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ASSESSING THE IMPACT OF SOCIAL DISTANCING ON COVID-19 CASES AND DEATHS IN BRAZIL: AN INSTRUMENTED DIFFERENCE-IN-DIFFERENCES APPROACH[1]

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ABSTRACT

Concern over the high rate of contagion of COVID-19 has prompted world authorities to use the strategy of isolation and social confinement as the main non-pharmacological weapon against the disease that has rapidly killed thousands of people worldwide. The aim of this study is to analyze the importance of the level of social isolation in reducing new coronavirus cases and deaths. For this, daily data on the level of contamination by COVID-19, social isolation and information from the Brazilian states between the months of February and May 2020 obtained from several databases are used. Taking advantage of the differences between the federal government of Brazil and state governors about the severity of the pandemic and the importance of social isolation, the article uses the Instrumented Difference-in-Differences approach, suggested by Duflo (2001), to obtain the causal impact of social isolation in mitigating COVID-19 cases and deaths, taking into account the relationship between the president of the republic and the states as an instrument. The results suggest that, in fact, the level of social isolation reduces the number of cases and deaths generated by the COVID-19 pandemic. In addition, the first and second stage estimates are robust and significant with the introduction of the various controls used in the analysis.

KEYWORDS: COVID-19. Instrumented Difference-in-Differences. Social Isolation.

1. INTRODUCTION

On June 23, 2020, the world reached the milestone of more than 9 million COVID-19 infections, with approximately 500 thousand deaths caused by the disease, highlighting the speed at which the pandemic progressed in only a few months. The World Health Organization (WHO) declared on January 30, 2020, that COVID-19 was a Public Health Emergency of International Importance and encouraged heads of state around the world to institute domestic policies of social isolation and confinement (WHO, 2020). Anderson, Heesterbeek and Hollingsworth (2020) stated that a high rate of COVID-19 infection in a population with no previous immunity and no vaccine against the virus tends to result in exponential growth in case numbers. Therefore, nonpharmacological actions are needed to reduce transmission and slow the spread of the disease. Among these measures, isolation and social confinement are the main nonpharmacological policies for reducing the transmission of infectious respiratory diseases. According to Costa et al (2020), social isolation is a tool that can reduce and flatten the curve of cases and thus protect people at the greatest risk, reducing the chances of serious conditions related to the disease, potential deaths and the collapse of the health system of the country (VAN BAVEL , et.al. 2020; BRZEZINSKI, et. al. 2020). Previous experience with H1N1 in 2009, which had a much lower transmission rate than the new coronavirus, had already shown that, in a globalized world, it is extremely difficult to prevent new diseases from reaching other countries.

Therefore, during the COVID-19 pandemic, most countries have decided to implement social distancing measures, enacting strategies to control population movement and suspend academic activities and nonessential trade (HATE and WEBSTER, 2020). However, despite the WHO recommendation and empirical evidence (BRISCESE, et. al. 2020; DOUGLAS, et. al., 2020.; KRAEMER, et.al. 2020; NICOLA, et. al. 2020), some leaders in the US, Europe, and Latin America are skeptical about the effectiveness of social distancing policies. These leaders have criticized these policies, arguing that social distancing aggravates the economic crisis without necessarily alleviating the pandemic.

The purpose of this article is to evaluate the effectiveness of social distancing, as measured by the Social Isolation Index (SII), in mitigating COVID-19 cases and deaths in Brazil. An intriguing aspect of this problem is that, as the number of infections has grown, there has been a natural trend toward self-confinement irrespective of whether social distancing is implemented as a policy. Therefore, social distancing and the number of cases of COVID-19 are simultaneously determined phenomena. To capture the causal effect of social distancing on the COVID-19 pandemic, in this research, we adopt a difference-in-difference instrumented (DDIV) strategy (Duflo 2001). Our identification hypothesis focuses on the idea that an exogenous shock was President Bolsonaro's speech encouraging Brazilians not to reduce their labor activities; by encouraging business as usual, this shock weakened quarantine orders at the state level.

Many studies have argued that the power of political discourse affects decision making and the behavior of society. There are numerous examples in the literature of how political leaders can motivate their followers to behave in certain ways through speeches and behavior (LAZEAR and ROSEN, 1981; HERMALIN, 1998; ACEMOGLU and

JACKSON, 2015). Political corruption scandals can also render citizens more dishonest (AJZENMAN, 2018). In contrast, good examples of care for the public good on the part of elected leaders encourage voluntary contributions (JACK, RECALDE, 2015). Recently, Briscese et al. (2020) showed the importance of public authorities in managing people's expectations during public health emergencies.

This study is divided into 5 sections, including the introduction. The next section provides useful context for the public health situation in Brazil at the time of the COVID-19 pandemic and a discussion of the importance of political discourse to social behavior. In the third section, the study describes the database and the empirical strategy used to estimate the causal effects of the lockdown. In the fourth section, we present and discuss the results of the DDIV model. Finally, we offer some concluding remarks and suggestions for future research in the fifth section.

2. BACKGROUND

Following WHO recommendations, the governors of the 27 Brazilian states, including the Federal District, on different days decreed social-distancing restrictions, with some decrees starting as early as February 29, 2020 (table 1). Although Brazil's Ministry of Health declared a Public Health Emergency of National Importance in the country (Ordinance no. 188, BRASIL, 2020) on February 3, 2020, the federal government, represented by the figure of the current President of the Republic of Brazil, Jair Messias Bolsonaro, encouraged the continuity of commercial activities and advocated for business as usual.

According to the Fiscal Decentralization Theorem (OATES, 1972), local authorities have an advantage over central governments in terms of knowing their citizens' preferences. In addition, since local governments are closer to society, local processes should take priority over central government bodies. Local governments can obtain better information by interacting much more easily with the locality and meeting regional demands more efficiently (KRUGMAN, 1991, 1995). Conversely, local governments are not necessarily equipped to address situations that transcend their borders and that require coordination at a higher level of aggregation.

Ball (2001) analyzed the new public management paradigm developed by the Organization for Economic Cooperation and Development (OECD) in 1995 and suggested replacing centralized management structures with decentralized management models, in which public policy proposals regarding resource management and decision making are built in an environment much closer to the service location and where conditions are created for the return of interest groups.

Indeed, the President of Brazil, in speeches and by modelling behavior, encouraged his supporters not to follow social-distancing restrictions issued by the states. On March 15, 2020, despite general recommendations on self-isolation, demonstrations occurred across the country on behalf of the President that brought thousands of supporters into large agglomerations[7]. The President himself participated in the demonstrations in the Federal District, having contact with the protesters[8]. In addition, a statement made on national television on March 24 positioned the President in opposition to most of the state governments in terms of policies for reducing the spread of COVID-19[9].

Table 1 shows for each Brazilian States the day on which social distancing measures were decreed, the percentage of the vote for President Jair Bolsonaro in the second round of presidential elections in each state and the states with governors supporting the President. We define “supporting” based on signing a manifesto against the President, called the Open Letter in Defense of Democracy, in April 19th, 2020.

Table 1: Date of social distancing measures decreed by Brazilian states and percentage of vote in states for President.

7 For more details, see https://g1.globo.com/politica/noticia/2020/03/15/cidades-brasileiras-tem-atos-pro-governo.ghtml. Available on April 28, 2020.

8 For more details, see https://agenciabrasil.ebc.com.br/.../**bolsonaro-participa**-de-**manifestacao**-de-simpatizantes-em-brasilia. Available on April 28, 2020.

9 For more details, see https://www1.folha.uol.com.br/equilibrioesaude/2020/03/ao-contrario-do-que-disse-bolsonaro-passado-de-atleta-nao-e-garantia-de-protecao-contra-coronavirus.shtml. Available on April 28, 2020.

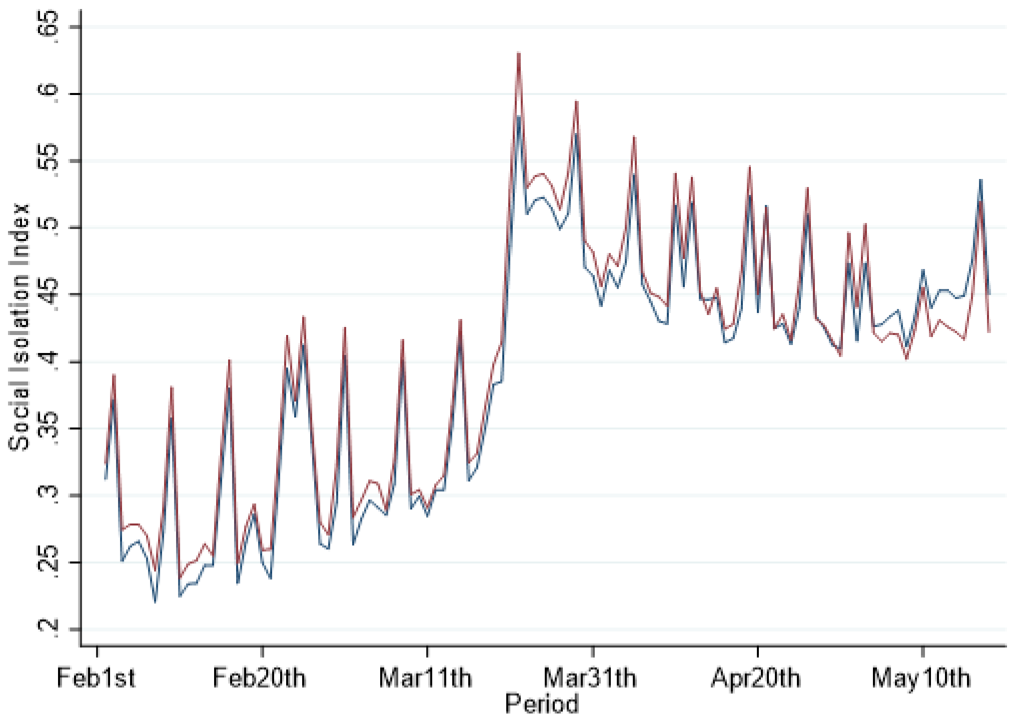
State	Social Distancing Decree	% of vote	Governors supporting the President*
Distrito Federal	February 29, 2020	70	Yes
Goiás	March 13, 2020	65.5	No
Minas Gerais	March 13, 2020	58.2	Yes
Paraíba	March 13, 2020	35	No
Pernambuco	March 14, 2020	33.5	No
Acre	March 16, 2020	77.2	Yes
Ceará	March 16, 2020	28.9	No
Espírito Santo	March 16, 2020	63.1	No
Rio de Janeiro	March 16, 2020	68	No
Rio Grande do Norte	March 17, 2020	36.6	No
Santa Catarina	March 17, 2020	75.9	No
Tocantins	March 18, 2020	49	No
Amapá	March 19, 2020	50.2	Yes
Bahia	March 19, 2020	27.3	No
Maranhão	March 19, 2020	26.7	No
Mato Grosso do Sul	March 19, 2020	65.2	No
Paraná	March 19, 2020	68.4	Yes
Piauí	March 19, 2020	23	No
Rio Grande do Sul	March 19, 2020	63.2	No
Alagoas	March 20, 2020	40.1	No
Pará	March 20, 2020	45.2	No
Rondônia	March 20, 2020	72.2	Yes
Sergipe	March 20, 2020	32.5	No
São Paulo	March 21, 2020	68	No
Roraima	March 22, 2020	71.6	No
Amazonas	March 23, 2020	50.3	Yes
Mato Grosso	March 23, 2020	66.4	No

Source: Official Journals of Brazilian States
* States with governors who did not sign a manifesto against the President, Open Letter in Defense of Democracy, on April 19, 2020.

One way to investigate the influence of the President's speech on compliance with social distancing is to divide Brazilian states by *support* (states with governors who are pro-President) and *nonsupport* (otherwise). Since January 2019, when he assumed the Presidency of the Republic of Brazil, the President has lost support from the governors of Brazilian states, including the leaders of the two most important states: Rio de Janeiro and São Paulo. In fact, on April 18, 2020, 20 of the 27 governors signed a document formalizing their discontent (Open Letter in Defense of Democracy[10]). Therefore, this article defines as pro-President (*support*) the 7 states with governors who did not sign the letter[11].

Figure 1 presents the trajectory of the Social Isolation Index (SII) of the states with governors in the *support* and *nonsupport* groups. The SII was developed by **INLOCO**[12] to assist in combating the COVID-19 pandemic by monitoring the coronavirus in Brazil. It shows the percentage of the population respecting the isolation recommendation. As expected, the SII grew substantially after the isolation decrees for both the President *support* and *nonsupport* states.

FIGURE 1: SOCIAL ISOLATION INDEX TRAJECTORY



Sources: COVID19 cases come from Kaggle's database. Election information comes from TSE. Red line represents *support* states, and Blue Line represents *nonsupport* states; Social Isolation Index (SII).

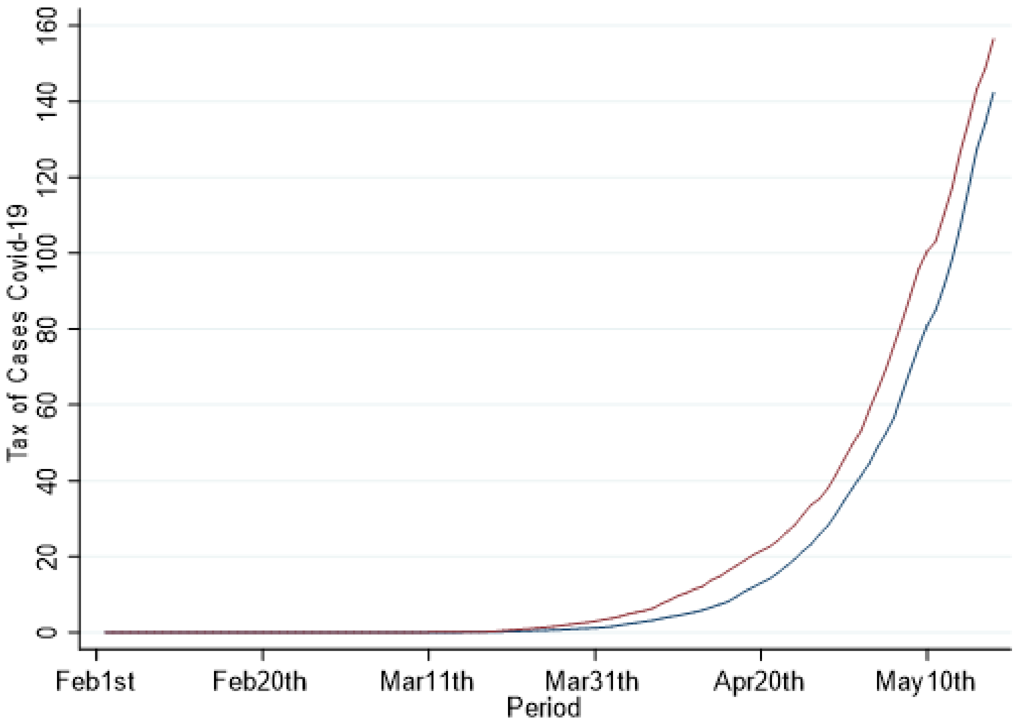
10 https://g1.globo.com/politica/noticia/2020/04/19/em-carta-governadores-de-20-estados-manisfestam-apoio-a-maia-e-alcolumbre.ghtml

11 Paraná, Minas Gerais, Federal District, Rondonia, Acre, Amazonas and Amapa

12 Brazilian Company founded in 2010 and based on the Recife Company founded in Recife, with branches in São Paulo, New York and San Francisco: https://mapabrasileirodaCOVID.inloco.com.br/en/

Figure 2 describes the growth in COVID-19 infections in the *support* and *nonsupport* states during the analyzed period. In every period after state decrees of isolation and social confinement, it is clear that the growth in COVID-19 incidence (number of cases per 100,000 inhabitants) is higher in *support* states than in *nonsupport* states.

FIGURE 2: CASE RATE OF COVID-19 TRAJECTORY



Source: COVID-19 cases come from Kaggle's database. Election information comes from TSE. Red line represents *support* states, and blue line represents *nonsupport* states; Social Isolation Index (SII).

The main objective of this analysis is an assessment of the effect of social distancing restrictions on outcomes, i.e., COVID-19 cases and deaths. As stated, measuring the social-distancing restrictions by a self-reported index (SII) is endogenous because, as the pandemic worsens, self-isolation can take place even in the absence of social distancing policies. Therefore, Ordinary Least Square (OLS) coefficients are biased. To address this problem, we used Two Stage Least Squares (2SLS). In doing so, we follow Duflo (2001) and run a Differences-in-Differences (DID) model in the first stage, in which the outcome is SII, and the treated variable is the interaction between *support* and *decreed* (the data for social-distancing restrictions decreed by Brazilian states, table 1). In the second stage, the predicted values of SII from the first stage (which are now exogenous) become the variable of interest in regressions on the outcomes. Our identification hypothesis is that the President's speech is able to explain COVID-19 cases and deaths only because it explains the population's social isolation adherence. This idea is discussed further in the next section.

3. METHODS

In this section, the current study presents information from the database used, as well as the empirical strategy (Instrumented Difference-in-Differences-DDIV) used to investigate the causal impacts of SII on COVID-19 cases and deaths in Brazil.

3.1. DATABASE

We worked with 27 Brazilian states, including the Federal District, over 108 days between February 1 and May 18, 2020, checking cases of and deaths from COVID-19 obtained from the Kaggle platform[13].

The influence of climatic factors on contamination with viral respiratory diseases was investigated in the literature. It can be concluded through these studies that the average temperature, the hours of sunshine and the precipitation of rain are important aspects when studying the determinants of the spread of these diseases (PAEZ, et. al., 2020; SUN *et al* 2020; KUDO *et al*. 2019; CASANOVA *et al*. 2010; MAKINEM *et al*. 2009; LIENER *et al*. 2003;). To control for these characteristics, we use Brazilian states' climate daily data for period under analysis from the National Institute of Meteorology (INMET).

13 Data from http://www.kaggle.com/unanimad/corona-virus-brazil. Accessed on April 28, 2020.

To control for greater traffic of people, such as cities with airports, we used information about on the number of people entering the country through airports for each Brazilian state from the National Civil Aviation Agency (ANAC)

Socio-economics of Brazilian states and characteristics such as population size, average income, proportion of employed persons, life expectancy and births come from the Brazilian Institute of Geography and Statistics (IBGE). In addition, the percentage of votes that the candidate for President of the Republic Jair Bolsonaro received during the second round of the 2018 elections comes from the Superior Electoral Court (TSE).

In addition, the information about mortality rates from COVID-19 comorbidities (respiratory diseases, hypertension and diabetes), the number of hospitalizations in public hospitals and the bed rate per 100 inhabitants came from DATASUS. All of these variables are described in table 2

Table 2: Definitions and statistical variables

VARIABLE		MEAN	SD	MIN	MAX
Cases	Cases of COVID-19 per 100 thousand inhabitants of state *i* on day *t*	19.73	50.12	0	504.66
Death	Death from COVID-19 per 100 thousand inhabitants of state *i* on day *t*	91.24	376.7	0	4823
SII	Social Isolation Index of state *i* on day *t*	0.4	0.1	0.14	0.73
Decree	Dummy that assumes a value equal to 1 if state i decreed social isolation on day t	0.56	0.5	0	1
Support	Dummy that assumes a value equal to 1 if the governor of the state supports the president	0.26	0.44	0	1
SOCIOECONOMIC CONTROLS					
Wage	Mean formal worker wage (in R$) of state *i* in 2019	3537.36	643.6	2694	5389.2
Employed	Employed population of state *i* in 2019	0.4	0.12	0.24	0.66
Foreign	Number of foreigners who entered state *i* during the month for day *t*	39712.9	128475	0	69507 1

Density	Demographic density of state *i* in 2019	75.92	118.3	2.66	523.41
CLIMATE CONTROLS					
Average Temperature	Average temperature of state *i* on day *t*	26.18	3.11	13.4	49.7
Insolation	Sunlight hours of state *i* on day *t*	5.94	2.81	0.1	20.4
Precipitation	Rain precipitation of state *i* on day *t*	7.3	15.16	0	195.6
HEALTH CONTROLS					
Hospitalization	Number of hospitalizations of state *i* in month for day *t*	517081	586579	45665	2900000
Respiratory	Mortality tax of respiratory diseases of state *i* in the month for day *t*	3635	3994	263	18905
Hypertension	Mortality tax of hypertension of state *i* in the month for day *t*	158	185	5	759
Diabetes	Mortality tax of diabetes of state *i* in the month for day *t*	414	418	23	1824
Bed Tax	Bed tax in hospitals per 100 thousand inhabitants of state *i* in the month for day *t*	204	33	130	274

Source: We are working with Brazil daily information on the number of confirmed cases of infected people; the socioeconomic characteristics are provided by the Brazilian Institute of Geography and Statistics (IBGE) and the National Civil Aviation Agency (ANAC), and the climate information is collected at the National Institute of Meteorology (INMET). COVID cases come from Kaggle's database; the SII comes from INLOCO's site.

EMPIRICAL STRATEGY

The main study goal is to verify the impact of social isolation and confinement on the contamination rate of COVID-19. It is supported that the results can be displayed with $Y_{it} = F(I_{it})$ and that

$$F(I_{it}) = \pi_0 + \pi_1 SII_{it} + \eta_{it}, \qquad (1)$$

where Y_{it} is our outcome (the COVID-19 confirmed cases and death) in state *i* on day *t*, and SII_{it} is the social isolation index of state *i* on day *t*. In addition, η_{it} is the error term of state *i* on day *t*. It is also believed that η_{it} is represented by

$$\eta_{it} = X'_{it}\gamma_1 + W'_{it}\gamma_2 + H'_{it}\gamma_3 + v_{it}, \qquad (2)$$

where X'_{it} is a vector of the socioeconomic characteristics of state i on day t, W'_{it} is a vector of the climatic characteristics of state i on day t, and H'_{it} is a vector of health information about state i on day t. Finally, v_{it} is, by construction, not correlated with X'_{it}, W'_{it} and H'_{it}. Therefore, it is believed that $E[SII_{it}, v_{it}] = 0$. If these vectors are observables, then

$$Y_{it} = \alpha + \rho SII_i + X'_i\gamma_1 + W'_{it}\gamma_2 + H'_{it}\gamma_3 + v_{it}, \qquad (3)$$

Equation (3) is a version of the linear causal model. The error term, v_{it}, in the equation is the random portion of the potential results that remains after the inclusion of the three vectors mentioned (X'_{it}, W'_{it} and H'_{it}). However, a problem arises when resources in X'_{it} or W'_{it} or H'_{it} are not observed. Such state information can determine both Y_{it} and SII_{it} and violate the assumptions that describe the Ordinary Least Squares (OLS) estimator as consistent ($COV(v_{it}, SII_{it}) = 0$) and nonbiased ($E[SII_{it}|v_{it}] = 0$)[14]. Thus, the OLS estimates in equation (3), in case these hypotheses are violated, would not provide the correct causal interpretation of the effect of the level of social isolation on the COVID-19 contamination rate.

To address this problem we can apply the Instrumental Variable approach. To, it is necessary an instrument. The instrument is a variable that must be correlated with a causal variable of interest, SII_{it}; however, it is not correlated with the dependent variable. The Instrumental Variable literature calls this hypothesis the Exclusion Restriction since the instrument can be excluded from the causal model of interest (WOOLDRIDGE, 2002).

The instrumental variable used in this study is developed using an Instrumented Difference-in-Differences (DDIV) approach (Duflo 2001). The analysis treatment group is composed of the states that support the current President of Brazil (state governors who did not sign the Open Letter in Defense of Democracy). The time-related variable is a

14 $COV(v_{it}, SII_{it})$ is the covariance between v_{it} and SII_{it}, and $E[SII_{it}|v_{it}]$ is the mathematical expectation of SII_{it} given v_{it}.

dummy that assumes a value of 1 when the state is exposed to the decree of isolation and social confinement and 0 in the period prior to this state decree (as shown in Table 1).

Thus, the instrument used is the Difference-in-Differences estimator built from the interaction between the treatment dummies and time variable exposed above (*DID* = *support***degree*). The specifications of the first and second stage equations follow the empirical strategy of Duflo (2001). To be a valid instrument, the variable DID_{it} must obey two conditions: first, it must be correlated with the index of social isolation of the Brazilian states; and second, it should not be correlated with the characteristics of the states that determined the incidence of contamination with COVID-19.

Biderman, Mello and Schneider (2010) suggested that, by discarding the purely cross-section and time series variations and controlling for the estimates by the effects of nonobservable characteristics invariant in the states' time, the design of the Diff-in-Diff mitigates problems caused by endogenous adoption, corroborating the suggestion for an instrumental variable in the current study. In addition, according to Angrist and Pischke (2008), the character of gradual adoption ensures the comparison of the first and last adopters, which in fact can reduce endogeneity.

This study works with the belief that, despite the social-distancing restrictions decreed in some states with governors supporting the President, their management and population adherence have had a smaller magnitude. We argue that the Brazilian President's speech and behavior to minimize the importance of social distancing for the reduction of cases of and deaths due to COVID-19 weakened not only the population's adherence to social distancing measures but also reduced the efforts of states' governors who support the President to implement this strategy. Such points explain the strong correlation between the instrumental variable DID_{it}, which represents support of the President, and our interest variable, the Social Isolation Index (SII_i).

The second hypothesis for a valid instrument ($COV(\eta_{it}, DID_{it}) = 0$) is guaranteed by the decision on who the next President of the Republic would be not being correlated with the determinant aspects of the spread of contamination with COVID-19. The first information about the disease dates from the period after the second round of the presidential election in 2018 in Brazil. It can be said, thus, that DID_{it} is exogenous in relation to the observable and unobservable characteristics that influenced the number of COVID-19 cases. The current literature on the contagion of communicable respiratory diseases points to temperature, vitamin D concentrations and social agglomerations as the main determinants of these types of diseases. It is certain that such contemporary information did not affect the individuals' decisions to support the current President Jair Bolsonaro in his presidential campaign in 2018. In addition, the control of nonobservable characteristics is invariant over time by the Difference-in-Differences approach, and the contingency of the controls used in the analysis contributes to reducing the endogeneity involved in this type of investigation. It follows, from equation (3), that

$$\rho = \frac{\{COV(Y_{it}, DID_{it})\}}{\{COV(SII_{it}, DID_{it})\}} = \frac{\{COV(Y_{it}, DID_{it})/VAR(DID_{it})\}}{\{COV(SII_{it}, DID_{it})/VAR(SII_{it})\}}, \qquad (4)$$

The coefficient of interest, ρ, is the ratio between the population regression of Y_{it} on DID_{it} (referring to the reduced form) and the population regression of SII_{it} on DID_{it} (first stage). The model is called 2-Stage Least Squares (2SLS) because it is performed in two stages. First, SII_{it} is estimated using the following equation:

$$SII_{it} = X_{it}'\gamma_{11} + W_{it}'\gamma_{12} + H_{it}'\gamma_{13} + \theta_1 Decree_{it} + \alpha_1 President_i + \beta_{it} DID + \epsilon_{1it}. \qquad (5)$$

The $Decree_{it}$ variable is a dummy related to the state *i* social isolation decree period on day *t,* and $President_i$ is a dummy variable referring to state *i* support for the President in the 2018 elections and summarizing the treatment of the specification.

Then, in the second stage, the equation (5) predicted variable, $\widehat{SII}$, is substituted in equation (3), and the following equation is estimated:

$$Y_{it} = X_{it}'\gamma_{21} + W_{it}'\gamma_{22} + H_{it}'\gamma_{23} + \theta_2 Decree_{it} + \alpha_2 President_i + \rho \widehat{SII}_{it} + \epsilon_{2it}. \qquad (6)$$

The interested variable, ρ, represents the impact of social isolation on COVID-19 cases. Thus, the hypotheses of the model are not biased.

4. RESULTS AND DISCUSSION

All of the analyses considered the socioeconomic, climatic, and public health characteristics of the states presented in the previous section. A total of 108 days were investigated between the months of February and May 2020, and a panel was developed with the 26 Brazilian states, plus the Federal District. The level of social isolation and the other control variables of the study determined the contamination rate of subsequent days, given that the virus incubation period varies between 1 and 14 days. Thus, the study uses the contamination rate of 7 days ahead of the independent variables.

Table 3 describe the Difference in Difference estimation corresponding to the first stages of 2SLS. In table 3, columns (1) to (4), the DID coefficients are negative and significant, meaning that, in states with governors supporting the President, the SII is one percentage point less than SII in states that do not support the President. This result goes on to argue that the President's speech against social isolation weakened the population's willingness to quarantine. Another important results is that the results do not change with the inclusion of states' characteristics, as described in columns (1) to (4). Table 4 describes the second stage of this strategy. In it, we analyze the impact of SII on COVID-19 cases and deaths.

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Table 3: Impact of Presidential Support on Social Isolation Index by Brazilian States. First Stage of DDIV. Dependent Variable (Social Isolation Index)

	(1)	(2)	(3)	(4)
DID	-1.34***	-1.33***	-1.28***	-1.19***
	(-4.82)	(-5.07)	(-4.95)	(-4.68)
Lockdown	15.56***	15.57***	15.83***	15.96***
	(15.20)	(15.23)	(15.42)	(15.46)
Support	1.75***	1.59***	1.86***	2.73***
	(11.28)	(10.30)	(8.38)	(12.00)

Socioeconomic Controls	No	Yes	Yes	Yes
Weather Controls	No	No	Yes	Yes
Health Controls	No	No	No	Yes
Observations	2727	2727	2727	2727

Sources: Kaggle's database; INLOCO; ANAC; IBGE; INMET; TSE; Official Journals of Brazilian states. ***Statistically significant coefficient at the 1% level. **Statistically significant coefficient at the 5% level. *Statistically significant coefficient at the 10% level. Robust errors in heteroscedasticity were noted. Coefficient standard errors appear in parentheses.

The second stage of the DDIV specification is described in table 4, columns (1) to (4). Panels A and B show the impact of the Social Isolation Index on both outcomes, respectively: COVID-19 cases and deaths per 100.000 inhabitants. After controlling for all characteristics (table 4, Panel A (Panel B), column (4)), we found that increasing social isolation by 1 percentage point reduces the number of cases (deaths) due to COVID-19 by 13.51 (0.42) per 100.000 inhabitants.

Table 4: Impact of Social Isolation on Outcomes by Brazilian States. Second Stage of DDIV.

	(1)	(2)	(3)	(4)
Panel A: COVID19 cases rates per 100.000 inhabitants				
SII	-11.39***	-12.04***	-12.68***	-13.51***
	(-3.61)	(-3.82)	(-3.70)	(-3.58)
Decreed	212.8***	223.2***	236.9***	251.1***
	(4.18)	(4.37)	(4.18)	(4.03)
Support	20.05***	12.41***	16.43**	32.94***
	(4.08)	(3.43)	(3.19)	(3.60)
Observations	2727	2727	2727	2727
Panel B: COVID19 death rates per 100.000 inhabitants				
SII	-0.276**	-0.340***	-0.371**	-0.425**
	(-3.05)	(-3.40)	(-3.19)	(-3.18)
Decreed	6.458***	7.487***	8.092***	9.000***
	(4.04)	(4.28)	(3.98)	(3.91)
Support	0.486**	0.433**	0.503**	1.459***

	(3.26)	(3.19)	(2.75)	(3.74)
Observations	2592	2592	2592	2592
Socioeconomic	No	Yes	Yes	Yes
Climate	No	No	Yes	Yes
Health	No	No	No	Yes

Sources: Kaggle's database; INLOCO; ANAC; IBGE; INMET; TSE; Official Journals of Brazilian states. ***Statistically significant coefficient at the 1% level. **Statistically significant coefficient at the 5% level. *Statistically significant coefficient at the 10% level. Robust errors in heteroscedasticity were noted. Coefficient standard errors appear in parentheses.

To facilitate the analysis of the impact of a reduction in SII on outcomes, we can calculate the effect of the SII increase on our outcomes (table 5). Therefore, we estimated the differences between the state SII (table 5, column (A)) and a hypothetic ideal value of SII = 51% (table 5, column (B)). Multiplying column (B) by the estimated coefficient in table 4, column (4), Panel A (Panel B), we found that the number of cases (deaths) decreased in each state per 100.000 inhabitants, as described in column (C) (column (D)). Table 5, column (E), shows the proportion of COVID-19 cases (deaths) that decreased in relation to the total COVID-19 cases (deaths) by state during the period of analysis.

Table 5: The Impact of Social Isolation Index Increase of up to 51% on COVID-19 Cases and Deaths in Brazilian States from February 1 to May 18

	(A)	(B)	(C)	(D)	(E)	(F)
States	Social Isolation Index (%)	Increase in state SII up to 51%	COVID-19 number of cases decreased per 100.000 inh	COVID-19 number of deaths decreased per 100.000 inh	% of reduction in number of COVID-19 cases	% of reduction in number of COVID-19 death
		51% - (A)	(B)*coef (cases)	(B)*coef (deaths)	(C) / COVID-19 cases	(D)/ COVID-19 death
Tocantins	35.58	15.42	-208.34	-6.55	-23.81	-36.69
Sergipe	37.39	13.61	-183.87	-5.78	-12.03	-17.31
Goias	37.43	13.57	-183.36	-5.77	-40.96	-30.16
Rio Grande do Norte	37.95	13.05	-176.38	-5.55	-11.89	-8.29
Mato Grosso	38.06	12.94	-174.85	-5.50	-41.47	-41.04
Roraima	38.27	12.73	-172.00	-5.41	-3.81	-6.18
Mato Grosso do Sul	38.40	12.60	-170.24	-5.35	-41.54	-43.39
Bahia	38.52	12.48	-168.63	-5.30	-18.27	-16.43
Minas Gerais	38.63	12.37	-167.13	-5.26	-39.48	-35.40

Paraíba	38.78	12.23	-165.18	-5.20	-13.00	-6.88
Alagoas	38.93	12.07	-163.10	-5.13	-10.97	-6.33
Piaui	39.11	11.89	-160.60	-5.05	-18.45	-14.65
Espirito Santo	39.31	11.69	-158.01	-4.97	-5.77	-4.78
Parana	39.44	11.56	-156.19	-4.91	-30.32	-17.81
Maranhão	39.86	11.14	-150.51	-4.73	-6.44	-4.05
São Paulo	40.22	10.78	-145.69	-4.58	-5.57	-2.24
Para	40.38	10.63	-143.56	-4.52	-7.52	-2.81
Rondônia	40.50	10.50	-141.87	-4.46	-9.11	-8.58
Amapá	40.59	10.41	-140.65	-4.42	-2.05	-2.24
Distrito Federal	40.62	10.38	-140.31	-4.41	-5.68	-10.09
Santa Catarina	40.93	10.07	-136.04	-4.28	-10.77	-15.41
Rio Grande do Sul	41.20	9.80	-132.47	-4.17	-21.00	-19.32
Pernambuco	41.55	9.45	-127.66	-4.02	-4.06	-1.56
Ceara	42.51	8.49	-114.78	-3.61	-2.71	-1.32
Rio de Janeiro	42.80	8.20	-110.82	-3.49	-4.46	-1.46
Acre	43.00	8.00	-108.07	-3.40	-3.38	-3.23
Amazonas	43.98	7.02	-94.85	-2.98	-1.37	-0.57

The results shown in table 5 suggested that, by increasing the social isolation to 51%, the Brazilian states will have different benefits depending on how far they are from hypothetical index and on their population. For example, São Paulo, the largest Brazilian state, had an average SII equal to 40.22% between February 1 and May 18, 2020. If its SII increases on average to 51%, the number of COVID-19 cases will be reduced by 5.57%, and the number of deaths will decrease by 2.4%. Its mean of 66,901.02 and 2,104.30 cases of and deaths from COVID-19, respectively, could be avoid. Indeed, our results suggested that, by increasing the SII by only 10.78 percentage points in São Paulo states, more them 2.000 lives could be saved between February and May 2020. Pernambuco state, had one of the higher SIIs among Brazilian states (41.55%), although if its SII was 51%, the numbers of cases and deaths could be reduced, respectively, on average by 4.6% and 1.5%. It is a mean of approximately 12.000 people without COVID-19, and more than 383 deaths could be avoided. Analyzing for Brazil, we can say that, if the Brazilian average SII increased from 39.77% to 51% between February 1 and May 18, 2020, the country would have had approximately 318,850.03 fewer cases of COVID-19, and more than 10.000 lives would have been saved.

5. CONCLUSION

The rapid transmission of COVID-19, associated with the absence of a vaccine capable of reducing its proliferation, has caused global health authorities to recommend nonpharmacological measures to contain the pandemic. In this context, the governments of many countries, including Brazil, have introduced social-distancing measures to reduce the spread of the pandemic and to avoid overburdening the health system. However, the success of this strategy depends on the awareness of the population, and coordinated action by public authorities had proved to be a decisive factor for the engagement of the population. Because of economic impacts, some countries' leaders have called into doubt the effectiveness of social distancing to mitigate the virus' consequences. Therefore, this paper aimed to calculate the impact of social distancing in mitigating the numbers of COVID-19 cases and deaths.

Since the proliferation of COVID-19 and self-confinement are phenomena simultaneously determined, the OLS estimator is biased, thus requiring an identification strategy to calculate the impact of social distancing on COVID-19 cases and deaths. Our identification hypothesis is based on the idea that the President's speech negatively affected the respect and obedience to social distancing decreed by governors of Brazilian states. We have applied as an estimation strategy a Difference-in-Differences Instrumental variable. In the first stage, an interaction between two dummies, *support* and *decreed,* is used as an instrument. In the second stage, the social isolation index predicted in the first stage is the interested variable to determine our outcomes (COVID-19 cases and deaths per 100 thousand inhabitants in the Brazilian states during the period between February and May). Since the decree of social isolation and confinement was staggered between the units of the Brazilian Federation, the specification of Difference-in-Differences in the second stage further mitigates the problem of endogeneity caused by endogenous adoption by controlling for nonobservable time-invariant factors.

The results agree with the literature on the topic and with the hypothesis suggested by this study. The estimated coefficients were consistent and significant, although they were controlled for by several socioeconomic and climatic characteristics and information about the public health of the states -- factors disclosed by previous studies as relevant for determining the rate of contamination of the disease. The estimates found reveal that support for the President reduced the magnitude of the Social Isolation Index, which, as seen in the second stage results, reduced the contamination rate of COVID-19 per 100,000 inhabitants. In addition, the Reduced Model's estimates converge with the idea that support for the President and his speech against the lockdown increased the rate of cases and deaths caused by the disease.

Therefore, the alignment between government spheres in times of social crisis must be increased through the consonance of speeches and public policies. In addition, this work corroborates that, in fact, solutions that are not essentially pharmacological, such as lockdown, are necessary to combat contamination with viral respiratory diseases with rapid spread. In addition, this study is available to policy makers who aim to improve public health management. For further investigations, an expansion of the database used to include greater variability of the observed characteristics is desired, increasing the degree of robustness of the analysis.

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