

ARTICLE

The Relationship between Ideology and COVID-19 Deaths: What We Know and What We Still Need to Know*

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Several recent studies have investigated if support for Jair Bolsonaro in the presidential election of 2018 is positively associated with COVID-19 infections and deaths in Brazil. In these studies, COVID-19 outcomes in 2020 and 2021 are the dependent variables, and votes for Jair Bolsonaro in the 2018 presidential election (as a proxy for ideology) are the key explanatory variable. This article discusses why ecological research designs are difficult to test empirically. We discuss why correlations between vote shares and COVID-19 outcomes using aggregate data can produce biased inferences, and we specifically focus on measurement error, aggregation bias, and spatial and temporal dynamics.

Keywords: Ecological inference; measurement error; omitted variable bias; temporal dynamics.

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The novel SARS-CoV-2 virus, first detected in China and initially reported to the WHO in December 2019, has rapidly spread worldwide. Since the onset of the pandemic, a critical debate has emerged in the media and academia about how political attitudes and ideology contribute to the exponential rise in infections and deaths in some countries, while others effectively managed to reduce the pandemic's toll. Among the emblematic cases and deaths (GOLLWITZER et al., 2020; KALIL et al., 2021; MARIANI, GAGETE-MIRANDA, and RETTL, 2020; PEREIRA, MEDEIROS, and BERTHOLINI, 2020). Right-wing populist leaders headed both countries at the pandemic's onset, and these leaders entered office in a polarized political environment that permeated their presidential terms and the pandemic. However, there were reasons to think that Brazil would have been relatively more effective in containing the pandemic due to its public health system and its experience in preventing, diagnosing, and treating infectious diseases, including HIV/AIDS and Zika (BORRE et al., 2022).

Instead, since the first confirmed case in Brazil on February 25, 2020, the pandemic has exacted a heavy toll (CASTRO et al., 2021). Although COVID-19 arrived in Brazil relatively later than in Asia, Europe, and North America, the country registered almost 10 percent of the world's cases (over 21 million) and nearly 13 percent of all deaths (588,597) by September 2021. Since the country has only 2.73 percent of the world's population (211 million people), these figures, which undoubtedly are lower-end estimates, given the low levels of testing and case reporting, signal the magnitude of the tragedy underway. Several recent studies have investigated how support for Jair Bolsonaro in the 2018 presidential election is positively associated with the COVID-19 transmission and deaths in Brazil (ALMEIDA et al., 2022; LEONE, 2021; XAVIER et al., 2022). In these studies, the vote share in the 2018 election (as a proxy for ideology) is the key explanatory variable, and the dependent variables are COVID-19 cases, deaths, excessive hospitalizations, excess mortality, or adherence to social distancing. The empirical findings in these studies suggest a statistically robust relationship between pandemic outcomes and ideology.

This article discusses the methodological challenges of ecological inference research designs. Our paper outlines why the argument that ideology drives higher

infections and deaths is difficult to test empirically. We show why ecological correlations are insufficient and why comparisons must be undertaken with greater rigor. Our discussion focuses on how past political views are used to predict future outcomes, but the issues we discuss apply to much larger research questions regarding the validity of causal arguments derived from ecological research designs. These problems are not specific to the case of Brazil, or the pandemic. They are illustrative of larger challenges facing scientists, and these dangers apply to a wide array of disciplines.

We proceed as follows. In the next section, we review ecological inference research designs. As we seek to emphasize, studies that make ecological inferences face complex hurdles. Since many studies in the case of Brazil focus on research designs where individual data is aggregated at the municipal level, we dedicate specific attention to discussing challenges in the field of aggregate ecological inference. There are at least three reasons why bias occurs in COVID-19 ecological research designs. First, most studies rely on proxies for unobserved individual and aggregate-level characteristics to capture political identities and beliefs. Measurement error is well-documented to cause bias. Second, aggregation bias can occur due to the type of data available for analysts to conduct empirical research. Finally, studies often use time-varying and invariant characteristics to make ecological inferences without accounting for dynamics. In the paper's conclusion, we offer some recommendations to help advance this challenging research topic.

What we already know: ecological inferences revisited

Ecological arguments have been advanced for centuries and so too have methodological debates about the validity of inferring individual behavior from aggregate data (FREEDMAN, 1999; FREEDMAN, et al., 1998; KING, 1997). A classic example is Durkheim's (2012) study of suicide rates and Protestantism (VAN POPPEL and DAY, 1996). Since suicide rates (the dependent variable) were higher in more heavily Protestant countries (the key explanatory variable), it was therefore argued that the social conditions of Protestantism promoted suicide. However, there were two problems with Durkheim's analysis (FREEDMAN, et al.,

1998). First, the issue of confounding variables: religion was not the only difference between Protestant and Catholic countries. In other words, other factors also made these countries distinct. Second, aggregate outcomes (suicide rates) were used to infer patterns about individual behavior. Thus, even if further control variables were included, Durkheim could not have concluded that differences in suicide rates between countries were attributed to an observed difference in religion using aggregated data.

In present-day debates on how political orientation affects pandemic outcomes, the ecological fallacy of concluding that relationships observed for groups necessarily hold for individuals needs to be carefully considered. As we will explain in further detail in this study, ecological inference challenges also arise when we seek to use either individual or aggregate data. In studies that investigate how political ideology affects pandemic outcomes, scholars seek to measure ideology at the aggregate level across municipalities and to use these measures to draw cause and effect conclusions. In fact, as we show, scholars can easily access data for groups defined by the area of residence for COVID-19 outcome (e.g., the dependent variable), but we lack reliable data that captures ideological preferences or adherence to social distancing policies across municipal districts (e.g., the key explanatory variable).

Even if we could measure these characteristics and account for relevant confounding variables, we still can never test individual contributions to aggregate patterns in these models. The models are limited to group-level analyses. Therefore, we cannot extrapolate our conclusions to the individual level. It is incorrect to conclude that because countries with more Protestants tend to have higher suicide rates, then Protestants must be more likely to commit suicide. In the same way, it is erroneous to conclude that just because municipalities with more Bolsonaro supporters have higher death rates, Bolsonaro supporters are more likely to suffer from COVID-19 infection, hospitalization, and death. Table 01 summarizes the main limitations and strengths of applying ecological regression analyses to examine the relationship between COVID-19 outcomes and 2018 Bolsonaro's vote share. In the next section, we further discuss the implications of the challenges to ecological inference by discussing research designs based on individual and municipal data.

Table 01. Limitations and advantages of ecological regressions applied to the study of the Effect of 2018 Bolsonaro's vote share on COVID-19 outcomes

	Strengths	Limitations
Key explanatory variable: 2018 Bolsonaro's vote share	Reliable aggregate data.	<p>By employing vote shares for Bolsonaro as a proxy for ideology, authors rely on the fragile notion that voter behavior is not only coherent but also ideologically oriented.</p> <p>The use of vote shares as a proxy for ideology implies that those who voted for Bolsonaro in 2018 were consistently loyal and supportive of his policies during his mandate. The underscoring assumption that support for Bolsonaro remains static amongst voters is not necessarily validated in research. Individuals who voted for Bolsonaro in the 2018 presidential election do not necessarily support the president (with the same intensity), regardless of events and actions.</p> <p>Aggregation assumes that everyone in a municipality supports the president equally, which leads to potential misclassification, especially for the largest municipalities. The link between ideological positioning and levels of compliance with social distancing measures, however, remains unclear and needs to be assessed by researchers.</p> <p>Even when effectively captured, ideology is hardly the only aspect affecting COVID-19 outcomes in terms of cases, hospitalizations, and deaths. Multifaced dynamics involving local infrastructure, public policies, sociodemographic characteristics, etc. should be considered.</p> <p>Considering the multiplicity of relevant factors that might affect and define COVID-19 outcomes, identifying a reliable measure for ideology is an important challenge.</p>
Dependent variable: COVID-19 Outcome	Frequently updated, publicly available data.	Low and heterogeneous testing and notification rates may lead to underestimating the number of COVID-19 cases and deaths over time and space, which could bias results. Data on cases and deaths could be similarly affected by local-level variables, such as available infrastructure and RT-PCR test processing laboratories, among others.
Study design: ecological regression	Feasible, low cost, and convenient. Allows inference at the municipal, state, and country levels.	<p>Difficulty in employing a variable capable of capturing the direct relation between ideology (or support) and COVID-19 outcomes.</p> <p>Cannot be used to make inferences about individual-level associations. Aggregation bias could occur if trends observed at aggregate-level data are assumed to apply to individual data points.</p> <p>Cannot adjust for variation in individual-level relevant factors such as age, gender, race, or behavior.</p>

Source: Authors based on the discussion adapted from Wu et al. (2020) on the challenges of making ecological inferences about the relationship between air pollution and COVID-19.

Ecological inferences at the individual-level

Several factors have been identified as increasing an individual's likelihood to be infected by SARS-CoV-2. Amongst these factors, individuals' adherence to prevention measures is a central object of study. Those who engage in risky behavior (e.g., refusing to wear masks, attending large public gatherings, and refusing to maintain physical distance from others when outside the home) are

more likely to be exposed to the virus and, similarly, to get infected. In terms of individual behavior, many factors may increase a subject's willingness to comply with prevention measures to avoid exposure to an airborne virus. Among these, ideology has been identified as key. Studies from Brazil and the United States argue that right-wing voters are less likely to adhere to social distancing policies (AJZENMAN, CAVALCANTI, and MATA, 2020; BRUCE et al., 2022; GOLLWITZER et al., 2020; LEONE, 2021; MARIANI, GAGETE-MIRANDA, and RETTL, 2020). Consequently, in countries where political elites provided cues that minimized the seriousness of the pandemic, as in the cases of Presidents Bolsonaro and Trump, supporters of the president are more likely to engage in riskier behavior and activities (e.g., protests against lockdowns).

Furthermore, other factors also contribute to an individual's propensity to adopt prevention practices. Gender has long been identified as a key factor in explaining individuals' behavior towards the prevention and treatment of diseases. In the case of COVID-19, women appear to be more likely to wear masks when they leave their homes (GALASSO et al., 2020; MOREIRA, 2021; PALMER and PETERSON, 2020). These findings suggest that even if ideology may be important, differences in age, gender, and race must be considered among those who share a similar ideology.

Moreover, other invariant and time-variant aggregated-level factors have played a relevant role in explaining individual behavior and COVID-19 outcomes (cases and deaths). For example, studies like Barberia et al. (2021) provide evidence that Brazilian citizens differed in their willingness to adhere to social distancing in response to state-level policies regulating mask use and physical distancing. Similarly, other studies confirm that government interventions played a relevant role in controlling the spread of the disease in other countries (FLAXMAN et al., 2020; HSIANG et al., 2020).

This discussion suggests that to study the effects of ideology on an individual's likelihood of dying from COVID-19, an appropriate research design would imply a model such that:

$$Covid - 19Death_{it} = \alpha + \beta_1 Ideology_{it} + \varepsilon_{it}$$

In other words, researchers require data at time t for an individual i about whether she or he is aligned with President Bolsonaro (ideology) and data on the dependent variable of interest (e.g., SARS-CoV-2 Infection, or Death). However, most research on COVID-19 political dynamics is not driven by empirical research on the causal linkages that explain individual-level dynamics. Instead, most studies are based on research designs using aggregate-level data. In Appendix (Table A01), we present a brief summary of the main findings and key aspects of these studies. As the survey of the literature shows, in the case of Brazil, a commonly observed approach uses statistical correlations between the number of deaths and cases at a given point in the pandemic and the vote share for Bolsonaro in the 2018 presidential election at the municipal level to justify cause-effect-oriented conclusions. As we discuss next, there are several challenges to making inferences in this type of research design.

Ecological inferences at the aggregate level

A common argument in the studies that claim to identify a causal relation between votes and pandemic outcomes is that the votes Bolsonaro received in 2018 in municipalities are a proxy for ideology. In other words, cities with higher vote shares for Jair Bolsonaro would be ideologically aligned with the president. These studies also reason that the ideology of voters propagates infections and deaths in these districts. In these studies, the dependent variable is predominantly COVID-19 outcomes (e.g., illness or deaths due to COVID-19) or population mobility patterns. On the other hand, the key explanatory variable is vote or vote shares for Bolsonaro. The assumed underlying model can be summarized as follows, where the individuals i belong to municipalities j at time t :

$$Covid - 19Deaths_{ijt} = \alpha + \beta_2 Ideology_{ijt} + \varepsilon_{ijt}$$

While this model has theoretical validity, we lack the data to empirically estimate it. We do not have reliable measures of ideology for individuals across municipalities at different moments during the pandemic. Therefore, researchers have employed an alternative estimation strategy in which pre-pandemic voting

behavior is used as a proxy for contemporary ideology. Since individual voting data is not available, aggregate data (average within a municipality) is employed to make predictions across individuals (GELMAN et al., 2001). Furthermore, aggregate past voting behavior is also assumed as a proxy for group-level behavior towards disease prevention. The aggregate model of the average observed outcomes of each j municipality at time t can be summarized as:

$$\overline{Covid - 19 Deaths}_{jt} = \alpha_{jt} + \overline{Votes}_{j-2018} + \varepsilon_{jt}$$

However, as we will discuss in this study, the major challenge in these studies is related to their ecological research design. There are fundamental problems with research designs based on testing hypotheses using aggregate data. In the next section, we focus on these methodological challenges.

What are some of the key methodological challenges?

We reviewed studies on how political orientation affects COVID-19 outcomes in Brazil. A total of 14 studies on how ideology or partisanship would be associated with COVID-19 matters were identified. This section highlights three important methodological problems that make inferences about the correlation between ideology and outcomes challenging to assess without a more rigorous research design. Specifically, we discuss measurement error, omitted variable bias, and temporal dynamics. Research designs that fail to account for these problems will produce biased inferences.

Measurement error

As we have stressed, one of the explanatory variables most frequently used as a proxy for ideology is the vote shares received by Jair Bolsonaro in 2018. The specific characteristics of this presidential election make it challenging to use the vote share in this particular year to infer ideological orientation in Brazil. In this section, we stress two issues. First, we explain that the 2018 election was exceptional, different from the previous elections that have taken place in Brazil since the country returned to democracy in the late 1980s. As we argue in this

section, the 2018 election may have been more about electing an 'outsider' than electing a conservative (ideology) per se. Second, we show that there are important differences between the first and the second rounds in a multiparty system, such as in the case of Brazil.

The 2018 election

The Brazilian 2018 election was exceptional (AMARAL, 2020; RENNÓ, 2020). Bolsonaro's election must be understood as the result of a combination of several factors, particularly the political and economic instability, 'antipetismo', and the widespread rejection of traditional political actors – with outsiders and anti-establishment candidates being favored instead (FUKS, RIBEIRO, and BORBA, 2021; HUNTER and POWER, 2019; SETZLER, 2020).

In this sense, we argue that, first, the integrity of Brazilian political institutions has been in question for a considerable time, especially after the popular demonstrations in 2013 and the disclosure of corruption scandals by the Lava Jato task force in 2014. Holder of the highest executive position since 2002, the PT was considered the most responsible for the economic and political crises, which ultimately resulted in the controversial dispute that led to the impeachment of Dilma Rousseff. Her successor, Vice President Michel Temer, experienced very high rejection rates, as high as 62% by the end of his mandate (FOLHA DE SÃO PAULO, 2018).

Second, the presidential elections of 2018 stressed voter rejection of traditional political parties. Voters were opposed to the Workers' Party (PT) even though this political party had successfully won four consecutive presidential elections in 2002, 2006, 2010, and 2014. In addition to Jair Bolsonaro – as the head of the far-right Social Liberal Party (PSL) –, 11 other candidates were in the first round vying for a second-round post. Bolsonaro's competitors included PT candidate Fernando Haddad, who had stepped in to substitute former president Luiz Inácio Lula da Silva and became his main rival in the second round – 'Lula' had been imprisoned since April 2018 on corruption charges and was therefore barred from running. Bolsonaro and Haddad together received 75% of the first-round votes. The other nine competitors included candidates from all other major political parties in

Brazil, including the PSDB, who received the remaining vote share, with no party managing to mount a successful challenge to these two front-runners.

It is worth noting, in this case, the small role played by Bolsonaro's controversial views on democracy, women's sexual and reproductive rights, and homophobia in his victory compared to aspects well established in political science, such as political ideology and partisanship, especially regarding the hostility to the PT (FUKS, RIBEIRO, and BORBA, 2021; SETZLER, 2020).

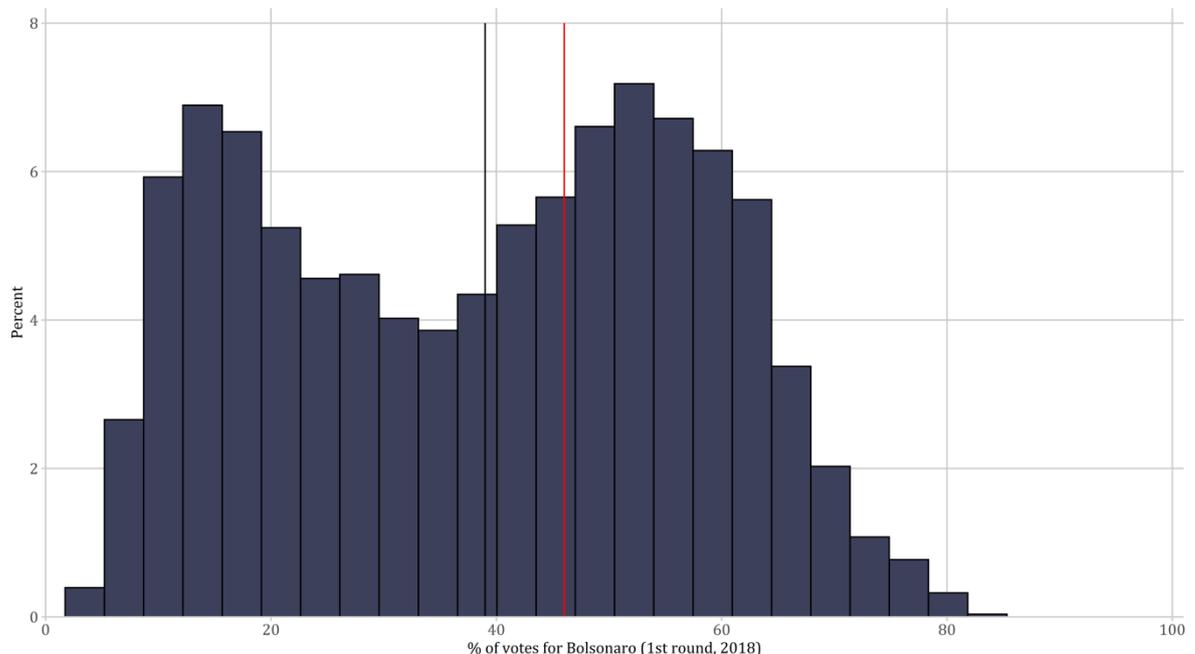
Finally, on the eve of the election, the economy was also performing poorly. Since 2015, the unemployment rate has been increasing substantially. In 2014, 6.66% of the total labor force was unemployed. In contrast, in 2018, the labor force unemployed rose to 12.33% (WORLD BANK, 2021). The country was also experiencing lackluster levels of economic growth. While in 2010 the country experienced GDP growth as high as 7.5%, GDP growth in 2018 was as low as 1.8% (WORLD BANK, 2021). After years of reduction in inequality, the country saw a surge in the number of families living in extreme poverty (7.4% of the population in 2017 compared to 6.6% in 2016) (BRASIL, 2018). A survey conducted by Gallup a few months before the 2018 election shows that 32% of the Brazilian population reported struggling to afford food in the last 12 months, and 25% did not have enough money to pay for shelter (REINHART, 2018). In sum, voter reactions to economic mismanagement and mistrust of traditional parties were two factors that also shaped voter preferences in the 2018 election (RENNÓ, 2020). For these reasons, there is ample evidence that using Bolsonaro's 2018 vote share as a proxy for ideology is problematic due to political and economic contextual factors.

First and second rounds of the presidential election in Brazil

The metric that is a valid proxy for ideology must also be considered. In a multiparty system such as the case of Brazil, first-round elections generally involve several political parties competing, vying for a slot in the second round of the election. Indeed, in the first round of the 2018 election, candidates from 11 political parties sought to pass to the second round. In the first round, voters typically vote for their preferred candidate. It bears mentioning that Jair Bolsonaro earned 46% of the votes in the first round. His share of votes, however, was largely

spread across Brazilian municipalities. As Figure 01 shows, there is a difference between Bolsonaro's mean municipal vote share and the percentage of votes he received in the 2018 first round (TSE, 2022). On average, his vote share across the municipalities ranged from 1.9% to 83.9%, and the distribution of these votes is bimodal. However, this distribution gives equal weight to all cities, regardless of population size. Across municipalities, the mean of Bolsonaro's vote share was 39% of votes cast in the first round. Thus, the mean municipal average is 07% lower than the national average.

Figure 01. Distribution of Jair Bolsonaro's vote share across municipalities, mean municipal and mean popular vote shares (First round of presidential election, 2018)



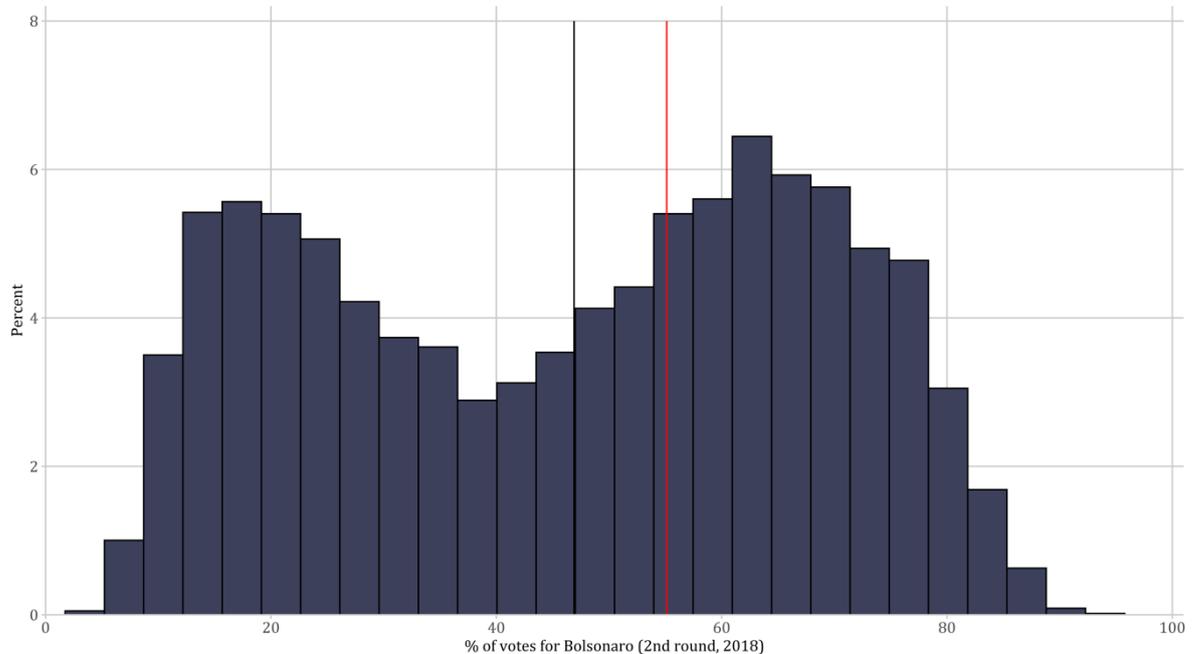
Source: Electoral Data Repository (TSE)

Note: The black vertical line is the mean municipal vote share, and the red vertical line is the mean of the popular vote share.

In the second round of the election, voters had to choose between Jair Bolsonaro and Fernando Haddad. As is well-known in political science and Brazil, second-round elections are a flawed measure of ideology. Instead, voters vote tactically in a majoritarian election restricted to two final candidates. For this reason, second-round votes tend to be less representative of voter preferences and usually reflect the expected patterns observed in majoritarian elections, as Figure

02 confirms. The mean proportion of votes received by Bolsonaro in a Brazilian municipality is 46.9%, while the popular vote share is 55.13%.

Figure 02. Distribution of Jair Bolsonaro's vote share across municipalities, mean municipal and mean popular vote shares (Second round of presidential election, 2018)



Source: Electoral Data Repository (TSE)

Note: The black vertical line is the mean municipal vote share, and the red vertical line is the mean of the popular vote share.

As we have stressed in this discussion, research on the causal link between ideological orientation and COVID-19 outcomes is challenging. By employing vote shares for Bolsonaro as a proxy for ideology, researchers assume that voter behavior is coherent and ideologically oriented and disregards key aspects of the electoral dynamics in Brazil. Even though some authors (FIGUEIRA and MORENO-LOUZADA, 2021) claimed to address this issue by reporting results based on first and second-round votes or used alternative measures, e.g., polling data on the level of support for Bolsonaro (ALMEIDA et al., 2022), it is not clear that the vote share captures the ideology of voters in 2018. Furthermore, it is not clear that Brazilians who voted for Bolsonaro in 2018 were consistently loyal and supportive of his policies during the pandemic from 2020 onwards (AJZENMAN, CAVALCANTI, and MATA, 2020; ALMEIDA et al., 2022; FIGUEIRA and MORENO-

LOUZADA, 2021), which is a further implication. We discuss this more extensively in the section on temporal dynamics, but we stress it here to emphasize that ideology is not equivalent to approving the government and the president. For these reasons, measurement bias is most likely a significant factor.

Omitted variable bias

The omission of factors that are correlated with both the dependent and explanatory variables is also an important methodological challenge. In this section, we briefly review some of the types of factors that may affect ideology and pandemic outcomes. These include demographic and regional factors.

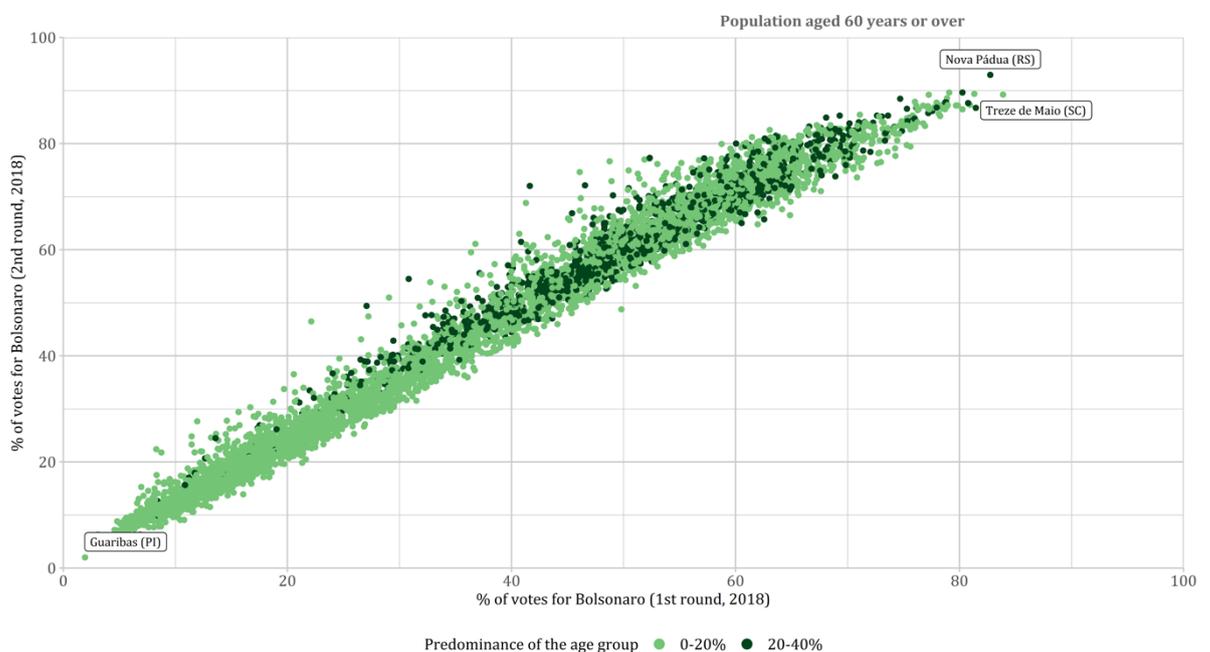
For each municipality in Brazil, we can calculate the percentage of adults aged 60 years and older and the percentage of votes received by Jair Bolsonaro in 2018. As Figure 03 illustrates, there is an ecological correlation between the demographic profile of municipalities and the vote share for Bolsonaro. In other words, there are higher shares of the elderly population that live in municipalities that also awarded higher vote shares to Jair Bolsonaro in 2018. Several of the studies we reviewed that reported a statistical association between votes for Bolsonaro and COVID-19 infection did not dedicate sufficient attention to showing that other factors that may affect behavior and the spread of COVID-19 may have contributed to the observed patterns (ALMEIDA et al., 2022; CABRAL; PONGELUPPE, and ITO, 2021; FERNANDES et al., 2020; MARIANI; GAGETE-MIRANDA, and RETTL, 2020; XAVIER et al., 2022).

However, these correlations need to be contextualized. Life expectancy is higher in Brazilian municipalities with higher income (MAGALHÃES and MIRANDA, 2009). Considering that older adults are more likely to die from COVID-19 (RANZANI et al., 2021), a positive ecological correlation will be observed between municipalities with a higher share of older adults and higher death rates. In other words, the relationship between the demographic profile of the municipality (a higher percentage of more senior citizens) and the likelihood that death rates are thus higher in these same districts is a relevant factor to consider.

Turning to demographics and voting, most municipalities with the highest percentage of people aged 60 years or over are also the municipalities where

President Bolsonaro received 30% or more of the votes in the second round. Additionally, according to Mariani, Gagete-Miranda, and Retzl (2020), pro-Bolsonaro cities did not display lower immunization levels or higher levels of flu-like illness in 2019 in Bolsonaro's first year in office. These same municipalities also had higher proportions of the population with private health insurance in 2019 (IBGE, 2019). In other words, these confounders might affect the association between votes and COVID-19 outcomes.

Figure 03. First- and second-round vote shares for Jair Bolsonaro in 2018 and the proportion of the population aged 60 and older in the Brazilian municipalities



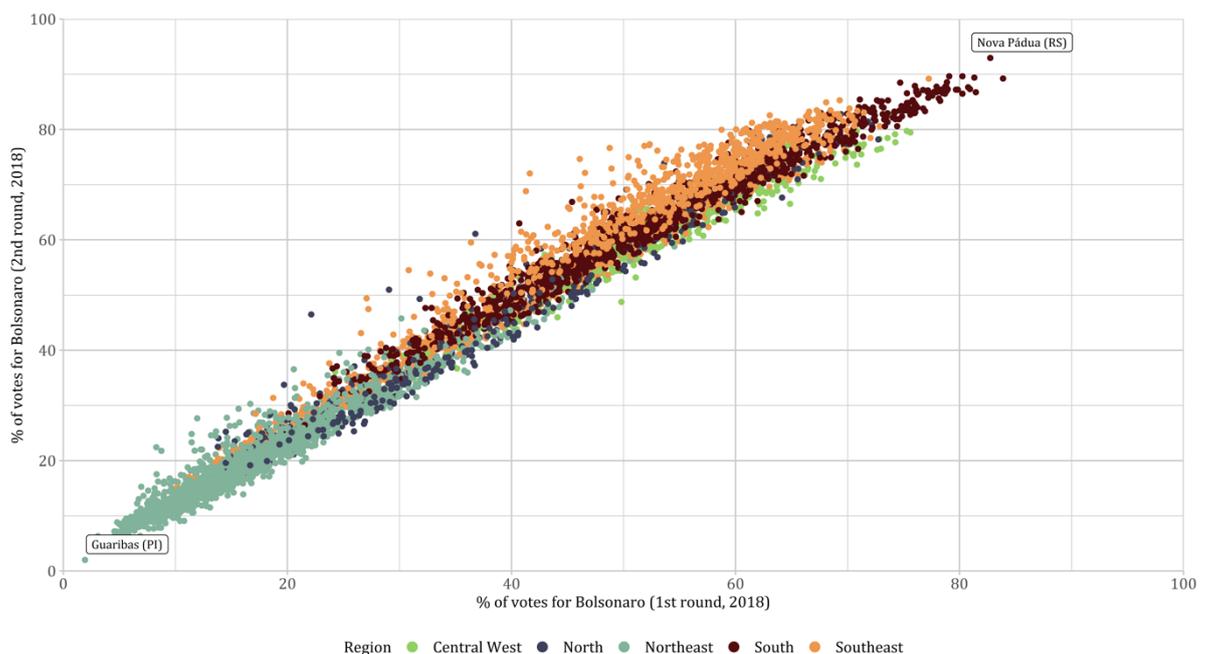
Source: Electoral Data Repository (TSE), IBGE, and DATASUS.

A significant body of research has been dedicated to understanding the influence of territory on electoral outcomes. This field of study has grown in recent years, popularly known as electoral geography, and it has become essential for a complete understanding of the political-electoral performance of candidates in elections. In the specific case of Brazil, several studies have established a direct relationship between the votes received by 'Lula' (Luiz Inácio Lula da Silva) – and by the Workers' Party (PT) – and the voters' place of residence, for example (KERBY,

2011; MAGALHÃES, SILVA, and DIAS, 2015; TERRON and SOARES, 2010). In the case of the PT, vote shares were concentrated in Greater Sao Paulo and the Northeast.

Figure 04 confirms that the votes for Jair Bolsonaro in the first and second rounds of the 2018 presidential elections were highly concentrated in specific regions. Bolsonaro received the lowest vote share in the Northeast and the highest shares in the South and Southeast regions. In this case, it is essential to emphasize that, although the 2018 election was exceptional compared to past presidential elections, the specific characteristics of the electorate did not change drastically, which explains why the PT kept its electoral base in the Northeast region.

Figure 04. Votes (%) for Jair Bolsonaro in the first (x-axis) and second (y-axis) rounds of the 2018 presidential election



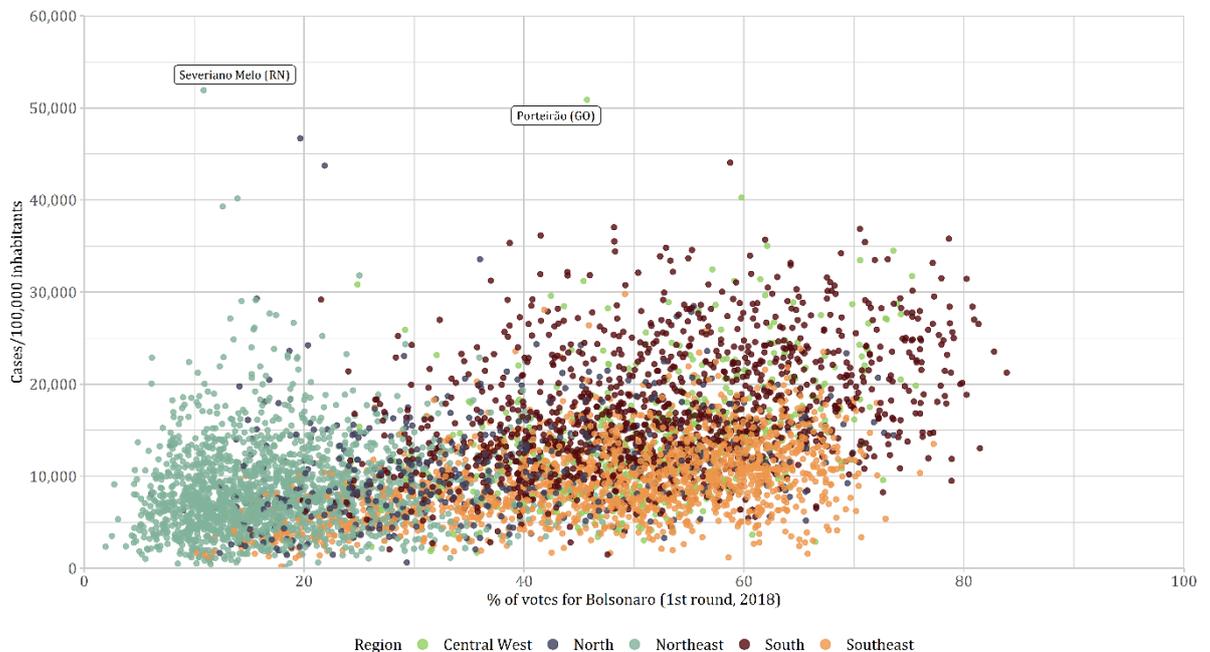
Source: Electoral Data Repository (TSE) and Brasil.io.

Several explanations have been offered for why votes for specific candidates are spatially concentrated in the case of Brazil. Studies have stressed spatial patterns aligned with socioeconomic factors, including demographics, population density, urban infrastructure, education levels, and the percentage of recipients of cash transfer programs (BOHN, 2011; NICOLAU, 2014). However, in most COVID-19 studies we reviewed for this study, ideology and

political-electoral choice of individuals in 2018 are stressed as playing a more decisive and more determinant role than these factors.

Figure 05 shows that although Bolsonaro had a geographically concentrated performance in the 2018 election, COVID-19 cases do not seem to follow a similar pattern of spatial concentration. Although Bolsonaro received the lowest share of votes in the Northeast region, cases in these municipalities vary more broadly. Heterogeneity in outcomes is even more widespread in the South and Southeast regions, where he obtained his highest relative electoral performance.

Figure 05. Votes for Jair Bolsonaro (% , first round, 2018) (x-axis) and Cases/100,000 (y-axis) across municipalities and by region

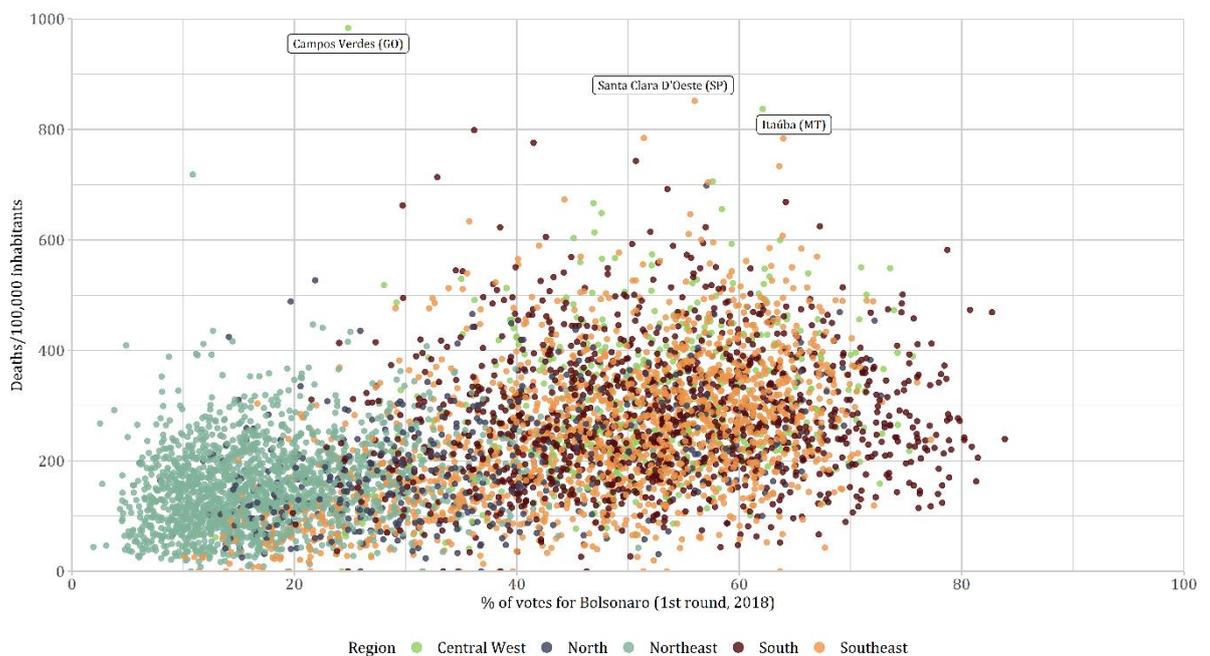


Source: Electoral Data Repository (TSE) and Brasil.io.

A similar pattern is observed concerning the correlation between the municipal vote share and the mean municipal number of deaths. Figure 06 again confirms that within regions, there is variation, and this variation is particularly marked in the South and Southeast, where the highest vote shares were recorded for the right-wing populist candidate.

Besides the known effect that older adults are more likely to die of COVID-19 (RANZANI et al., 2021), the population size of municipalities is likely to impact COVID-19 cases and deaths. In municipalities with more than 31,500 inhabitants, Bolsonaro received more than 60% of the votes in both rounds; in cities with less than 4,600 inhabitants, he received between 40% and 60% of second-round votes. As shown in Figure 07, the median values of cases and deaths increase as the number of inhabitants increases. However, smaller cities have more significant outliers both in deaths and in cases.

Figure 06. Votes for Jair Bolsonaro (% , first round, 2018) (x-axis) and deaths/100,000 (y-axis) across municipalities and by region

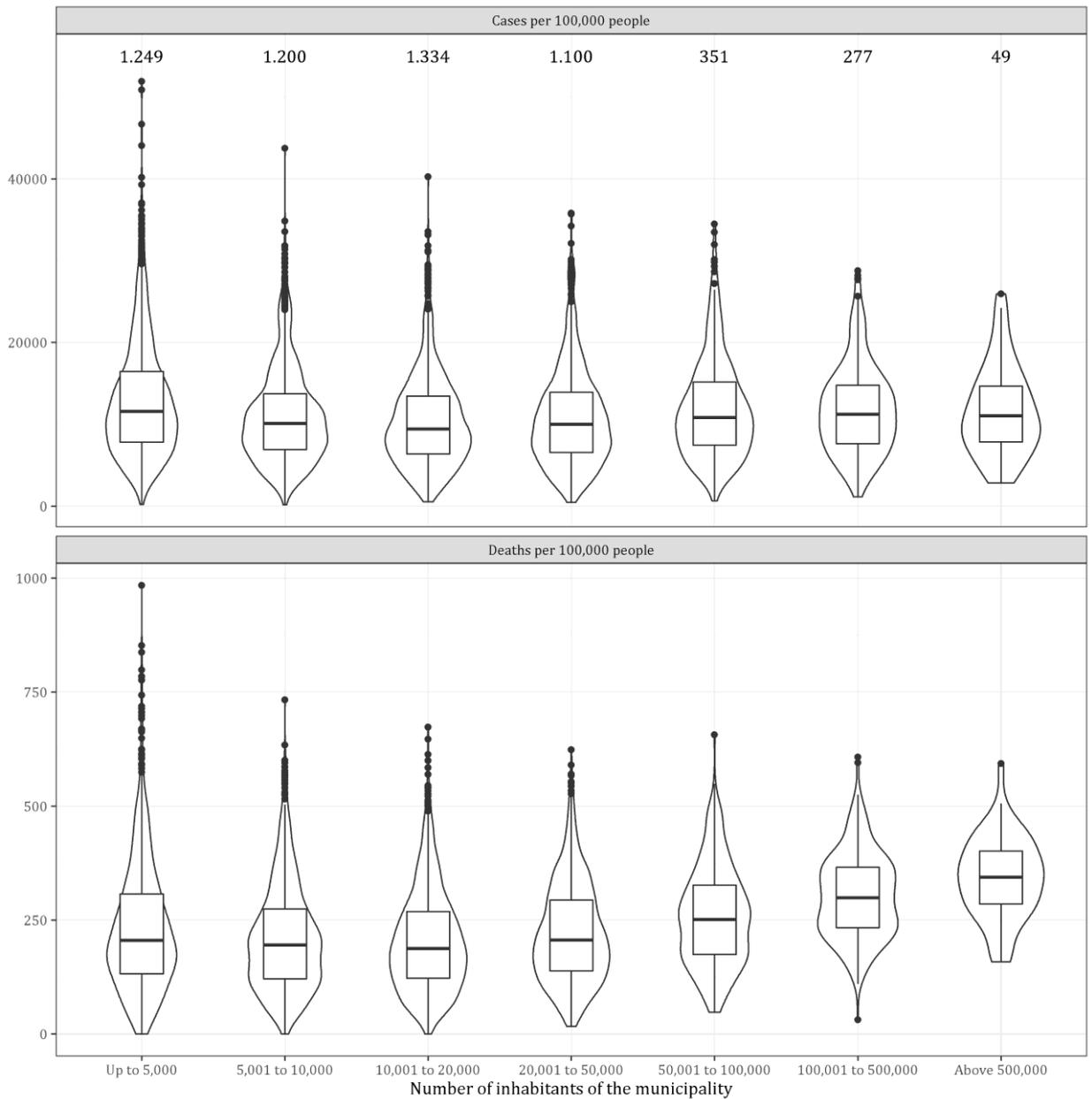


Source: Electoral Data Repository (TSE) and Brasil.io.

According to the IBGE estimates, in 2020, most of the cities in Brazil had up to 20 thousand inhabitants (68%). Only 49 municipalities of 5,570 have more than 500,000 inhabitants. However, these 49 municipalities comprise 30% of the country's population. In the other municipalities, health infrastructure varies considerably. Many municipalities, especially the poorest and most remote, lack the health investments necessary to deliver critical care to save lives, such as hospitals, ICU beds, and equipment such as ventilators (NORONHA et al., 2020).

Population density is also likely to impact COVID-19 outcomes. Figure 08 depicts cases and deaths by quartile. The quarter of cities with smaller population density has a larger proportion of extreme values than the quarter with higher density. However, in the deaths per 100,000, the difference in cases is not observed.

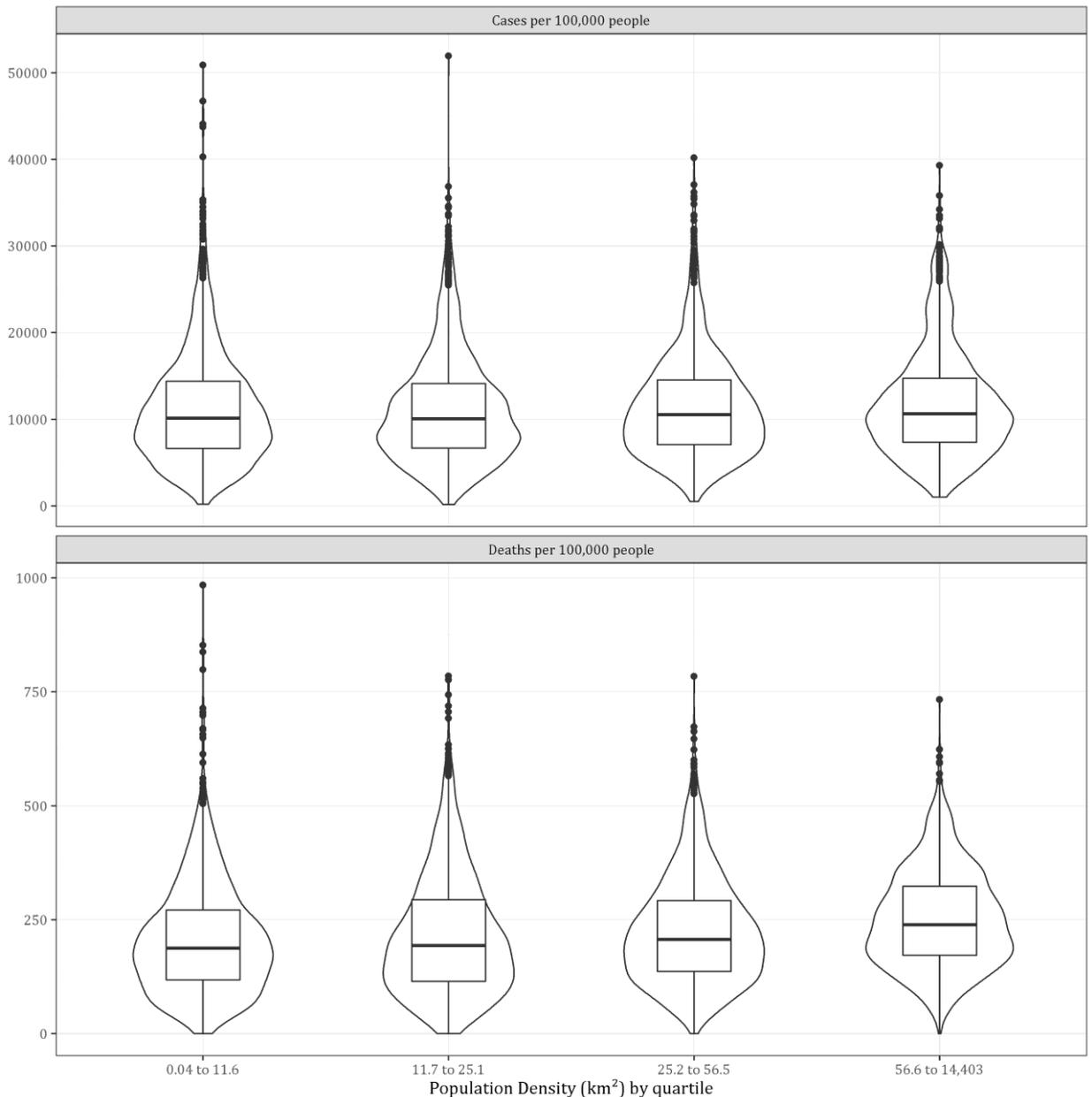
Figure 07. COVID-19 cases and deaths per 100,000 people by municipality population size



Source: IBGE and Brasil.io.

In part, this is because of the variation that exists within municipalities. For example, according to the IBGE, 7.8% of households in Brazil live in housing that is considered below minimum acceptable standards. These households are characterized by irregular and improvised constructions, a lack of essential services, including running water and sanitation, and higher numbers of people living in more dense spaces, such as *favelas* (IBGE, 2020).

Figure 08. COVID-19 cases and deaths per 100,000 people by municipality population density



Source: IBGE and Brasil.io.

Temporal dynamics

As the previous section showed, our results suggest high levels of variation in terms of COVID-19 deaths across municipalities in the regions where Bolsonaro received a high vote share and where he received a low vote share. In this section, we present a time-variant analysis of COVID-19 outcomes across Brazilian municipalities. We provide evidence that the relationship between COVID-19 deaths and the 2018 Bolsonaro vote share varies considerably over time, thus suggesting the latent need for variables other than 'ideology' to be considered when analyzing these aspects.

As we have stressed, the studies that employ the vote shares for Jair Bolsonaro in the 2018 election as the key explanatory variable generally assume that the causal mechanism is the following: ideology impacts individuals' behavior, which in turn affects COVID-19 infections and deaths. That is, individuals who voted for Jair Bolsonaro are assumed to be voters that are ideologically aligned with the president. It is assumed that because these voters voted for this candidate in 2018, they continue to follow Bolsonaro's speeches, advice, and guidance in 2020 and 2021. These 'loyal' voters disobey local government mandates, social distancing policies, and even federal laws (e.g., mask mandates passed by the Brazilian Congress after overriding a presidential veto in July 2020). In other words, these voters follow their leader, who has consistently opposed social distancing and masks (AJZENMAN, CAVALCANTI, and MATA, 2020; FIGUEIRA and MORENO-LOUZADA, 2021; LEONE, 2021; MARIANI, GAGETE-MIRANDA, and RETTL, 2020; XAVIER et al., 2022).

However, even if one assumes that vote share is a good proxy for ideology, ample evidence in political science has documented that voters' support for the president is malleable. For instance, Bolsonaro's approval rating has varied considerably during the pandemic (YAM et al., 2020). Electoral studies provide sufficient grounds to know that this is quite common for presidential approval. Presidents experience honeymoon periods early on and traditionally lose a significant portion of the electorate as their terms advance. This empirical regularity has also been reported for Brazil, and it is most likely to have occurred during the pandemic. For example, in the state of São Paulo, Bolsonaro won by 53% of the votes

in the first round and 68% in the second round. In April 2019, in the first months of his mandate, Bolsonaro was approved by 57% of the São Paulo state voters. Nonetheless, evidence from a survey conducted in July 2021 shows that the share of voters that supports the president's job performance decreased significantly. Only 40.1% of the São Paulo state voters approved of Bolsonaro's performance in office. In other words, there is no credible evidence that the same voters that voted for the right-wing populist in the 2018 elections continued to support him after he assumed office, or that they did so consistently up to the present. Throughout a mandate, support for a president varies substantially due to events, scandals, the performance of the economy, and the response to the COVID-19 pandemic (BAEKGAARD et al., 2020). Hence, we cannot infer that those who voted for him continue to approve of his job performance, nor that they continue to follow his advice and guidance concerning social distancing.

Furthermore, voters' behavior changes over time and across space. In the context of the COVID-19 pandemic, there is evidence showing that adherence to social distancing policies varied throughout the pandemic. As Figure 09 illustrates, data based on smartphone geolocation tracking show that home permanence (%) varied substantially throughout 2020 across the Brazilian state capitals. We use data from InLoco, a location analysis company that tracked approximately 60 million smartphone users across Brazil throughout 2020. The measure used here is the percentage of mobile phones that remain at the same geographical location during the day (06 am to 10 pm) as during the night (10 pm to 06 am). Unfortunately, InLoco discontinued releasing this data in April 2021. Notably, a spike in home permanence coincided with the week when the WHO declared COVID-19 a pandemic. Panel A of Figure 09 depicts the average home permanence (%) across the capitals in which Bolsonaro won 50% or more of the votes and in those where he received less than 50% of the votes in the first round. In contrast, Panel B depicts the average home permanence (%) for the second round of the 2018 elections.

There are two relevant patterns to be highlighted. First, the average home permanence in the capitals where Bolsonaro won (50% or more of the votes) is similar over time to the average in the capitals where he lost (less than 50% of the

votes). The two series overlap during most of the period under study. Second, from the end of April to the end of May 2020, the two series depart slightly from each other. However, the difference between them is less than six percentage points. Thus, Figure 09 shows that voters' behavior in places where Bolsonaro won is quite similar to voters' behavior in places where he lost. In summary, this evidence contradicts the speculation that adherence to social distancing measures was substantially lower in areas where Bolsonaro won most of the votes compared to places where he lost.

Furthermore, the relationship between COVID-19 deaths and Bolsonaro's vote share in the 2018 elections has varied significantly over time. Since the beginning of the pandemic, Brazil has experienced two major waves: the first wave from the onset of the pandemic to week 43 in 2020 and the second wave starting on week 44 in 2020 (BASTOS et al., 2021). It bears stressing that Brazil remained one of the countries with the highest infection and death rates compared to other countries and that the second wave has been even more devastating than the first. We now evaluate whether there is a clear distinction in the pattern observed between COVID-19 deaths and Bolsonaro's vote share in the first and the second waves.

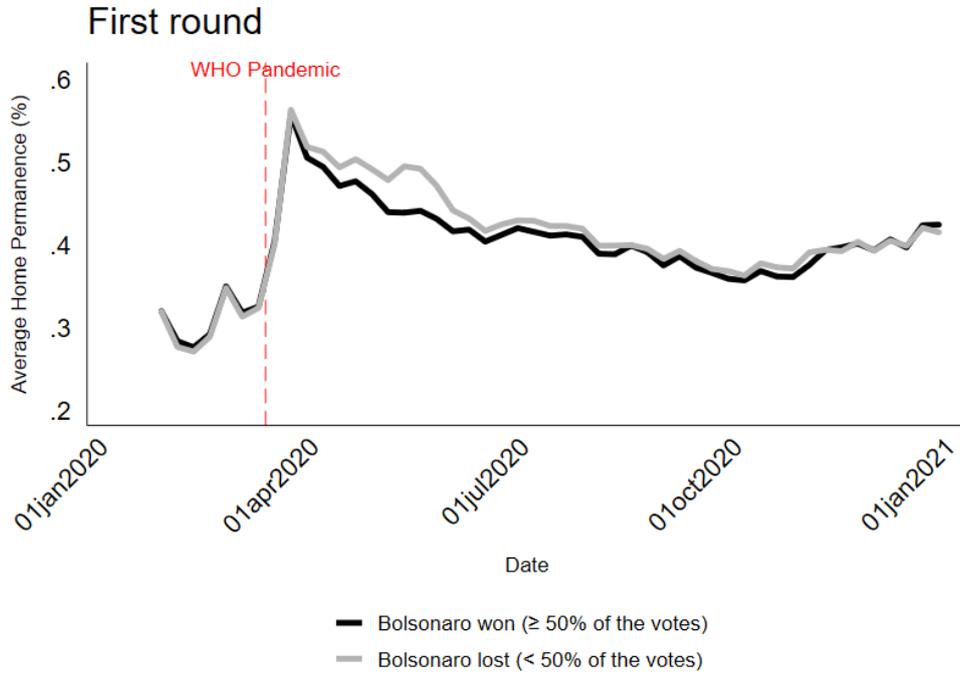
Figure 10 shows the estimated effect of Bolsonaro's 2018 vote share (first round) on COVID-19 cumulative deaths in the first wave. To calculate the effect of Bolsonaro's vote share in each j municipality, the following linear regression model was estimated for each month t :

$$Deaths_{jt} = \alpha_1 + \beta_1 \text{Bolsonaro vote share}_j + \varepsilon_{jt}$$

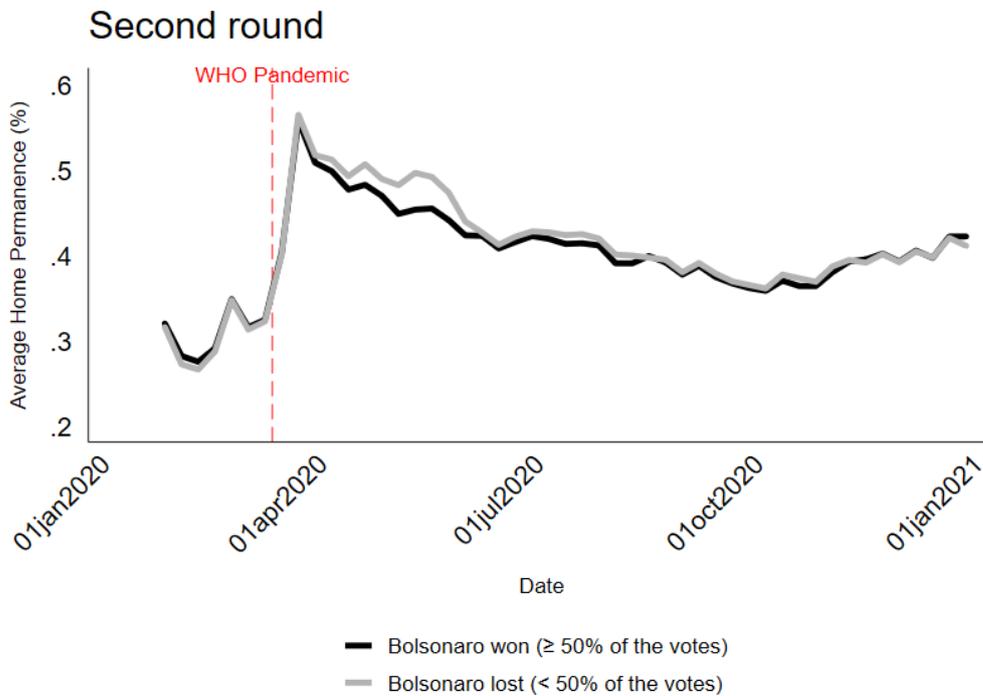
The coefficient on Bolsonaro's vote share in 2018 is not statistically significant in three out of the eight months of the first wave (March, April, and August 2020). The relationship between votes and deaths is negative in the other three months (May, June, and July 2020). That is, municipalities more supportive of Bolsonaro had fewer COVID-19 deaths in those months of the pandemic. However, after these early months, the relationship reverses. The number of COVID-19 cumulative deaths per 100,000 in municipalities less supportive of Bolsonaro stopped increasing. In contrast, cities more supportive of Bolsonaro saw a trajectory of increased deaths in September and October 2020.

Figure 09. Average home permanence (%) in state capitals where Bolsonaro won and lost the majority of votes in the 2018 elections

Panel A. First round



Panel B. Second round



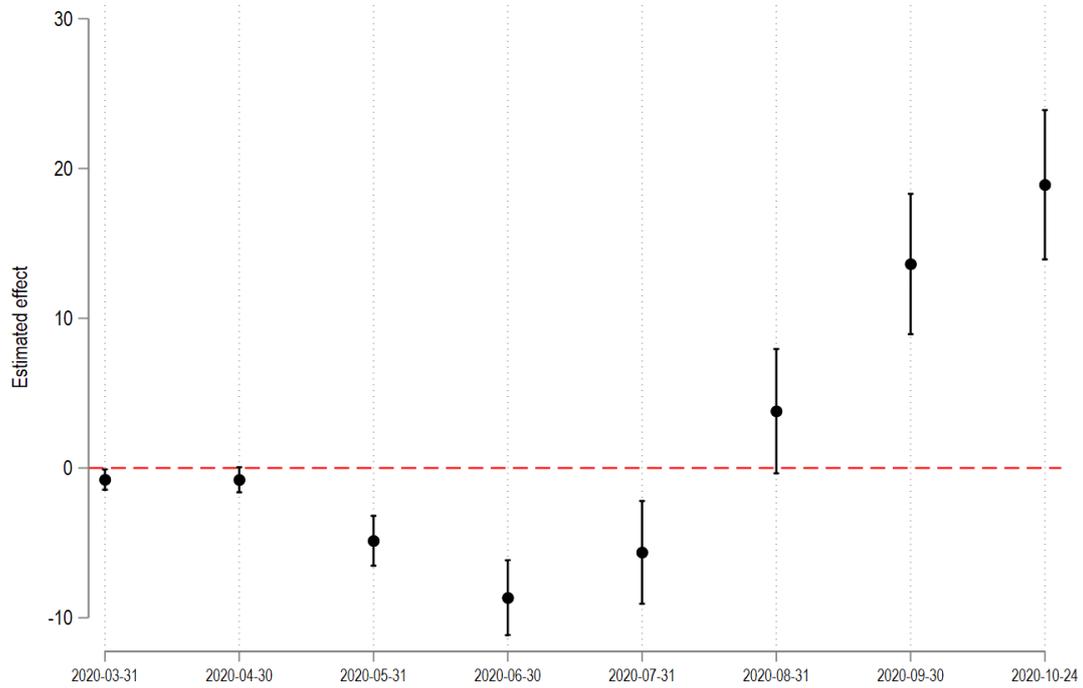
Source: Data on home permanence (%) by state from InLoco.

In contrast, there is much less variation in the relationship between Bolsonaro vote share (first round) and COVID-19 cumulative deaths during the second wave. As shown in Figure 11, the relationship between Bolsonaro's vote share and COVID-19 cumulative deaths is positive and statistically significant in the second wave. This finding is consistent even if we analyze Bolsonaro's vote share in the second round instead of the first. In sum, the relationship between COVID-19 deaths and vote share exhibits distinct patterns in the first and the second waves.

A possible explanation for such variation is that pro-Bolsonaro municipalities suffered less at the beginning of the pandemic because they were also the most developed ones. To evaluate this hypothesis, Figure 12 presents Bolsonaro's 2018 vote share's estimated effect on deaths per 100,000 in the poorest Brazilian municipalities (the 25th percentile of GDP per capita) and the richest ones (the 75th percentile of GDP per capita). As the figure shows, the only months in which the poorest and the richest experienced different patterns are May, June, and July 2020. Throughout the rest of the first and the second waves, the effect of Bolsonaro's vote share on COVID-19 deaths is very similar across the poorest and the wealthiest cities. As this analysis shows, other factors may play a relevant role in explaining the relationship between votes and COVID-19 deaths and thus need to be taken into account, such as social distancing policies.

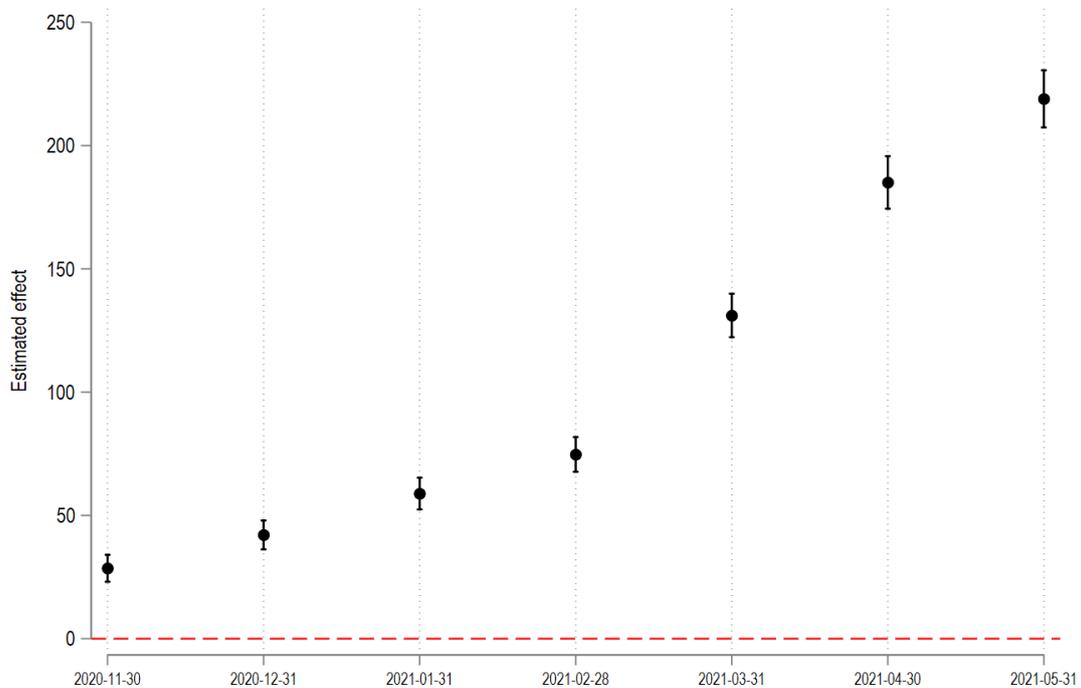
Previous research shows that individuals' behavior was substantially impacted by the social distancing policies implemented by the governments (HSIANG et al., 2020). In the case of Brazil, Barberia et al. (2021) demonstrate that voters' behavior was affected by the social distancing policies implemented at the state level. This is especially important because the Brazilian response to the pandemic was significantly heterogeneous across states (BARBERIA et al., 2021) and municipalities (SANTOS et al., 2021). For these reasons, studies seeking to understand the relationship between vote share in the 2018 elections and COVID-19 cases and deaths in 2020 and 2021 should account for how voters' behavior has changed over time, given the social distancing policies in place.

Figure 10. Estimated effects of 2018 first-round Bolsonaro vote share on COVID-19 deaths per 100,000 in first wave

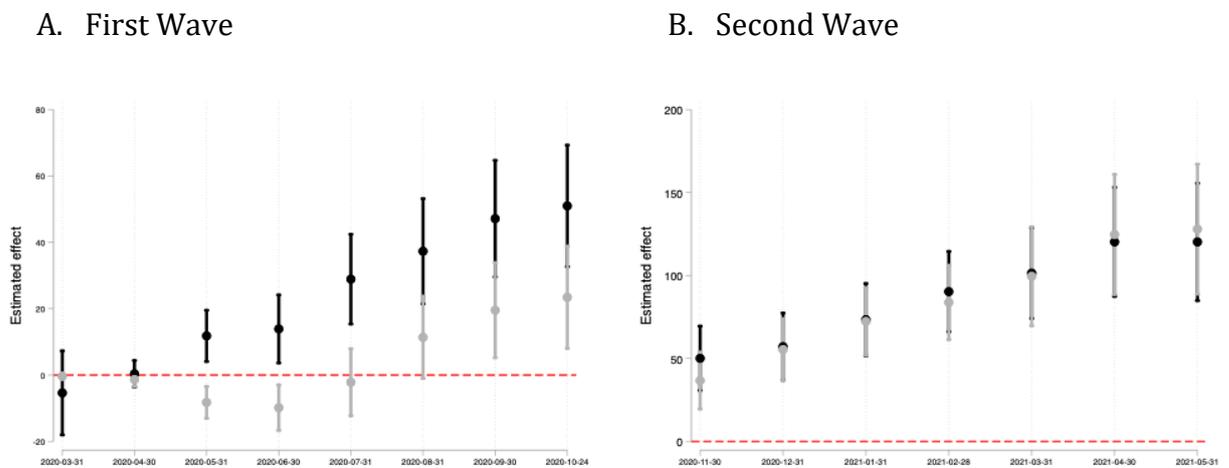


Source: Electoral Data Repository (TSE).
 Note: Estimated effect and 95% confidence intervals.

Figure 11. Estimated effects of 2018 Bolsonaro first-round vote share on COVID-19 deaths per 100,000 in second wave



Source: Electoral Data Repository (TSE).
 Note: Estimated effect and 95% confidence intervals.

Figure 12. Estimated effects of 2018 Bolsonaro first-round vote share on COVID-19 deaths per 100,000

Source: Electoral Data Repository (TSE).

Note: Estimated effect and 95% confidence intervals. The black lines indicate the estimated effects for the poorest municipalities (25th percentile of GDP per capita) and the gray lines for the richest municipalities (75th percentile of GDP per capita).

What we still need to know

In the scholarship on the COVID-19 pandemic, the debates on the challenges of ecological inference remain ever-present (WU et al., 2020). In this paper, we have sought to highlight methodological challenges so that scholars may be alerted to some of the difficult questions that need to be addressed in order to make valid inferences and avoid bias. We have sought to underscore that measurement error is a major challenge. Ideology is not equivalent to vote choice. Furthermore, we have also sought to emphasize that ideology and government approval ratings are time-varying concepts, and research studies that treat these as static and equivalent should be questioned.

A second point we have sought to emphasize is that municipal-level studies are ecological by definition. This data is, by nature, aggregate data, and inferences are limited to the group level. Scholars and journalists need to understand the limits of group-level inferences and avoid engaging in ecological fallacies. Indeed, it is even possible that the correlation of two variables at the aggregate level can have the opposite sign as the correlation at the individual level (JARGOWSKY, 2005).

Thirdly, omitted variable bias is a well-known problem in social science. In both individual and aggregate-level studies, the statistical correlations from simple bivariate or reduced-form models are often not robust when models are fully specified. For this reason, researchers need to be more honest and upfront about omitted variable bias and acknowledge that this source of bias has not been eliminated. We hope that our discussion here and the presented data help underscore the complexity of the inference and the types of data needed.

Finally, temporal dynamics matter for ecological inferences. Most analyses that have been produced focusing on the correlation between past electoral voting patterns and behavior towards social distancing policies or pandemic outcomes generally analyze the first six months of 2020. The longer the space between past and existing outcomes, the more challenging it is for researchers to make inferences and the more necessary it is to adequately acknowledge the uncertainties and potential biases at play. There are learning processes at work during the pandemic, and ecological studies must devise strategies to address how these changes might be influencing behavior and outcomes. For example, while at first there were many unanswered questions about the best ways to prevent and treat infection and about the duration of the COVID-19 pandemic, information on the effective means to contain the pandemic increased throughout the pandemic, as well as citizens' knowledge about the risks posed by SARS-CoV-2. Consequently, individuals have adapted their behavior over time. Concomitantly, government policies also varied significantly across this period.

In conclusion, our objective in this paper has been to use this systematic discussion to help provide a more guided understanding of the challenges of ecological inferences. As we hope to have highlighted, research designs that ignore these problems or attempt to minimize their importance produce biased findings. In light of these challenges, there are inherent limitations to what we can conclude about voter ideology and how it affects pandemic outcomes in Brazil. We must be willing to acknowledge that we know much less than we would like to know at this stage, and we should continue to invest in research designs that have the potential to help map cause and effect pathways.

Recently, a few studies have undertaken novel approaches to the study of how ideology affects pandemic outcomes. For the sake of brevity, we cite one example here. Larsen et al. (2022) conducted a large-scale randomized controlled trial to assess whether the partisan cue of a pro-vaccine message from Donald Trump induced adults to get COVID-19 vaccines in the U.S. The results showed that the campaign increased the number of vaccines in the average treated county. However, the study also found that ideology matters. In counties with an above-median Trump share, there is no significant response to the treatment. This example is a randomized control trial. All else equal, the study shows that counties responded differently to the treatment contingent on 2020 Trump vote patterns. There is a behavioral response among certain counties (those with less than 70% of voters favoring Trump), and not among those with extreme proportions of Trump supporters. It would be interesting to replicate this type of research design in Brazil.

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Appendix

Table A01. Review of literature in COVID-19 and support for Bolsonaro

Spatial and Temporal Units	Level of Aggregation	DV	IV	Controls	Methods	Main Conclusions
Author: AJZENMAN et al (2021)						
daily, municipality	Municipality	Mobility (Location data)	Bolsonaro's speech, Support for Bolsonaro on 1st round of 2018 elections	Population, TV broadcasters, consumer spending using card transaction data, income, religion, and poverty. Non-pharmaceutical interventions. Within state variation control	Dynamic difference-in-differences model for Brazilian municipalities. Treatment measured as "pro-government" dummy based on 2018 election data.	"Following the prominent speeches by the president against social isolation policies, the social distancing index immediately falls in municipalities with a larger share of Bolsonaro's supporters versus municipalities where his support is lower. (...)To further support our results, we use daily data on credit card expenses from one of Brazil's largest banks. We document a consistent (opposite) effect on consumer spending, mirroring those on social distancing. We also find that the results seem to be driven by in-person consumer spending (excluding purchases in pharmacies). This result suggests that the effect documented on mobility is hardly driven by lower-risk activities (such as outdoor running, which would not affect in-store purchases) or essential trips (such as buying medicines) (pp 3) "(...) Finally, we document a stronger effect in places with a larger proportion of Evangelical Christians, a religious group that represents around a quarter of the population and who not only heavily supported the president in the 2018 election, but also showed stronger approval of the president's handling of the pandemic" (pp 3)
Author: CALVO, E.; VENTURA T.(2020)						
Daily	Individual	Voter risk perceptions	Party Support (vote for Haddad or Independent), Bolsonaro's Speech, "Anger" treatment	employment, education, assessment of government performance, and age.	Difference-in-differences design. Experimental design.	"It shows that supporters of the Bolsonaro administration in Brazil report lower subjective levels of job and health risks, along with greater support for the government's response to the COVID-19 pandemic." (pp 2) (...) The results show that among opposition voters, perceptions of job and health risk increased after Bolsonaro's speech, compared to independents, while no changes were perceived among government partisans. (pp 2) "(...)The results also show that, on average, negative tweets by Bolsonaro increase perceptions of personal job risk ("losing your job"), while negative tweets by Haddad reduce

						perceptions of job risk (p = 0.12). Health risks, however, do not seem to be affected by the different treatments." (pp 15)
Author: FERNANDES, I; et al (2020)						
weekly, municipality	Municipality	COVID-19 results (number of deaths, confirmed cases, lethality rate, and the rate of contamination by inhabitants)	Votes for Bolsonaro in the first round of the 2018 elections; social isolation	Quadratic trend variable, fixed effects for the 27 federation units, and the weeks; municipal GDP per capita, population density, population size (in 1000 inhabitants), latitude, longitude, altitude, distance in kilometers between the municipality and the federal and state capitals, and the number of hospital and ICU beds in municipalities.	Local average treatment effect (LATE). Cross-sectional data by OLS instrumental variable. Random-effects models for panel data with instrumental variable	"(...) isolation has a positive effect on the number of deaths, which would be counterintuitive, given that the policy is adopted to reduce the spread of the disease (...) However, when we correct the β with Bolsonaro's share of votes, it becomes negative and significant, indicating that an increase in one percentage point of the general municipal average of social isolation decreases deaths by 45%."(pp12-13) "Table 2 indicates the existence of a self-correlation between isolation and the number of deaths, both the total and weekly counting measures of deaths. The result of isolation, when corrected by the Bolsonaro effect, becomes, as expected, negative, thus indicating that the proportion of votes is positively associated with the accumulated number of deaths."(pp 14)
Author: GOLLWITZER, A.; et al (2020)						
daily, county	Counties	infection growth rate, fatality growth rate, physical distancing	partisanship (pro-vote Trump voting), partisan media	Mediator (lagged physical distancing), number of COVID-19 cases per capita, median income, percentage employment, average travel time to work, governor political affiliation, and racial make-up, age, ethnicity, low store access, Gini coefficient, population, life expectancy	Three-level mixed-effects model with random intercepts; mediation model	"We found that the more a county favored Donald Trump over Hillary Clinton in the 2016 election, the less that county exhibited physical distancing between 9 March and 29 March 2020."(pp 1187) "(...)To put this into context, partisanship was more strongly associated with distancing than counties' number of COVID-19 cases per capita, median income, percentage employment, average travel time to work, governor political affiliation, and racial make-up, as well as the other variables noted above" (pp 1188) "(...) our model indicated that extremely pro-Trump-voting counties (+2 z-score in the vote gap variable) experienced a daily infection growth rate of 0.59 percent-age points higher than average.(...) Our findings suggest that partisan differences in physical distancing were linked to higher growth rates of infections and fatalities in pro-Trump counties than necessary" (pp 1193)

Spatial and Temporal Units	Level of Aggregation	DV	IV	Controls	Methods	Main Conclusions
Author: LEONE,T. (2020)						
daily, municipality	Municipality	Social Distancing Index (SDI) based on geolocalized mobile phone data	Lockdown, Bolsonaro's vote share in 2018	lagged values of the accumulated cases, lagged values of the accumulated deaths, GDP per capita, dummies indicating whether any COVID-19 case had already been registered in Brazil and in the municipality	difference-in-differences and panel data regression	"(...) this paper confirms a statistically significant association between political support for Bolsonaro and social distancing, suggesting that the positive impacts of stay-at-home orders are higher in municipalities with a lower share of Bolsonaro voters" (pp 15)
Author: PEREIRA, C; et al (2020)						
individual	Individual	Fear of death, fear of losing the job, social distancing	Support for Bolsonaro, fear of losing the job, covid-19 infection	gender, income, age	ordinal logistic regressions	"Our research revealed that as the individuals in the sample became aware of fatal victims among their acquaintances, their perceptions changed. They became more favorable of social distancing and willing to follow such policy for longer. Also, the respondents evaluated the president's performance as 'worse' and the governors' as 'better.' Thus, the identity connections between the group and its leader became malleable and fragile."
Author: MARIANI, Lucas et al. (2020)						
daily, municipality	Municipality	Citizen's compliance with public health measures, specifically compliance with social distancing norms in the pandemic context; Log	Bolsonaro's manifestations regarding COVID-19 and social distancing measures, Bolsonaro's participation in events against social distancing policies, particularly the president's attendance at protests on	Municipality fixed effects, controls for state and time trends, interaction of municipalities' population with time and with the number of cases one day before the demonstrations - that is on March 14th, interaction of municipalities' GDP per capita with time and with the number of cases right before the demonstrations.	Difference-in-differences approach	"We conclude that Bolsonaro's behavior increased the pace of COVID-19 diffusion. In particular, after the day of the manifestations, the daily number of new COVID-19 is 19% higher in cities that concentrate Bolsonaro's voters as compared to cities that concentrate opposition voters. The impact is verified even in cities where no demonstration took place, which indicates that the quicker spread of COVID-19 was not only due to people agglomerating during the manifestation, but also due to the changed behavior of Bolsonaro's supporters regarding social distancing measures (...)." (pp. 104).

		COVID-19 deaths	March 15, responses to a nationally representative poll [DataFolha, 2020] by Bolsonaro's voters and non-voters, results of the 2018 presidential elections used to measure cities' support for Bolsonaro, data on the location of the March 15th demonstration s to check for heterogeneous impacts of Bolsonaro's behavior, an index of social isolation			
Author: BRUCE et al. (2021)						
static, municipality	Municipality	The effects of female leaders on the epidemiological outcomes of COVID-19 policy	Margin of victory of the winning female mayor candidate in the previous mixed-gender electoral race. (pp. 4)	A set of policy and communication-related control variables, socioeconomic and demographic controls, mayor-specific controls, party-level index, municipal ideological score.	Regression Discontinuity (RD) design	"Female leadership reduced deaths and hospitalizations per 100 thousand inhabitants while increasing enforcement of non-pharmaceutical interventions. [...]. The effects are stronger in municipalities where Brazil's far-right president, who publicly disavowed the importance of non-pharmaceutical interventions, had a higher vote share in the 2018 election."

Spatial and Temporal Units	Level of Aggregation	DV	IV	Controls	Methods	Main Conclusions
Author: ROCHA et al. (2021)						
monthly, municipality	Municipality	COVID-19 death rate	Socioeconomic vulnerability over time	Housing vulnerability (%), informal workers (%), population with health risk factors (%), population aged ≥60 years (%), SUS ICU beds per 100000 people, private ICU beds per 100000 people, ICU physicians per 100000 people, community health agents coverage (%), family health strategy coverage (%), Bolsa Família coverage (%), new ICU beds (per 100000 people), new ICU beds (% of pre-existing), policy stringency index, change in physical distancing adherence since February 2020 (percentage points), COVID-19 deaths per 100000 people, age-adjusted, new ICU beds (per 100000 people), new ICU beds (% of pre-existing)	Linear regressions on a municipality-by-month dataset from February to October 2020 to characterize the dynamics of COVID-19 deaths and the response to the epidemic across municipalities.	"The initial spread of COVID-19 was mostly affected by patterns of socioeconomic vulnerability as measured by the SVI rather than population age structure and prevalence of health risk factors. The states with a high (greater than median) SVI were able to expand hospital capacity, to enact stringent COVID-19-related legislation, and to increase physical distancing adherence in the population, although not sufficiently to prevent higher COVID-19 mortality during the initial phase of the epidemic compared with states with a low SVI. Death rates accelerated until June, 2020, particularly in municipalities with the highest socioeconomic vulnerability. Throughout the following months, however, differences in policy response converged in municipalities with lower and higher SVIs, while physical distancing remained relatively higher and death rates became relatively lower in the municipalities with the highest SVIs compared with those with lower SVIs."
Author: CABRAL et al. (2021)						
daily, municipality	Municipality	New COVID-19 cases and deaths	Five speeches by Mr. Bolsonaro. (pp. 3)	2018 presidential election results, demographics, healthcare resources, and comorbidities in 2019, week and municipality fixed effects	Regression Discontinuity Design, panel data of all 5,570 Brazilian municipalities with daily observations from February 25th, 2020 to February 18th, 2021	"The results show that municipalities in which Mr. Bolsonaro obtained the majority of votes in the second round of the 2018 presidential elections are precisely the ones more affected by COVID-19. The higher the proportion of votes for Mr. Bolsonaro, the higher is the incidence of new cases and new deaths among the municipal population after his denialist speeches." (pp. 5)

Spatial and Temporal Units	Level of Aggregation	DV	IV	Controls	Methods	Main Conclusions
Author: MORRIS (2021)						
daily, county-level data	County	Cumulative COVID-19 cases per 100,000 county residents and cumulative COVID-19 deaths per 100,000 county residents	Time (in days) and a continuous measure of the percentage of the county that voted for Donald Trump in the 2016 presidential election	State fixed effects, age, race-ethnicity, socioeconomic status, health indicators, demographic/Geographic characteristics	Multilevel linear growth models with state fixed effects to estimate the relationship between county-level support for Donald Trump and the trajectory of cumulative COVID-19 cases and deaths per 100,000 county residents between March 17, 2020, and August 31, 2020.	"Counties more supportive of Trump had fewer COVID-19 cases and deaths in the early months of the pandemic. However, as the summer moved into July and August, counties less supportive of Trump stopped growth rates of COVID-19 cases and deaths, while counties more supportive of Trump saw a trajectory of increased cases and deaths in July and August. This is likely due to the widely divergent beliefs and behaviors displayed by Republicans and Democrats toward COVID-19."
Author: ALMEIDA et al. (2022)						
monthly, state	State	Fatality rates due to COVID-19	Level of support for the Brazilian President in the country's various regions (pole data from the 2018 presidential elections)	Period during which General Eduardo Pazuello was acting Health Minister for the central government, excess deaths by COVID-19	Pearson's correlation; basic regression model	"[...] we show here that it is possible to estimate this number for Brazil with relatively low uncertainty, resulting in an excess of 350 ± 70 thousand deaths by the mid of November 2021, or about $(57 \pm 11)\%$ of the total number of deaths. The key parameter allowing this estimation is the inhomogeneity of political support for the central government throughout the national territory, from which we extrapolate to obtain the number of deaths not influenced by this factor. Our analysis also reveals the temporal dynamics of such political risk aspects in Brazil, showing its increase during 2020 up to dominance in 2021". (pp. 1) "[Our analysis] reveals, specifically, the somewhat unexpected magnitude of such political bias over the spread and fatality of the pandemic in Brazil, overcoming at a certain point in time other strong factors such as poverty levels and the mutation dynamics of the virus itself.". (pp. 8).

Spatial and Temporal Units	Level of Aggregation	DV	IV	Controls	Methods	Main Conclusions
Author: FIGUEIRA et al. (2021)						
monthly, electoral districts	Electoral districts	Excess deaths by COVID-19 (patients under 60 years old)	Votes for Bolsonaro in the 1st round of the 2018 Presidential Elections (people under 60 years old)	Paulista Social Vulnerability Index, access to clean water, income, and age controls, time spent in public transport to access workplaces, % of the population covered by teams of Basic Health Attention and by Family Health programs (basic medical attention), votes for other Right-leaning candidates	OLS model	"The results are significant and indicate the existence of a relationship between votes for Bolsonaro and deaths during the pandemic — between one and three additional deaths per 100k people for each percentage point of votes. Our conclusions are robust when using excess deaths to control for exogenous determinants of mortality, as well as when including controls by age, average income, and other indicators of socioeconomic vulnerability."
Author: XAVIER, D. et al (2022)						
monthly, municipality	Municipality	COVID-19 deaths	second round of the 2018 Brazilian presidential elections	income, inequality index, health service quality, and partisanship	Regression tree analysis	"Municipalities that supported then-candidate Jair Bolsonaro in the 2018 elections were those that had the worst COVID-19 mortality rates, mainly during the second epidemic wave of 2021. This pattern was observed even considering structural inequalities among cities."