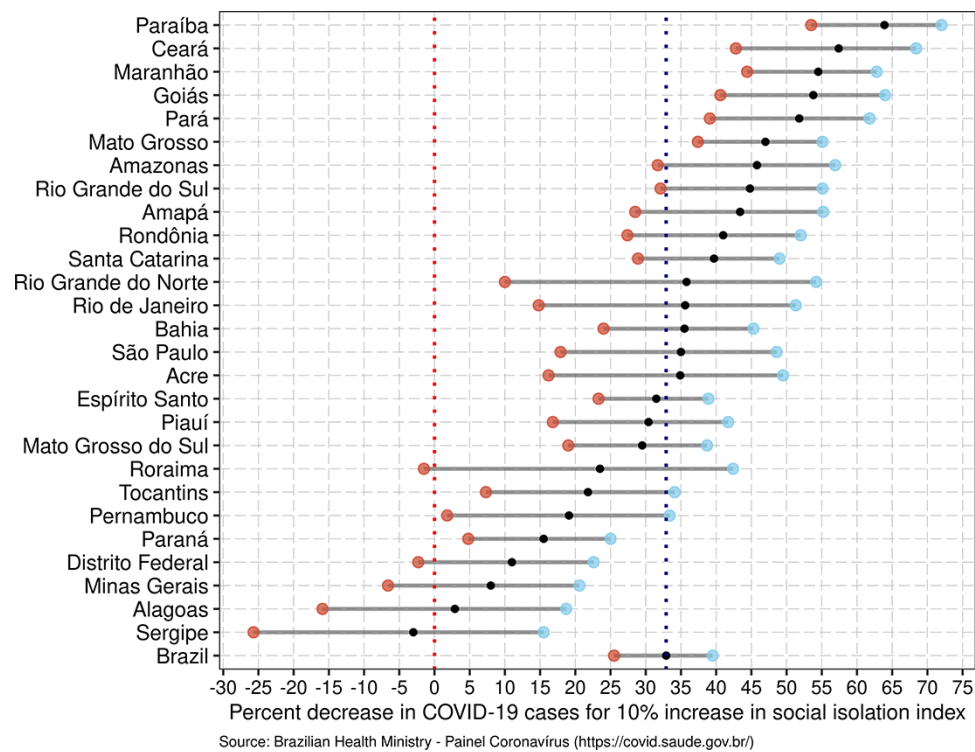
[Table 1](#) displays the results of national and state estimates of incidence rate ratio (IRR) (exponential of beta parameter) of SII on the number of daily new cases of COVID-19. The association's result means that in a scenario of 100% physical distancing, the incidence of COVID-19 will have reached approximately only 1.9% of the magnitude when there is no physical distancing for Brazil (95% CI 0.7–5.3%). For the states analysed, the values would be 1.2% in Rio de Janeiro (95% CI 0.1–20.3%), 0.2% in Amazonas (95% CI 0.0–2.2%) and 0.3% Rio Grande do Sul (95% CI 0.0–2.1%) and would be fully controlled in Ceará (IRR = 0; 95% CI 0.0–0.4%).

We also present IRR values scaled to 0.1 of SII to comprehensively comprehend the results ([Figure 2](#)). The results indicate an overall protective effect of the physical distancing on the number of daily reported COVID-19 cases. A 10% increase in SII in the country reflects a 32.90% decrease in cases in 14 days.

Measures of physical distance in Brazil vary significantly between states. The division of states into clusters describes the epidemiological timing of each measure's implementation, according to the number of days before or after the date of implementation of each category of actions based on the first confirmed COVID-19 case (early, intermediate I, intermediate II and late) ([Table 2](#)). Cluster 1 comprises 17 states and has a profile of early adoption of all the distance measures used for the cluster's composition. Many states adopted suspension of events, school closure, quarantine for risk groups and economic lockdown (full or partial) even before confirming the first case. Cluster 2, on the other hand, presents a profile of adopting measures later than the first group. In this cluster, we highlight that most states' restriction on transportation was not adopted, which means that the population displacement routes remained active despite the other measures.

The states have a heterogeneous profile concerning labour, political and health indicators. Concerning testing, population coverage was low in the reference period, and the range was 5.83–19.41%. Regarding remote work, the states presented a proportion that varied between 3.06 and 25.65. On the other hand, informal employment has a large proportion and ranged between 20.30 and 52.34%. Finally, 29.63% of the states have a left-wing orientation on the political spectrum, 40.74% have a centre orientation, and 29.63% have a right-wing direction.

The Poisson model used to associate the magnitude of physical distance identified a positive association between increased physical distance and the proportion of people



**Figure 1.** Expected decrease in reported COVID-19 cases 14 days after a 10% increase in Brazil and states' social isolation indices, Brazil, 2020

employed and working remotely and restrictive politics implementation. After the over-dispersion examination (Supplementary File 1), we could test the associations. Therefore, the earlier measures were adopted. The more the population had the opportunity to incorporate remote work, the greater the physical distance level. On the other hand, test coverage and the proportion of informal workers were negatively associated with distance. Thus, the result points out that the greater the coverage of testing for COVID-19 and the more significant proportion of informal work, the reduced the magnitude of physical distance. Finally, the political spectrum was also associated, in a statistically significant way, with physical distance. The states whose governor has the most right-wing spectrum showed less adherence to physical distance measures than left-wing spectrum (Table 3).

## Discussion

There is an association between physical distancing and COVID-19 new cases in Brazil. However, physical distancing effects on reduction of COVID-19 spread are heterogeneous among states. In addition, adoption of physical distancing was associated with other aspects related to the ability to detect the virus infection and availability to adopt measures to reduce the movement of people on the streets, such as test coverage, home office adoption, informal work proportion, political spectrum and early moment of restrictive politics implementation.

Brazil currently has one of the fastest-growing severe acute respiratory syndrome coronavirus 2 epidemics worldwide (Candido *et al.*, 2020). The rapid spread of COVID-19 in Brazil can be attributed to many factors, including urban

density, delays in implementing and maintaining physical distance policies, and limited testing capacity. Taking Brazil as a case study, we can corroborate the idea that the restricted approach to the pandemic as an infectious cycle limits the possibilities of understanding the disease's social history (Horton, 2020). In this sense, Brazilian states are quite distinct from each other, and the description of some social and demographic indicators makes this characteristic evident (Supplementary File 2).

Most non-pharmaceutical interventions reduce social contact rates through different physical distancing policies without a vaccine and effective antiviral medications. The COVID-19 infection rate is determined by its reproductive number ( $R_0$ ), representing the number of secondary infections produced by an infected person. The COVID-19  $R_0$  is estimated at 1.3–6.5, with an average of 3.3 (Liu *et al.*, 2020). Therefore, physical distance plays a crucial role in reducing the pandemic's burden on the health system. Thus, physical distancing is the most effective practice of increasing the space between people to decrease the chance of spreading disease (Sen-Crowe *et al.*, 2020).

The timing of implementing and easing physical distancing measures seems to have significant effects on the number of COVID-19 cases instead (Alagoz *et al.*, 2021). According to the moment of restrictive politics implementation, the clusters' composition allows us to reinforce this hypothesis. In Brazil, preliminary analysis in four capitals identified that physical distancing measures reduced the incidence and mortality from COVID-19. The interrupted time-series analysis highlights a statistically significant drop in new confirmed cases in all capitals, although with different magnitudes (Silva *et al.*, 2020).



**Table 1.** Incidence rates for SII for Brazil and states

States	SII Coefficient ( $\beta$ )	IRR (95% CI)	P-Value
North			
Rondônia	-5.268	0.005 [0.001;0.041]	<0.001
Acre	-4.299	0.014 [0.001;0.171]	0.001
Amazonas	-6.117	0.002 [0.000;0.022]	<0.001
Roraima	-2.682	0.068 [0.004;1.158]	0.063
Pará	-7.292	0.001 [0.000;0.007]	<0.001
Amapá	-5.686	0.003 [0.000;0.035]	<0.001
Tocantins	-2.464	0.085 [0.015;0.468]	0.005
Northeast			
Maranhão	-7.879	0.000 [0.000;0.003]	<0.001
Piauí	-3.621	0.027 [0.005;0.158]	<0.001
Ceará	-8.542	0.000 [0.000;0.004]	<0.001
Rio Grande do Norte	-4.436	0.012 [0.000;0.349]	0.010
Paraíba	-10.191	0.000 [0.000;0.000]	<0.001
Pernambuco	-2.120	0.120 [0.017;0.834]	0.032
Alagoas	-0.297	0.743 [0.126;4.371]	0.742
Sergipe	0.299	1.348 [0.185;9.844]	0.768
Bahia	-4.384	0.012 [0.002;0.065]	<0.001
Southeast			
Minas Gerais	-0.838	0.432 [0.099;1.887]	0.265
Espírito Santo	-3.787	0.023 [0.007;0.071]	<0.001
Rio de Janeiro	-4.401	0.012 [0.001;0.203]	0.002
São Paulo	-4.310	0.013 [0.001;0.139]	<0.001
South			
Paraná	-1.680	0.186 [0.057;0.614]	0.006
Santa Catarina	-5.066	0.006 [0.001;0.033]	<0.001
Rio Grande do Sul	-5.937	0.003 [0.000;0.021]	<0.001
Midwest			
Mato Grosso do Sul	-3.500	0.030 [0.008;0.121]	<0.001
Mato Grosso	-6.344	0.002 [0.000;0.009]	<0.001
Goiás	-7.711	0.000 [0.000;0.005]	<0.001
Distrito Federal	-1.164	0.312 [0.078;1.259]	0.102
Brazil	-3.983	0.019 [0.007;0.053]	<0.001

Physical distancing policies in Brazil have been implemented mainly by states. It means that the analysis of the rigour of the states regarding the implementation of the measures is a central aspect in mitigating the pandemic. In this regard, [Moraes \(2020a\)](#) argues that people respond more to compulsory rules of physical distance than to the pandemic's severity. Our results support this hypothesis since we obtained a significant association between the time series of the physical distancing and the incidence of COVID-19.

However, the importance of policies addressing physical distancing cannot be an isolated strategy. This evidence had already been described by [McCombs et al. \(2020\)](#). The authors reinforce that the effectiveness of a specific policy depends on the other implemented strategies. In the world, these strategies included implementing interventions at various levels, such as border-control measures, community-transmission control measures, case-based control measures, and health, well-being, and economic support ([Baker et al., 2020](#)).

On the one hand, the relative importance of testing and screening also depends on the general physical distance level. The lower adherence to the distance in places where the test coverage is higher suggests that individuals with a low-risk perception of having contracted the virus minimize the

need to combine individual and collective protection measures ([Lammers et al., 2020](#)). We can attribute it to a misinterpretation of the possibility of carrying out the tests.

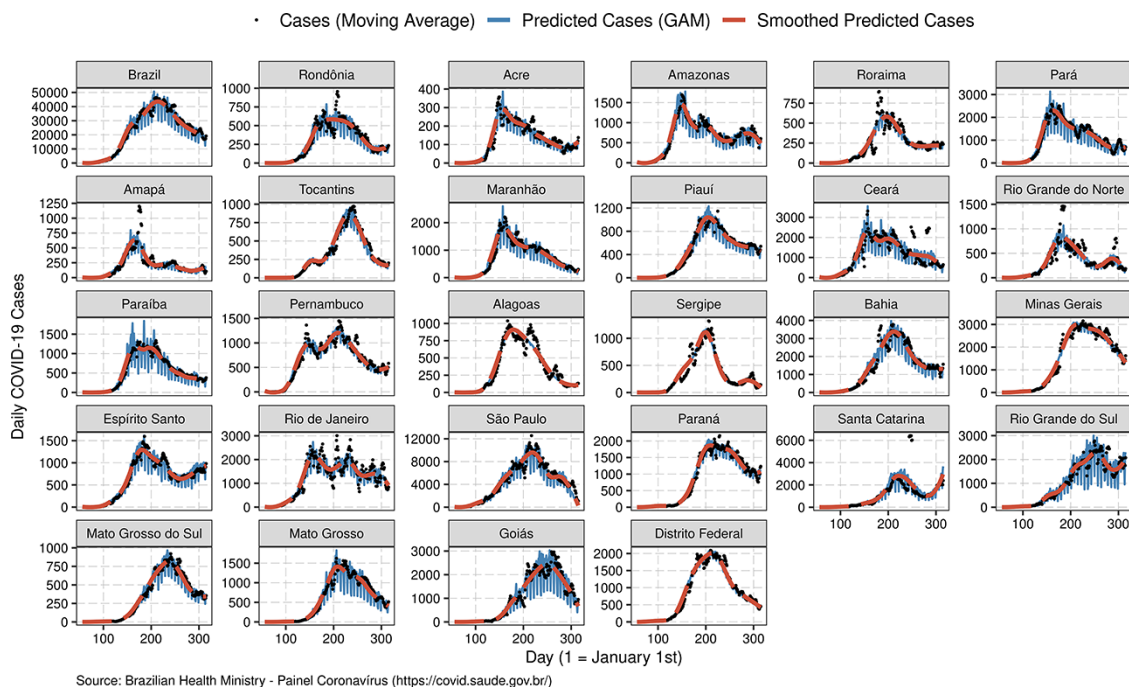
In this sense, public confidence in the government's ability to manage the pandemic is crucial, as this confidence supports public attitudes and behaviour at a precarious moment for public health ([Bargain and Aminjonov, 2020](#)). Few models have considered the population's behaviour triggered by the political distrust that can often fuel the pandemic COVID-19, a phenomenon called the Cummings effect ([Fancourt et al., 2020](#)). Since May 2020, the Federal Government has faced an institutional crisis regarding the measures to be adopted in the country and establishing the case and death defining criteria for COVID-19 ([The Lancet Editorial, 2020](#)). A study carried out in the USA ([Allcott et al., 2020](#)) argues that political beliefs significantly limit the effectiveness of physical distancing orders at the state level. Residents in Republican counties are less likely to be entirely at home after a state order has been implemented than those in Democratic counties. This result is close to our study's findings. The premise is that the duality between Republicans and Democrats in the USA is like the relationship between left wing and right wing in the Brazilian political spectrum.

There is great concern in the current scenario of the pandemic in Brazil. The rigour of the physical distancing measures adopted by governments has been reduced over the past few months. Simultaneously, the population's isolation level—here understood as how much people stay at home—fell by half in the same period ([Moraes, 2020b](#)). On the other hand, the pandemic's consequences on the economy increased unemployment rates and reinforced the Brazilian family's emergency salary needs for the Federal Government. These two aspects mark different social classes.

It is also important to mention that physical distance measures' sustainability and effectiveness depend on establishing social protection policies and support for vulnerable populations. In Brazil, as mentioned, there are immense social and regional inequalities, a non-negligible proportion of poor and extremely poor people, and a large proportion of informal workers or those with precarious ties ([Aquino et al., 2020](#); [Werneck and Carvalho, 2020](#)). These populations, which faced the most severe effects of the pandemic, had emergency salary support until December 2020. However, the end of this benefit might hinder the economic and health recovery of these population groups.

[Laroze et al. \(2020\)](#) mention that infectious diseases generate spatial dependence or contagion between individuals and geographical units. Aside from the strength of social ties among the municipalities' population, it is essential to consider the organization of health services due to regional management. It is central to the discussion of health service management. ([Moraes 2020a](#)) introduced a typology of state governments' policies concerning relations with city halls in managing the epidemic. These policies can be assertive when the state government imposes control; articulated, when the state government formulates joint positions with city halls, especially capital; exempt when the state's government delegates decision-making power to city halls; and impediments, when the state government seeks to limit mayors' authority to adopt restrictive measures.

This significant variation between states and, in many cases, between municipalities within the same state directly



**Figure 2.** Daily reported COVID-19 cases in Brazil and states, 2020

**Table 2.** Cluster description according to physical distance measures. Brazil, 2020

Physical distance measures	Categories	Cluster 1 <sup>a</sup>	Cluster 2 <sup>b</sup>	Total	P value
Suspension of events	Early (before first case)	47.1%	0.0%	29.6%	0.003
	Intermediate I (Case 1 to Case 10)	52.9%	60.0%	55.6%	
	Intermediate II (Case 11 to Case 50)	0.0%	40.0%	14.8%	
	Total	100.0%	100.0%	100.0%	
School closure	Early (before first case)	35.3%	10.0%	25.9%	0.014
	Intermediate I (Case 1 to Case 10)	64.7%	50.0%	59.3%	
	Intermediate II (Case 11 to Case 50)	0.0%	40.0%	14.8%	
	Total	100.0%	100.0%	100.0%	
Quarantine for risk groups	Early (before first case)	29.4%	0.0%	18.5%	0.018
	Intermediate I (Case 1 to Case 10)	70.6%	70.0%	70.4%	
	Intermediate II (Case 11 to Case 50)	0.0%	30.0%	11.1%	
	Total	100.0%	100.0%	100.0%	
Restriction on transportation	None <sup>c</sup>	0.0%	60.0%	22.2%	<0.001
	Intermediate I (Case 1 to Case 10)	88.2%	0.0%	55.6%	
	Intermediate II (Case 11 to Case 50)	5.9%	40.0%	18.5%	
	Late (after Case 50)	5.9%	0.0%	3.7%	
	Total	100.0%	100.0%	100.0%	
Economic lockdown (full or partial)	Intermediate I (Case 1 to Case 10)	94.1%	20.0%	66.7%	<0.001
	Intermediate II (Case 11 to Case 50)	5.9%	80.0%	33.3%	
	Total	100.0%	100.0%	100.0%	

**Legend:** <sup>a</sup> States that are part of this cluster: AC, AM, AP, CE, GO, MA, MT, PA, PB, PE, PI, PR, RO, RR, RS, SC and SE.

<sup>b</sup> States that are part of this cluster: AL, BA, DF, ES, MG, MS, RJ, RN, SP and TO.

<sup>c</sup> Did not implement this category of physical distancing.

impacts health services' regional organization. Brazilian Unified Health System (SUS) decentralization was established to optimize the system's management, the rationalization of resources and the institutional contribution to creating healthcare networks. Since assistance to COVID-19 demands services at different stages of infection, states and municipalities need to be organized to carry out primary prevention actions through suppressing contagion and immunization to the timely clinical management of severe cases, including

intensive care and respiratory rehabilitation (Daumas *et al.*, 2020; Guimarães *et al.*, 2020).

Just over a year and a half after the first case, Brazil is still experiencing a challenge due to the COVID-19 pandemic. Brazil accounts for 10.1% of cases and 13.2% of deaths worldwide, accounting for only 2.7% of the World's population (Ritchie *et al.*, 2021). Transmission indicators remain high, such as the incidence rate and test positivity, and some of the country's significant problems facing COVID-19

**Table 3.** Crude and adjusted Poisson model form physical distancing and covariates. Brazil, 2020

Variables	Crude model		Adjusted model	
	RR	95% CI	RR	95% CI
Test coverage	1			
5.83–7.58 %	0.991	0.988–0.994	0.988	0.986–0.991
7.81–9.01%	0.976	0.974–0.979	0.976	0.973–0.979
9.13–19.41%				
Work from home	1			
3.06–7.20%	1.007	1.004–1.011	1.033	1.029–1.038
7.27–9.47%	1.015	1.013–1.018	1.042	1.039–1.046
9.58–25.65%				
Informal work proportion	1			
20.30–33.42%	0.985	0.983–0.988	0.975	0.972–0.979
34.52–42.45%	0.972	0.969–0.976	0.961	0.958–0.965
43.18–52.34%				
Political spectrum	1			
Left-wing	0.993	0.990–0.995	0.980	0.976–0.983
Centre	0.983	0.981–0.986	0.977	0.975–0.980
Right-wing				
Moment of restrictive politics implementation	1			
Late (Cluster 2)	1.011	1.009–1.013	1.017	1.013–1.021
Early (Cluster 1)				

persist. There is still a lack of coordination and strategic and target policies reflected in an institutional crisis generated by the executive government's public manifestation, minimizing the severity of COVID-19 and the need for rigidity of social distance measures. It contributed decisively to the tragic epidemiological situation still in progress (Hallal, 2021).

Also, during this period, Brazilians experienced the collapse of the health system, as we can see by local crises of lack of oxygen, overwhelming of hospital beds and lack of intubation equipment, as well as an explosion of maternal mortality, excessive indirect deaths due to carelessness of health care, and witnessed the emergence of variants of concern in the national territory (Barberia *et al.*, 2021). Recent data suggest that the pandemic's impact is being gradually reduced by advancing vaccination. However, at the end of July, data showed full vaccination coverage of ~20% in Brazil (Fiocruz, 2021).

Finally, and perhaps most important, political aspect is a major issue in Brazil. Although Brazilian political organization requires decentralization, health policies need to have a single command, with convergence between central and local government, at risk of the pandemic spreading for a long time, causing numerous social and economic problems.

The study has limitations. First, it is necessary to be cautious when analysing the incident cases of COVID-19, as there is a delay in diagnosis and low coverage of population testing. We believe this issue was minimized using the weekly moving average cases and a 14-day time lag between the physical distancing and the incident cases.

## Conclusion

Physical distance is a measure that should be suggested early to flatten the epidemiological curve with the least possible economic impact. In this paper, we study national- and state-level COVID-19 incidence and physical distancing trends to evaluate the effect of physical distancing measures in mitigating

the pandemic's spread. Further, we investigate the association between the physical distancing measures and socio-economic and political alignments of states in the physical distancing. Our results suggest that physical distancing effects on the reduction of COVID-19 cases are heterogeneous across the country.

Regarding social issues, there is a context of substantial social inequality in Brazil, with strata of the population living in precarious situations due to both the difficulty of access to basic sanitation and the aggregation of housing conditions. In this sense, it is essential to recognize these characteristics, to characterize the national territory due to physical distancing measures. These analyses are crucial to support government decisions and improve the community's adherence to preventive measures. Rapid and science-based risk assessment, linked to early and decisive government action, is therefore critical.

## Supplementary data

Supplementary data are available at *Health Policy and Planning* online.

## Data availability statement

The data sets were derived from sources in the public domain: <https://covid.saude.gov.br/>.

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