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When Science Strikes Back - Has a scientific background helped leaders against COVID-19?

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Abstract

In this paper, we try to answer the question: "Has a scientific background helped leaders against COVID-19?". To do so, we use a regression discontinuity design in close mayoral races between STEM (science, technology, engineering and math) and Non-STEM candidates to estimate the causal impact of having a mayor with scientific background on COVID-19 epidemiological outcomes in Brazil. We find that STEM mayors reduced COVID-19 deaths and hospitalizations, mediated by the number of non-pharmaceutical interventions (NPIs), such as face mask obligatory usage. We also find suggestive evidence that these results were moderated by leaders' scientific intensity. We also show that this estimated impact is not due to other observable mayoral characteristics, such as years of education, ideology, or gender. Our findings suggest that, overall, municipal leaders with STEM training better handled a scenario involving emergencies and small amounts of data and evidence. We discuss that our results may indicate that investment in science and technology-related human capital produces non-intended externalities - such as improvements in public management issues.

RESUMO EXECUTIVO

Esta dissertação teve como objetivo investigar o impacto da eleição de prefeitos com formação científica na gestão da pandemia de COVID-19 no Brasil. A relevância do tema se dá na descoberta de externalidades não previstas no investimento em capital humano científico. Demonstramos que prefeitos com formação em STEM conseguiram reduzir o número de mortes e hospitalizações por COVID-19, principalmente através da implementação de intervenções não farmacêuticas, como o uso obrigatório de máscaras faciais. As implicações práticas desta tese é o destaque da importância de líderes terem conhecimentos científicos para aplicar mais evidências em sua gestão e também destacar importância de investimentos em capital humano relacionado à ciência e tecnologia.

Keywords: STEM, COVID-19, externalities, public-management, RDD.

*the next time you listen to Borodin
remember he was just a chemist
who wrote music to relax;
(Charles Bukowski)*

1 INTRODUCTION

Different leaders around the world have responded to the COVID-19 crisis in different ways. One case that exemplifies it is the leadership of Angela Merkel, which was extensively discussed in an article featured in *The Atlantic* (Miller, 2020). The article's main point was that Merkel's educational and professional background as a scientist helped her "personify evidence-based thinking" and succeed in better handling the pandemic. The use of evidence in management is well documented in literature as "evidence-based management" (Pfeffer & Sutton, 2006), and scientific education, such as Merkel's, has been associated with the concept of "evidence-based" (Bybee, 2013). For instance, professionals with such a background are recognized for their ability to draw conclusions based on evidence, make decisions rooted in evidence while navigating uncertainty and data, and construct explanations of real-world phenomena grounded in evidence (English, 2016; Shernoff, Sinha, Bressler, & Ginsburg, 2017). Moreover, a substantial body of literature has highlighted the significance of adopting a "scientific approach" to decision-making, advocating that managers and entrepreneurs can benefit from and should incorporate elements of the scientific method into their practices (Camuffo, Cordova, Gambardella, & Spina, 2020). In terms of public leaders, Hjort, Moreira, Rao, and Santini (2021) demonstrated that they are likely to update their beliefs when presented with scientific evidence, while Bruce, Cavgias, Meloni, and Remígio (2022) revealed that their personal characteristics influenced the outcomes of the Covid-19 pandemic. However, to the best of our knowledge, the impact of scientific background on public leaders' performance during Covid-19 responses is still uncertain.

Despite the consolidated notion that investing in science-related human capital is crucial for maintaining a nation's competitiveness (Atkinson Mayo, 2010) and despite the increasing role of scientific research in public policy (Hjort et al., 2021), there seems to have been no conclusive results on the impact of leaders' scientific background outside scientific fields, especially in leadership roles during a crisis. In the field of management literature, researchers who have examined the causal impact of training entrepreneurs with a scientific approach on firms' performance have emphasized the need for additional investigation, particularly when considering the case where the treated have a science background (Camuffo, Gambardella, & Spina, 2020, p.27). More broadly, some correlational studies have shown that human capital accumulation in science-related fields is highly associated with social positive externalities (Winters, 2014), such as firm-level innovation (Brunow, Birkeneder, & Rodríguez-Pose, 2018), and have also shown that science-related skills are used outside of scientific careers (Mellors-Bourne, Connor, & Jackson, 2011, p.129). On the other hand, public policy applied studies have found no robust impact of politicians' scientific background on public matters, such as public sector reforms (Bastos & Sánchez, 2021) and legislative voting about scientific issues (Goodwin, 2015).

Therefore, this paper aims to contribute in three different ways. Our first contribution comes from filling a gap in the literature by identifying whether there is a causal relationship between leaders' scientific background and relevant outcomes during times of crisis. We do so by applying a regression discontinuity design to answer the causal question: "Does a scientific background help leaders against COVID-19?". Our proposition is that mayors with a scientific background reduced epidemiological outcomes during the COVID-19 crisis, in comparison with their counterfactual. We also find suggestive evidence that non-pharmaceutical interventions (NPIs) mediated this effect and that leaders' scientific intensity and municipalities' level of development acted as moderators. The second contribution involves bridging the gap between the scientific approach, scientific literacy, and evidence-based management on one hand, and the STEM literature on the other. The final contribution of this paper is empirically testing a novel definition of science, technology, engineering and mathematical (STEM) occupations in the Brazilian context. We do so by creating that proxy of scientific literacy testing a new classification of STEM jobs in Brazil (Machado, Rachter, Schanaider, & Stussi, 2021). Finally, after showing that STEM mayors had better results during the pandemic we conclude by arguing that public investments in science-related fields may produce non-expected externalities in public administration practices, such as using previous evidence to support the use of NPIs.

In the following sections we develop the hypotheses (Section 2), describe the data and the variables (Section 3), and present the empirical approach (Section 4). We finally present our results (Section 5) and add our discussion (Section 6).

2 HYPOTHESIS' THEORETICAL FRAMEWORK

Many confounding variables could be affecting incumbent leaders' performance during a crisis, such as its country's health and science investments, citizens' wealth, or even its leader's other personal characteristics. Several studies have shown that policy outcomes are considerably affected by leaders' personal characteristics, such as ideology (Pettersson-Lidbom, 2008), education (Besley, Montalvo, & Reynal-Querol, 2011), age (Alesina, Cassidy, & Troiano, 2019), incumbency (Frey, 2021), professional background (Hyytinen, Meriläinen, Saarimaa, Toivanen, & Tukiainen, 2018; Kirkland, 2020, 2021; Kuliomina, 2021; Szakonyi, 2021). Besides that, the literature has already shown that mayors' personal characteristics, such as gender (Bruce et al., 2022), affected epidemic outcomes during the pandemic. Previous research has also shown that leaders are likely to update their beliefs when presented with scientific findings (Hjort et al., 2021), but has found little evidence of heterogeneity in treatment effects based on leader characteristics, such as the impossibility of running in the next election. However, it is currently unclear whether other personal characteristics that are deeply relevant for policymaking, such as education and professional background could enhance leaders' use of evidence in the general method of thinking problems. Therefore, it is still unknown whether having an educational and/or professional background in scientific fields could further enhance leaders' use of evidence and scientific advice.

It is plausible that leaders with backgrounds in STEM (Science, Technology, Engineering, and Math) - where STEM acts as a proxy for scientific training and skills could develop an evidence-based management style. This "evidence-based" approach could potentially enhance management decisions. EBM) involves obtaining information based on evidence on which decisions can be made (Pfeffer & Sutton, 2006). EBM is commonly used in areas such as medicine and public health, and it also has applications in fields such as engineering and education. The main objective of EBM in policymaking is to enhance government effectiveness by developing, evaluating, and utilizing more rigorous evidence to guide decisions about program design, funding, and implementation (Heinrich, 2007). In addition to EBM, the concept of the "scientific approach" has also been applied to decision-making within a management context. This approach encompasses several crucial steps, as described by Novelli and Spina (2022). First, it involves the development of a theory, followed by the formulation of hypotheses that logically stem from the theory. Subsequently, evidence is collected to either support or challenge these hypotheses. Finally, a disciplined assessment of the collected evidence is conducted. These fundamental steps of the scientific approach serve as a framework for informed decision-making in management, ensuring a systematic and evidence-based approach to problem-solving and strategy development. Besides being theoretically developed, several empirical studies tested the causal impact of the scientific approach on management performance. A study was conducted

by Camuffo, Gambardella, and Spina (2020) to examine the impact of scientific approach training on entrepreneurs employing randomized controlled trials (RCTs). The authors adopted a categorical variable ranging from 1 to 5 to classify treated entrepreneurs based on their level of scientific approach adoption. This variable measured the extent to which entrepreneurs utilized various components of the scientific approach, such as theory, hypothesis, tests, and evaluation. The study reaffirmed the findings of Camuffo, Cordova, et al. (2020) by showing that scientifically trained entrepreneurs performed better but also emphasizing the mechanisms. Beyond that, they revealed that higher scientific intensity adopted by entrepreneurs caused better firm performance through selecting better ideas, making these more precise, or pivoting in ways that enhance their ideas. Another study (Novelli & Spina, 2022) employing RCTs to assess the influence of training entrepreneurs with a scientific approach on firm performance discovered heterogeneous effects for firms' development stage. They found that treating entrepreneurs with a scientific approach training caused a positive effect on the size of firms, a measure of performance. However, the impact on another performance measure, revenue, was only positive for firms in a higher stage of development, while firms in the early stages even experienced a negative impact. The researchers put forth a theory to explain this moderation effect, suggesting that firms in different stages of development face distinct challenges, and a scientific approach is more beneficial for more advanced firms Novelli and Spina (2022). Building upon these findings, we also examine the moderation effect of two variables, mimicking the ones used in the studies mentioned above. Hence, it's possible to believe that the connection between a STEM background and management may have reduced leaders' inclination to disregard scientific recommendations, a problem demonstrated by Cabral, Ito, and Pongeluppe (2021). These leaders would be more inclined to implement preventive measures, such as social distancing, mandatory mask usage, and other NPIs, suggested by scientific committees or their peers in the scientific community. Embracing such a science-oriented approach could effectively increase the implementation of interventions, consequently leading to a reduction in hospitalizations and fatalities.

We formalize this logical path between STEM background and epidemiological outcomes into the following hypothesis:

- **H1:** The election of a candidate with a STEM background in 2016 resulted in a significant decrease in COVID-19 hospitalizations and deaths in 2020;
- **H2:** The implementation of non-pharmaceutical interventions, such as mandatory face mask usage, mediated the effect of H1 on COVID-19 outcomes;
- **H3.a:** The level of scientific expertise possessed by leaders, as measured by their years of experience in STEM occupations, moderates the effect of H1 on COVID-19 outcomes;

- **H3.b:** The level of development in leaders' municipalities, measured by cities' revenue in 2015, moderates the effect of H1 on COVID-19 outcomes.

3 DATA AND DESCRIPTIVE STATISTICS

3.1 Data

Our sample includes all municipalities where a STEM candidate placed first or second in the 2016 mayoral elections. We only considered counties where elections were decided in a single round and classified as "ordinary elections" by the Superior Electoral Court of Brazil (TSE). In total, our main sample has 98 municipalities and our robustness sample has 404. Within the main sample, to estimate the causal effect of a STEM mayor in the epidemiological outcomes, only counties where the elections were decided by a small margin difference were considered in our regressions. Mayors' and elections data were collected and processed by the project "Base dos Dados" (Dahis, Carabetta, Scovino, Israel, & Oliveira, 2022).

Elections and mayors' characteristics: We use data from Tribunal Superior Eleitoral - TSE¹, to select the municipalities where a STEM mayor was one of the top two voted candidates. Besides that, we also collected candidates' characteristics, such as age, gender and occupation to serve as control covariates. To characterize a mayor as STEM or Non-STEM, our main data source comes from the linked employer-employee records RAIS (Relação Anual de Informações Sociais), a database from the Brazilian Ministry of Labor that offers comprehensive individual employee information on occupations and other characteristics of the formal labor market. Besides that, to refine our classification we also use data from social media, municipalities' websites, and "Escavador", a web page that aggregates personal public information.

Epidemiological outcomes: Based on the literature, we use data from SIVEP-Gripe² (Bruce et al., 2022) to build the outcomes variables for hospitalizations and deaths.

Baseline characteristics: Baseline variables were chosen to represent relevant characteristics related to demography, public health and ideology at the municipality level. The demographic characteristics source is the Brazilian National Census of 2010. Public health data comes from IEPS Data index³ and the Ideology index follows the work from Power and Rodrigues-Silveira (2019)⁴

Policy mechanisms: This data set was built by the research team from de Souza Santos et al. (2021) and Brazil's National Confederation of Municipalities (CNI). The information gathered regards Non-Pharmaceutical Interventions (NPIs), such as restriction of

¹ Available at: https://basedosdados.org/dataset/br-tse-eleicoes?bdm_table=resultados_candidato_municipio. Date of access: 22/06/21.

² Available at: <https://opendatasus.saude.gov.br/dataset/srag-2021-e-2022> and <https://opendatasus.saude.gov.br/dataset/srag-2020>. Date of access: 22/06/21.

³ Available at: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/5P03UL>. Date of access: 22/12/05.

⁴ Available at: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/5P03UL>. Date of access: 22/11/10.

transportation and obligatory use of facial masks, adopted by mayors between May and July 2020. The mayors were surveyed by phone calls and 72.3% of all the 5568 Brazilian mayors participated.

3.2 Main variables

3.2.1 Outcome variables

Cases, Hospitalizations and Deaths per 100k inhabitants - Y_hosp, Y_deaths: We created these two variables to measure different levels of epidemiological impact (medium and high). These outcomes were calculated per 100,000 inhabitants at the municipal level, which is a standard approach in epidemiological studies (Bruce et al., 2022, p.3). We included hospitalizations and deaths that were registered as "SRAG-COVID-19" or "Non-specified SRAG" to determine these outcomes. For the cohort of mayors elected in 2016, we used outcomes reported from March 1, 2020, until November 30, 2020. We chose this period because the pandemic began to impact Brazil around May 2020. The ending period was chosen because local elections took place between November 15, 2020, and November 29, 2020, after which the management of municipalities became mixed between incumbent and newly elected officials until the beginning of the next year. This period is called a "transitional government" (Rezende, 2019), and it would be difficult to determine whether the effects on epidemiological outcomes were caused by the incumbent or the newly elected mayor.

3.2.2 Independent variables

STEM candidate - stem_job_4: This is our main variable and our treatment. To define if a candidate is considered STEM, we first check, using the RAIS database, if he has worked at least 1 month in a STEM occupation. We do this to avoid input mistakes since some observations appear with 0 months of tenure. If a candidate has worked more than 1 month in a STEM occupation, we then check if he has a STEM college degree. We chose this method because candidates' bachelor information is not publicly available. and time constraints make it difficult to search for degree information of the two most-voted candidates per 5570 municipalities in 2016 and 2020. Therefore, briefly, we created a dummy variable that assumes the value of 1 if the candidate fulfills the following conditions, or 0 if any of these are not present:

- **i:** has worked at least 6 months in a STEM occupation;
- **ii:** has a STEM bachelor's degree.

STEM occupation - A STEM occupation is defined as having its' classification number from the Classificação Brasileira de Ocupações (CBO) inside Machado et al. (2021) list of CBOs classified as STEM. In total, this list classifies 65 CBOs as STEM occupations, which represents 10.5% of all CBOs (Machado et al., 2021, p.10). The full list of CBOs classified as STEM can be found in Appendix A.

STEM bachelor's degree : To construct this variable, we use primary data from various sources. We first select only the candidates that are STEM candidates (see definition above). We then search for the candidate's name in "Escavador"⁵, a web page that aggregates personal public information. If a candidate isn't on the page, we check his social media profiles. We then attribute the value of 1 for candidates that studied in a STEM field and 0 otherwise. In total, we have found information about 188 from 401 candidates (47%). In order to enlarge our sample, we have used a supervised machine learning technique that decides if the other mayors have or do not have a college degree, based on our 188 classifications and TSE public available data on mayors' characteristics. We can summarize our automatic classification process in the following steps. First, we defined what are STEM courses. We then used this definition to manually categorize, or "label," a subset of mayors' undergraduate degrees in our database (around 45% or approximately 188 observations). Finally, we use this data to train a boosting classification model (Schapire, 2003) and assess its performance. In practical terms, this method replicates the manual categorization of mayors' undergraduate degrees as STEM or Non-STEM.

STEM winning margin: This works as the running variable for our estimation. To create it we use data from TSE in order to point out the vote margin between the first and the second most-voted candidates. We attribute it a positive value if a STEM candidate won the election and a negative value otherwise.

Cohort: The cohort indicates the list of candidates registered in TSE for the local executive elections in the year 2016.

Tenure: Time of employment in a STEM occupation in years. Since we only observe RAIS data from 2003 until 2018, candidates that were already working in a STEM occupation in 2003 appear with higher number tenure. This happens because the tenure variable restarts every time a person changes jobs. Therefore, we could be misinterpreting this variable and measuring job stability, for example, instead of labor market experience or learning by doing skills. Therefore, we use a logarithm function that reduces extremes on the tenure measures, approximating the distance between them.

3.3 Descriptive statistics

The main variables and their descriptive statistics are presented in Table 1 and descriptive statistics by treated/non-treated municipalities in Table 2. The distribution

⁵ Available at:<https://www.escavador.com/>. Date of access: 28/07/21.

of our treatment across the states shows a mean of 1.6% STEM candidates in 2016, as shown in Figure 1. These proportions go by our expectations, considering that the mean of STEM jobs in Brazil in 2017 was 2.9% (Machado et al., 2021, p.10). In 2016, the outlier is the state of Acre, as seen in Figure 2. It's hard to find structural reasons why that specific state is an outlier, but a possible explanation is the low number of municipalities in that state (Acre is the third state with less number of municipalities). Therefore, electing a few STEM mayors could make it an outlier. Nevertheless, excluding it, Bahia and São Paulo are the top two with more STEM mayors in 2016.

Table 1 – Descriptive Statistics

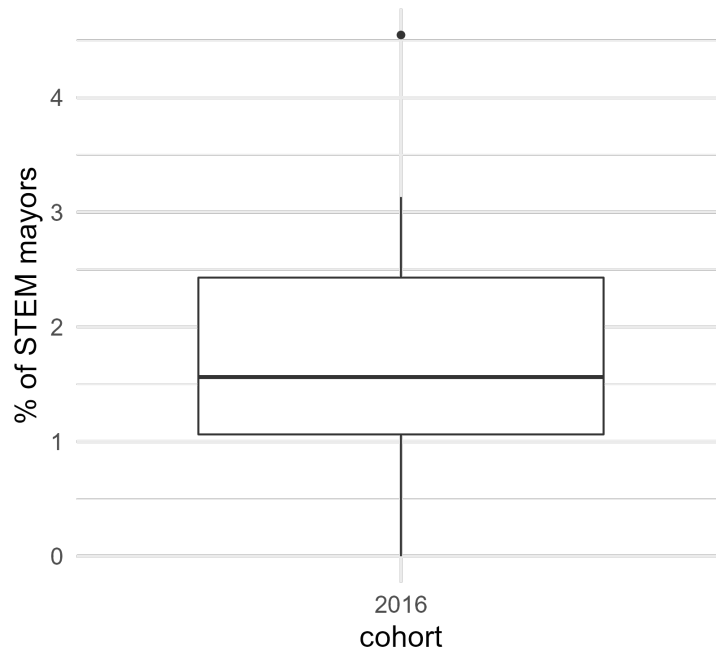
	N	Min	Mean	Max	SD
<i>Mayors' characteristics</i>					
tenure_stem_job	98	0.00	72.38	477.00	120.83
female	98	0.00	0.09	1.00	0.29
age	98	27.00	50.90	79.00	11.21
education	98	7.00	7.00	7.00	0.00
incumbent_when_elected	98	0.00	0.16	1.00	0.37
party_ideology	98	-0.62	0.26	0.76	0.38
<i>Municipalities' outcomes and NPIs</i>					
deaths_per_100k	98	0.00	86.92	261.10	54.15
hospitalizations_per_100k	98	34.51	315.16	1070.03	196.45
cases_per_100k	98	327.42	2404.11	5864.04	1383.46
cordon_sanitaire	71	0.00	0.46	1.00	0.50
face_covering_required	70	0.00	0.94	1.00	0.23
closure_of_non_essential	70	0.00	0.74	1.00	0.44
gathering_prohibition	70	0.00	0.97	1.00	0.17
public_transport_restriction	68	0.00	0.50	1.00	0.50
number_of_npi	68	1.00	3.60	5.00	0.88
<i>Municipalities' characteristics</i>					
population_2010	98	2420	39 529.70	814230	87 006.05
illiteracy_rate	98	1.97	16.00	39.91	10.68
gini	98	0.29	0.49	0.79	0.06
hdi	98	0.54	0.68	0.79	0.07
pc_income	98	196.57	544.65	1098.31	229.53
density	98	2.07	84.75	741.57	124.07
urban_pop_rate	98	0.17	0.71	0.99	0.21
men_pop_rate	98	0.47	0.50	0.58	0.01
physician_per_1k	98	0.00	0.96	4.42	0.74
health_municipal_spending_rate	98	15.28	23.15	35.98	4.97
community_health_agency_rate	98	0.00	82.58	100.00	26.93
hosp_beds_per_100k_pop	98	0.00	163.06	816.50	165.00

Notes: This table aggregates the summary statistics of all the observations used in the study (98). Municipalities chosen were those that held ordinary elections in 2016 whose mayor was elected in the first round and among the top two most voted was a STEM candidate. NPI data has null values since not all the mayors responded to the survey.

Table 2 – Descriptive Statistics by Mayor Background

	Non-STEM Mayor (N=54)		STEM Mayor (N=44)		Diff. in Means	p
	Mean	Std. Dev.	Mean	Std. Dev.		
<i>Mayors' characteristics</i>						
tenure_stem_job	0.00	0.00	161.20	135.22	161.20	0.00
female	0.15	0.36	0.02	0.15	-0.13	0.02
age	50.44	11.19	51.45	11.35	1.01	0.66
education	7.00	0.00	7.00	0.00	0.00	
incumbent_when_elected	0.22	0.42	0.09	0.29	-0.13	0.07
party_ideology	0.28	0.36	0.22	0.40	-0.06	0.45
<i>Municipalities' outcomes and NPIs</i>						
deaths_per_100k	79.97	50.64	95.45	57.61	15.48	0.17
hospitalizations_per_100k	303.98	194.20	328.89	200.55	24.90	0.54
cases_per_100k	2339.52	1373.52	2483.37	1407.33	143.85	0.61
cordon_sanitaire	0.54	0.51	0.39	0.49	-0.15	0.20
face_covering_required	0.91	0.29	0.97	0.17	0.06	0.29
closure_of_non_essential	0.74	0.45	0.75	0.44	0.01	0.89
gathering_prohibition	0.97	0.17	0.97	0.17	0.00	0.97
public_transport_restriction	0.53	0.51	0.47	0.51	-0.06	0.63
number_of_npi	3.68	0.73	3.53	1.02	-0.15	0.50
<i>Municipalities' characteristics</i>						
population_2010	45996.76	111881.23	31592.86	39130.77	-14403.90	0.38
illiteracy_rate	17.05	11.06	14.72	10.17	-2.32	0.28
gini	0.49	0.06	0.49	0.07	0.00	0.83
hdi	0.68	0.07	0.68	0.06	0.01	0.55
pc_income	534.12	237.48	557.59	221.42	23.47	0.61
density	89.68	118.56	78.70	131.64	-10.98	0.67
urban_pop_rate	0.72	0.21	0.71	0.20	-0.01	0.82
men_pop_rate	0.50	0.02	0.50	0.01	0.00	0.54
physician_per_1k	0.93	0.76	1.00	0.72	0.07	0.65
health_municipal_spending_rate	22.38	5.06	24.10	4.74	1.72	0.09
community_health_agency_rate	84.30	25.76	80.47	28.47	-3.83	0.49
hosp_beds_per_100k_pop	161.37	178.08	165.14	149.40	3.77	0.91

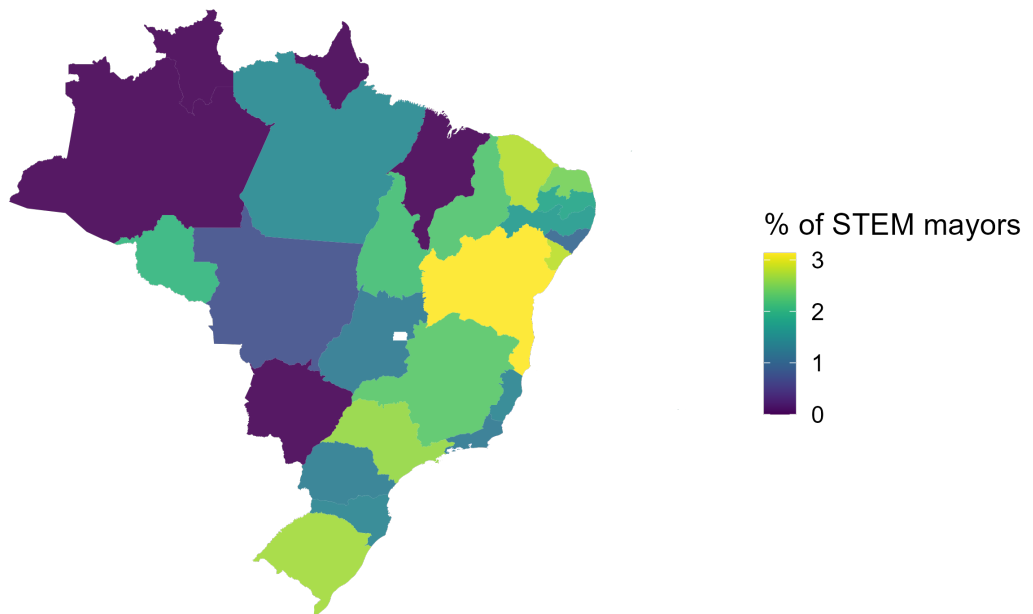
Figure 1 – Percentage of STEM mayors per state



Notes: This plot shows the distribution of STEM mayors per state in the elections of 2016. Outlier is the state of Acre.

In Figure 3 we colored all 44 municipalities where a STEM candidate was among the top 2 voted in 2016. In red are the municipalities where the STEM candidate lost and in blue are the municipalities where the STEM candidate won. It's visible that most parts of the cities where a STEM candidate was among the top 2 voted are concentrated in the East of Brazil. Nevertheless, since our sample only includes the colored municipalities, we don't expect this regional distribution to bias our results. Besides that, as discussed later, our estimation strategy includes state-fixed effects to control for regional characteristics that are constant in time.

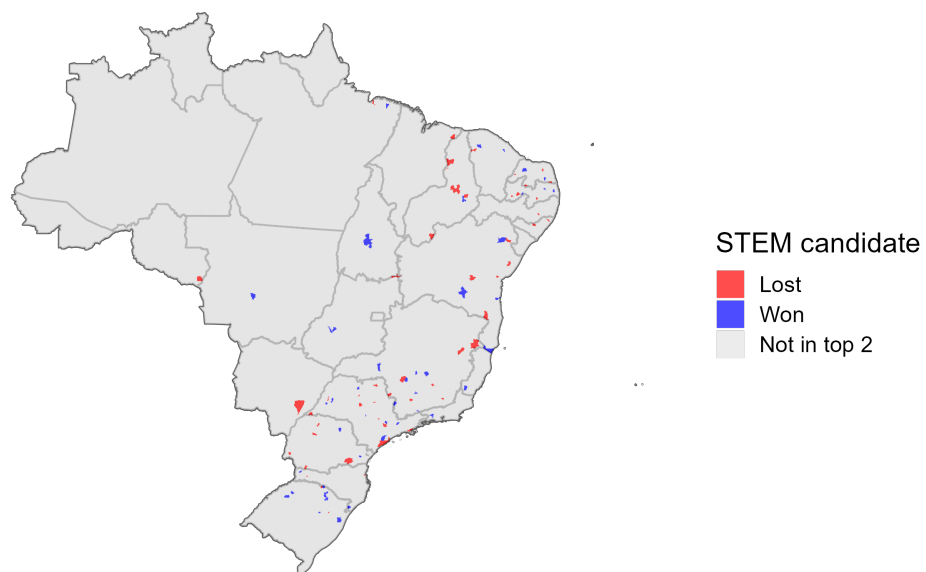
Figure 2 – Percentage of STEM mayors per state (2016)



Source: Author

Notes: In this figure, we colored all states based on the percentage of STEM mayors' elected in 2016. The darker the state, the fewer STEM mayors it has elected. The state of Acre was removed because, as it is an outlier, its presence in the graph doesn't allow for comparing the numbers between the other states.

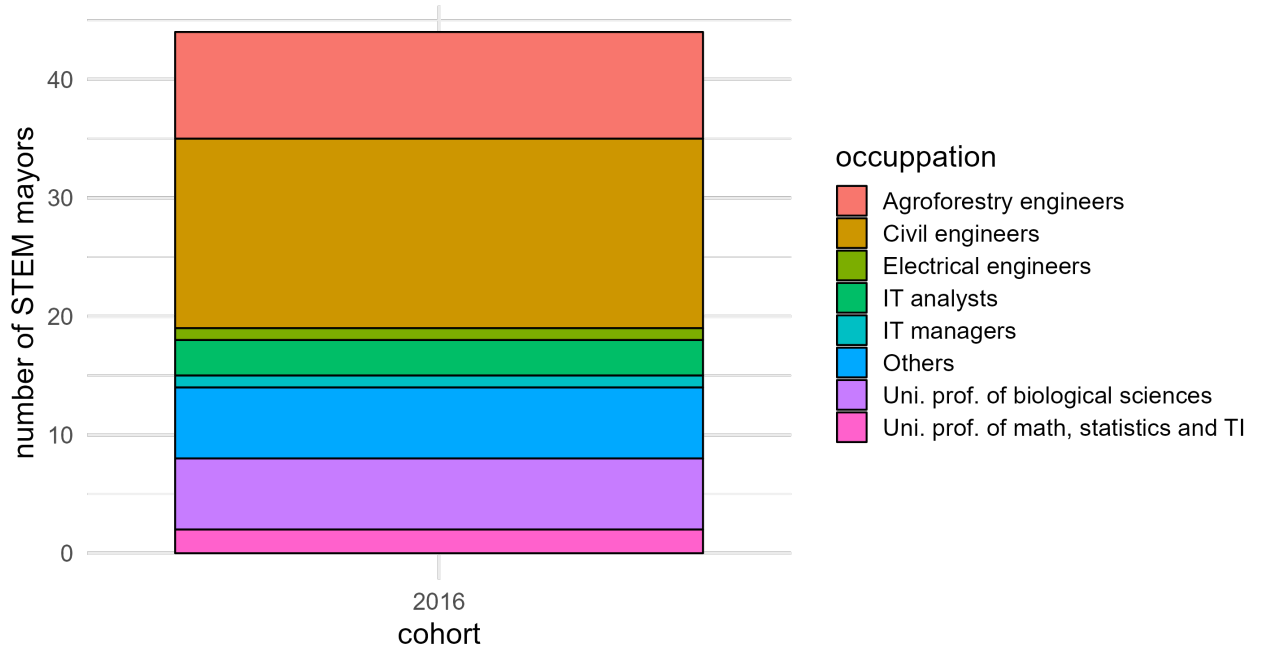
Figure 3 – Municipalities where a STEM candidate was among the top two most voted (2016)



Source: Author

Notes: In this figure, we colored all municipalities where a STEM candidate was among the top 2 voted in 2016. In red are the municipalities where the STEM candidate lost and in blue are the municipalities where the STEM candidate won. In gray are all the municipalities with no STEM candidate among the top two most voted.

Figure 4 – STEM candidates’ most common occupations.



Notes: This figure shows the top five most common occupations among STEM mayors elected in 2016 or 2020.

We also try to understand what kind of STEM jobs the elected mayors have been working. To do it we look at candidates’ most common occupations according to the four-digit classification CBOs in RAIS. As illustrated in Figure 4, the most common professions are engineers and university professors of biological courses. It is important to note and clarify that doctors are not considered STEM workers in our analysis. Even though there are broad STEM classifications that include health occupations in STEM (Kuenzi, 2008), also adapting the term to STEMM (additional M for Medicine) (Riise, Willage, & Willén, 2022) - or even including social scientists, psychologists, economists, and sociologists (NSB, 2012) - health occupations are not universally recognized in the STEM field, especially in the more restricted classifications (Green, 2007). Some authors justify that the health sector has its own dynamics, which differentiates it from the engineering and applied sciences, such as biology, physics, chemistry, mathematics, statistics, information technology, agronomy and others considered (Nascimento, Maciente, Gusso, Araújo, & Pereira, 2014). In the United States, there is an official definition for the occupations that are considered to belong to STEM areas according to Standard Occupational Classification (SOC) 2010 from the Bureau of Labor Statistics ⁶. According to that classification, occupations are separated into: (i) Life and Physical Science, Engineering, Mathematics, and Information Technology Occupations; (ii) Social Science Occupations; (iii) Architecture Occupations; and (iv) Health Occupations. Doctors belong with the last, but not with the first one. Following this method, as done by other studies on STEM occupations in the world

⁶ https://www.bls.gov/soc/Attachment_C_STEM.xls

(Ransom & Winters, 2021) and in Brazil (Nascimento et al., 2014), Machado et al. (2021) creates her classification, the one that is used in this paper. Even though we do not define doctors as STEM workers, some graduated doctors may have worked in a STEM job, such as a biomedical. If that were the case, we could be measuring not the effect of STEM background on epidemiological outcomes, but rather the effect of health professionals on these. Since only 2.7% of elected candidates declared themselves to be doctors, we consider that our estimation is really measuring the effect of STEM backgrounds. Besides that, as expected and discussed in the Results section, there is a relevant difference in the percentage of female mayors' between STEM and Non-STEM groups, and also incumbent mayors (non-expected). Finally, it's remarkable that all baseline characteristics chosen are aligned even in the full sample. This may indicate that municipalities that elect STEM mayors are not that different from municipalities that elect Non-STEM mayors and comparing. Nevertheless, as it's generally recognized, that may exist unobserved characteristics that could affect epidemiological outcomes and also the probability of electing a STEM mayor, biasing estimates that consider the full sample. In order to avoid that bias and estimate a causal effect, we develop the following empirical framework.

4 EMPIRICAL FRAMEWORK

4.1 Estimation Strategy

Identifying the causal impact of a policymaker’s professional background on epidemiological outcomes is a difficult task. By simply comparing municipalities with STEM candidates and without STEM candidates, we are likely to estimate biased outcomes. This is the case since our dependent variables may be correlated with variables that could also influence the mayor’s professional background. Also, one of the main difficulties in our empirical design is the limited number of observations near the cutoff. This is the case since the number of treated cities isn’t big already. As already shown in Figure 1, the mean of STEM candidates in 2016 is 1.6%. Besides that, the RD design accounts for municipality-specific omitted variables, however, it does not control for mayors’ characteristics. These characteristics, such as level of education and ideology, could be relevant to the epidemiological outcomes in which we are interested (Bruce et al., 2022, p.8). Therefore, one of the main challenges of our research is to control for some of these characteristics to better understand the mechanism through which STEM education could act upon the epidemiological outcomes. Following Calonico, Cattaneo, Farrell, and Titiunik (2019), in our specifications (2) and (4), from Table 4, we control for mayors’ personal characteristics that appear to have a discontinuity near the cutoff.

We construct a sharp regression discontinuity (RD) strategy. Through it, we expect to estimate the causal impact of having a STEM candidate on epidemiological outcomes. Our strategy has the following specification:

$$y_{ms} = \alpha + \beta \text{STEMcandidate}_{ms} + f(\text{STEMcandidateVoteMargin}_{ms}) + \lambda_s + Z_{ms} + \varepsilon_{ms} \quad (4.1)$$

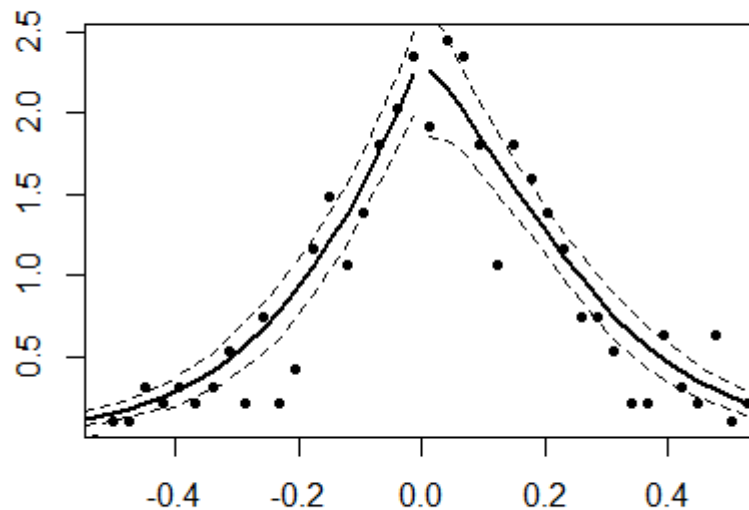
In the previous equation, m denotes a municipality, and s denotes a state. $\text{STEMcandidateVoteMargin}_{ms}$ is the margin of victory of the STEM mayor candidate in an election where the second place is a non-STEM candidate. This variable assumes a positive value if the winner was a STEM candidate and the second place was a non-STEM candidate. Likewise, it assumes a negative value if the opposite takes place. The independent variable $\text{STEMcandidate}_{ms}$ receives the value 1 if the running variable $\text{STEMcandidateVoteMargin}_{ms} \geq 0$ and zero otherwise. We assume that $f(\cdot)$ is a flexible polynomial on both sides of the threshold. We estimate an optimal bandwidth using the non-parametric procedure from (Calonico, Cattaneo, & Titiunik, 2014). Our coefficient of interest β estimates the effect of having a STEM candidate mayor on outcome y_{ms} . We denote λ_s as a state election fixed-effect term, following (Calonico et al., 2019, p.10), and Z is a vector of control variables, that include mayors’ personal characteristics, such as age (the only one in our main specification).

4.2 Identification Strategy

The key assumption behind a sharp RD design is that the probability of treatment assignment changes discontinuously, from 0 to 1, at the cutoff. Therefore, it's possible to identify causal effects for the individuals whose scores are near this threshold (Cunningham, 2021). In our case, the key assumption is that the probability of $STEMcandidate_{ms} == 1$ changes discontinuously at $STEMcandidateVoteMargin_{ms}$ near 0. However, to interpret our coefficient of interest β as causal we need to satisfy the two validity conditions of an RD design: (i) the treatment does not affect baseline covariates; and (ii) there is no manipulation of the running variable near the threshold. The (i) condition means that our sample must be balanced between treated and untreated observations in their baseline characteristics. In Table 3 we show that all our baseline characteristics are balanced.

We show in Figure 5 that $STEMcandidateVoteMargin_m$ does not present any discontinuity near the cutoff. We test this using a McCrary test in which the p -value achieves 0.93, therefore, indicating that there is no manipulation in our running variable.

Figure 5 – McCrary test



Notes: McCrary test shows that there is no discontinuity (p-value 0.93) near the cutoff, indicating that there is no manipulation in our running variable.

Table 3 – Baseline characteristics - RD estimates

	Demography						Health				Ideology	
	Gini	PC income	Population	Illiteracy	HDI	Ln Density	% Masc. Pop	% Health spend.	Docs.	CHA program	Hosp. beds	Mun. ideo.
RD estimator	-0.01	33.74	0.13	-3.87	0.00	0.74	0.00	1.36	-0.28	-17.89	11.19	-0.07
Conv. sd.	[0.03]	[73.10]	[0.32]	[1.87]	[0.02]	[0.38]	[0.01]	[2.70]	[0.32]	[11.24]	[82.83]	[0.05]
Robust pv.	0.51	0.46	0.50	0.57	0.41	0.51	0.75	0.50	0.58	0.99	0.18	0.28
Eff.number.obs.	34	31	29	34	35	34	22	38	35	37	40	35
Window	7.13	6.29	5.95	7.07	7.64	7.23	4.37	8.39	7.61	7.95	8.64	7.42

Notes: This table reports the RD estimates for the election of mayors with scientific background on municipalities' baseline characteristics in 2015 in Brazilian municipalities. All specifications use state fixed-effects, triangular kernel and optimal bandwidths calculated following Calonico et al. (2014). Baseline variables were chosen to represent relevant characteristics related to demography, public health and ideology at the municipality level. We report robust-bias corrected p-values, conventional (non-robust) estimates and standard errors.

5 RESULTS

5.1 Main results

The tests presented in the previous section demonstrate that municipalities governed by almost elected Non-STEM mayors are an appropriate counterfactual for those headed by barely elected STEM mayors. This approach provides a consistent estimate of the impact of a mayor with a STEM background election on epidemiological outcomes during the COVID-19 crisis. In all our four specifications, the election of mayors with a STEM background caused a reduction in hospitalizations and deaths of COVID, rejecting the null hypothesis, as shown in Table 4 and Figure 6. These first findings go according to what we expected since the literature has already shown that mayors' personal characteristics, such as gender (Bruce et al., 2022), affected epidemic outcomes during the pandemic.

In all our specifications we consider state-fixed effects, as shown in Equation (4.1). We chose a specification with state-fixed effects because of a few reasons. First, it allows us to control for unobserved heterogeneity across states. Besides that, adding fixed effects turn our estimates more efficient without biasing them (Calonico et al., 2019). Moreover, we compare the performance of cities subject to similar state regulations since governors have autonomy in enforcing NPIs. Finally, Brazil is a large, continental country with many municipalities. Because of this, when adding fixed effects we decrease the chances of comparing areas where COVID-19 waves behaved differently at the time we selected the outcomes.

Considering the mean of epidemiological outcomes in the non-STEM municipalities, our preferred specification (4) indicates that municipalities managed by STEM mayors experienced 103.05 fewer deaths per 100k inhabitants (p-value = 0.01). In the second panel, we show that treated municipalities had 375.68 fewer hospitalizations per 100k inhabitants (p-value = 0.01). These results indicate that cities that elected a STEM candidate had better epidemiological outcomes compared to their counterfactual. That means, if these same cities had elected a Non-STEM candidate, they would have faced more deaths and hospitalizations due to COVID-19. To better understand results, we also run specifications with a 10% winning window fixed. We do so because the optimal window changes when adding covariates, and therefore, it's hard to comprehend the effect of covariates in the previous sample (a larger window will include more municipalities in the sample). All specifications provide evidence that STEM mayors caused a reduction in hospitalizations and deaths by COVID-19. The optimal bandwidth calculated for this specification, following Calonico et al. (2014), is 6.79% for hospitalizations and 7.47% for deaths. This bandwidth results in an effective number of observations of 34 for hospitalizations and 35 for deaths. Our results indicate that the impact of having a mayor with a STEM background on the reduction in deaths and hospitalizations due to the COVID-19 virus is statistically

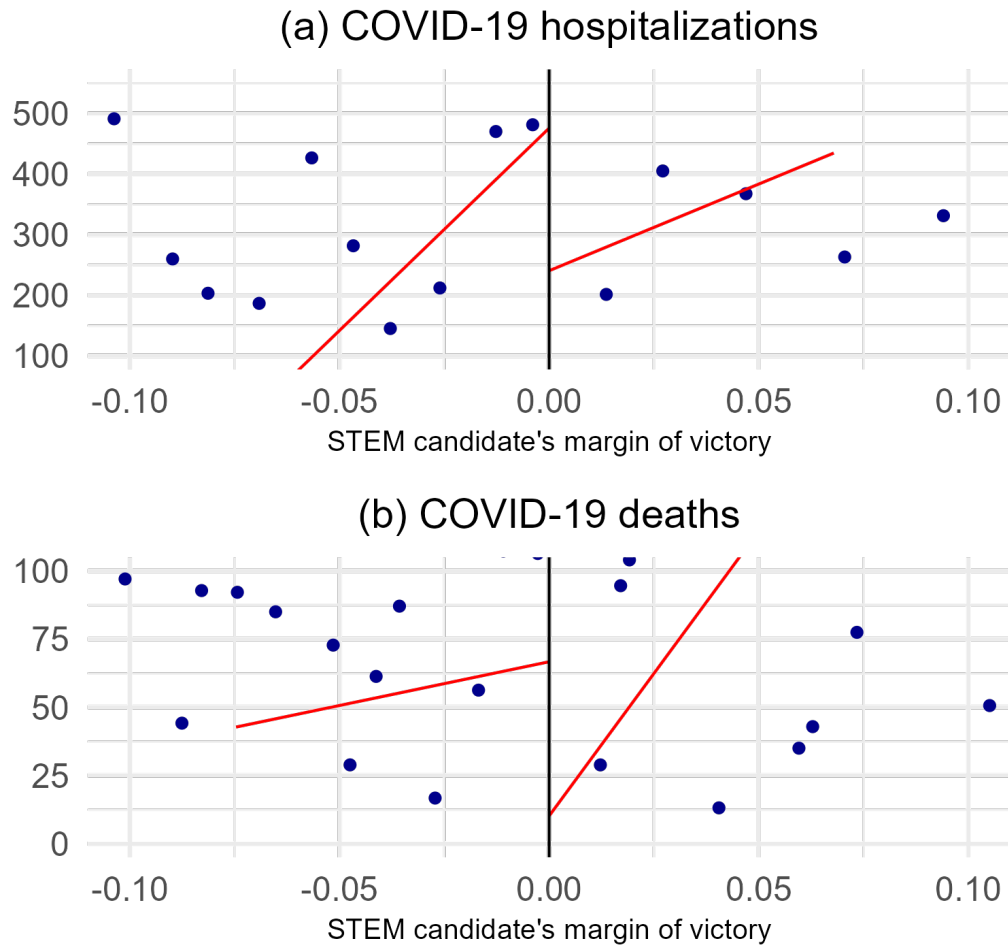
Table 4 – Impact of STEM Leadership on Epidemiological Outcomes — RD estimates

	(1)	(2)	(3)	(4)
<i>Panel A: Deaths</i>				
RD estimate	-81.35	-83.78	-141.29	-103.05
Rob. sd	[41.28]	[41.01]	[50.83]	[39.89]
Rob. p-value	0.05**	0.04**	<0.01***	<0.01***
Eff.number.obs.	45	45	29	35
Window	10	10	5.92	7.47
State.FE	Fixed	Fixed	CCT Opt.	CCT Opt.
Pers.charact		X		X
<i>Panel B: Hospitalizations</i>				
RD estimate	-342.13	-358.73	-262.64	-375.68
Rob. sd.	[153.55]	[152.11]	[148.40]	[136.05]
Rob. p-value	0.03**	0.02**	0.08*	<0.01***
Eff.number.obs.	45	45	37	34
Window	10	10	8.36	6.79
State.FE	Fixed	Fixed	CCT Opt.	CCT Opt.
Pers.charact		X		X

Notes: This table reports the RD estimated impact of mayors with scientific background on deaths and hospitalizations by COVID-19 per hundred thousand inhabitants in 2020 in Brazilian municipalities. All specifications use state fixed-effects and triangular kernel. Estimations (1) and (2) use optimal bandwidths calculated following Calonico et al. (2014), while estimations (3) and (4) use a 10% vote margin difference between the two most voted candidates, in order to best understand the inclusion of covariates. Estimations (2) and (4) control for mayors' age. We report robust-bias-corrected p-values, coefficients and standard errors.

significant at the 1% level for deaths and hospitalizations.

Figure 6 – Impact of STEM mayor election on epidemiological outcomes



Notes: This figure reports the RD estimated impact of mayors with scientific background on deaths and hospitalizations by COVID-19 per hundred thousand inhabitants in 2020 in Brazilian municipalities. These results represent the impact of our main estimation (2) that uses first-degree polynomial, state fixed-effects, triangular kernel, optimal bandwidths calculated following Calonico et al. (2014) and control for mayors' age.

We consider specification (4) as our preferred. While specification (31) accounts for municipality-specific omitted variables, as assumed in an RD design for close elections, it does not control for individual characteristics of mayors that are relevant to policymaking. Examples of personal characteristics that may be cofounders are age (Alesina et al., 2019), education (Besley et al., 2011), ideology (Pettersson-Lidbom, 2008), reelection incentives (Frey, 2021) and gender (Bruce et al., 2022). Therefore, we test whether those STEM candidates who win close races against Non-STEM candidates are different in observable characteristics.

By examining Table 5 we notice that the STEM group has older mayors than the Non-STEM one. Then, we run specification (2) controlling for mayors' age, besides fixed effects, following Calonico et al. (2019). Our results remain very similar and robust, suggesting that our findings are driven by STEM mayors' non-observable characteristics.

Table 5 – STEM candidates’ personal characteristics - RD estimates

	Women	Incumbent	Age	Party ideology
RD estimator	-0.06	0.12	6.76	0.05
Conv. sd.	[6.81]	[0.21]	[4.15]	[0.10]
Robust pv.	0.41	0.56	0.09*	0.73
Eff.number.obs.	46	46	35	37
Window	10.5	10.55	7.47	8.11
Bandwidth	CCT Opt.	CCT Opt.	CCT Opt.	CCT Opt.

Notes: This table reports our RD estimates of the association between STEM mayors and four outcomes. In the first column, we see the effect on mayors’ gender. In the second column, the outcome measure if mayors were incumbents. The third column measures the effect of mayors’ age. The fourth column regards mayors’ party ideology, whereas negative numbers represent left-wing parties and positive right-wing (Power & Rodrigues-Silveira, 2019). All specifications use state fixed-effects, triangular kernels, and first-degree polynomials. Optimal bandwidths were calculated following Calonico et al. (2014). We report robust-bias corrected p-values and conventional (non-robust) estimates and standard errors.

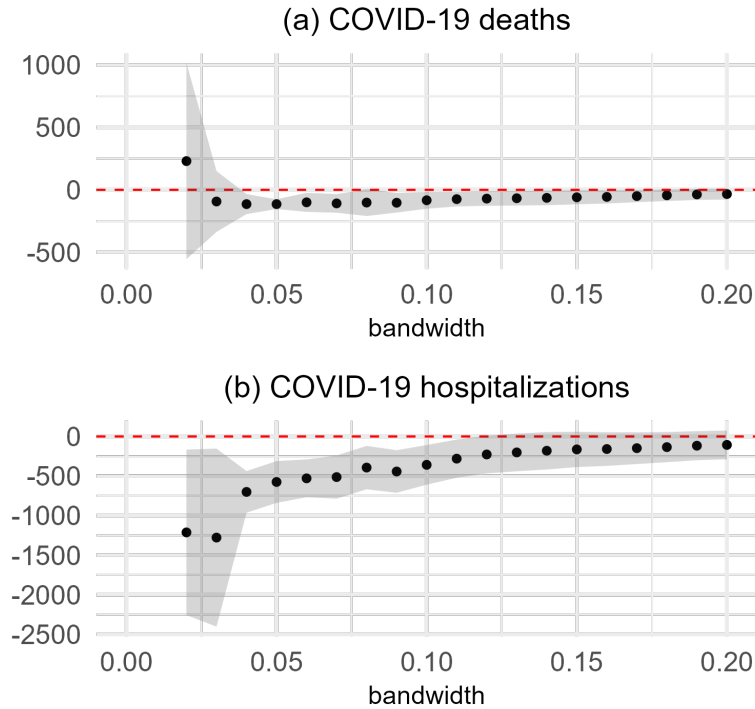
In order to better comprehend the effect of STEM background on epidemiological outcome and also to test with these estimations hold even with other polynomial format assumptions, we rerun our specifications creating specifications (1) and) by fixing the window at a 10% winning margin. It’s interesting to notice that the size of the effect gets larger when accounting for age differences between STEM and Non-STEM municipalities. This means that the age of mayors is negatively correlated with their impact on reducing epidemiological outcomes — an initial indication that our model is robust. The impact of our treatment remains statistically significant, negative, and in the same signal across this and all four specifications. Nevertheless, other tests must be done in order to prove the robustness of our estimates.

5.2 Robustness checks

We run a series of tests to check if our results that STEM mayors reduced deaths and hospitalization by COVID in their municipalities are robust. The first test is to run the same specification showed in Equation (4.1) that estimated the coefficients in (2), Table 4, but with different windows instead of the optimal bandwidth. As shown in Figure 7, the results of deaths only are statistically significant after a 3% margin of votes between the STEM candidate and the Non-STEM candidate. We understand that, since our sample is small, low windows have higher standard errors, which turn the results non-statistically significant, even though estimates’ magnitude and signal are the same as in larger windows. Besides that, municipalities that are outliers could influence the results if their candidate were elected with a low margin. When the bandwidths get larger, around 15% percent, we also can not reject the null hypothesis. This is also expected, since municipalities that elected STEM mayors with very large margins may be very different from municipalities

where they had a close race, and that's exactly what regression discontinuity designs try to address.

Figure 7 – Impact of STEM mayor on epidemiological outcomes using different bandwidths



Notes: This figure reports the RD estimated impact of mayors with scientific background on deaths and hospitalizations by COVID-19 per hundred thousand inhabitants in 2020 in Brazilian municipalities. In the horizontal axis, we test different winning margins (bandwidth) between the elected mayor and the second most voted. These results represent the impact of our main estimation (2) that uses first-degree polynomial, state fixed-effects, triangular kernel, and control for mayors' age.

Another way to test the robustness of our estimates is by using another definition of STEM as the treatment. We do so by only using TSE mayors' occupational data. We first define, for every profession registered in the TSE in 2016, if it is a STEM profession. We classify as STEM engineers, biomedical, chemists, statisticians, TI technicians, astronomers, mathematicians, physicists, and computer programmers. All the others are classified as Non-STEM professions. Since we are not using the profession of "mayor", we are only selecting first mandate STEM candidates, so no incumbent STEM mayors were included in this sample and, therefore, we drop the Non-STEM incumbent mayors.

All baseline characteristics are aligned, except for municipalities' ideology at the Robust specification (but is balanced considering conventional p-value and standard errors) Table 6. We then run a regression on epidemiological outcomes with different windows to see if this new definition has a similar impact as our main definition of STEM. We find similar results, as shown in Figure 8. Mayors' characteristics are unbalanced for gender and party ideology. By this classification, STEM mayors were more left-wing and had fewer women. This last difference was expected since the under-representation of women

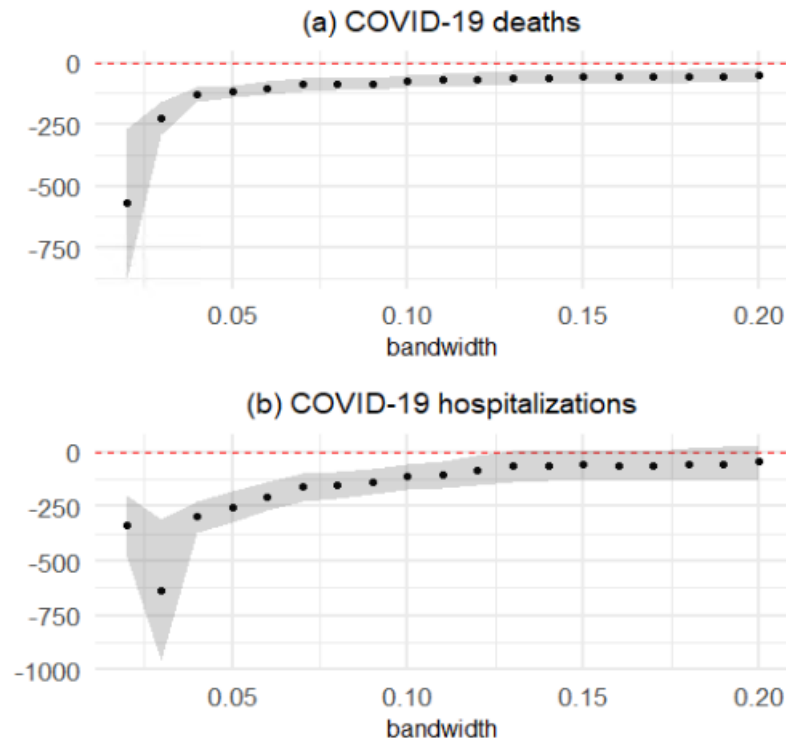
in STEM fields is a well-documented disparity that has been the focus of national and international public policy efforts to improve diversity in STEM fields (Wang & Degol, 2017). Also by controlling for it we expect to find a higher impact for STEM mayors, since one study has shown that female mayors caused a large, negative, and significant decrease in the number of deaths and hospitalizations from COVID-19 (Bruce et al., 2022). The left-wing inclination of STEM candidates is harder to explain.

Table 6 – Baseline characteristics - RD estimates for STEM mayors (TSE robustness classification)

	Demography					Health				Ideology	
	Gini	PC income	Population	Illiteracy	HDI	% Masc. Pop	% Health spend.	Docs.	CHA program	Hosp. beds	Mun. ideo.
RD estimator	-0.01	-35.74	-0.02	-0.45	-0.01	0.01	-1.36	0.23	0.55	-41.56	0.04
Conv. sd.	[0.02]	[51.98]	[0.27]	[1.07]	[0.02]	[0.00]	[2.05]	[0.27]	[7.68]	[46.26]	[0.03]
Robust pv.	0.97	0.68	0.94	0.54	0.43	0.17	0.60	0.16	0.88	0.54	0.02**
Eff.number.obs.	52	48	55	49	52	37	57	42	57	52	37
Window	12.62	10.12	13.01	11.03	11.92	8.39	14.06	8.82	14.44	12.43	8.07

Notes: This table reports the RD estimates for the election of mayors with scientific background on municipalities' baseline characteristics in 2015 in Brazilian municipalities. We now use only TSE data to define a STEM mayor in order to test another definition of STEM as a robustness test. All specifications use state fixed-effects, triangular kernel and optimal bandwidths calculated following Calonico et al. (2014). Baseline variables were chosen to represent relevant characteristics related to demography, public health and ideology at the municipality level. We report robust-bias corrected p-values, conventional (non-robust) estimates and standard errors.

Figure 8 – Impact of STEM mayor on epidemiological outcomes using different bandwidths (TSE robustness classification)



Notes: This figure reports the RD estimated impact of mayors with scientific background on deaths and hospitalizations by COVID-19 per hundred thousand inhabitants in 2020 in Brazilian municipalities. We now use only TSE data to define a STEM mayor in order to test another definition of STEM as a robustness test. In the horizontal axis, we test different winning margins (bandwidth) between the elected mayor and the second most voted. These results represent the impact of our main estimation (2) that uses first-degree polynomial, state fixed-effects, triangular kernel, and control for mayors' gender, parties' ideology and municipalities' ideology.

5.3 Mechanisms

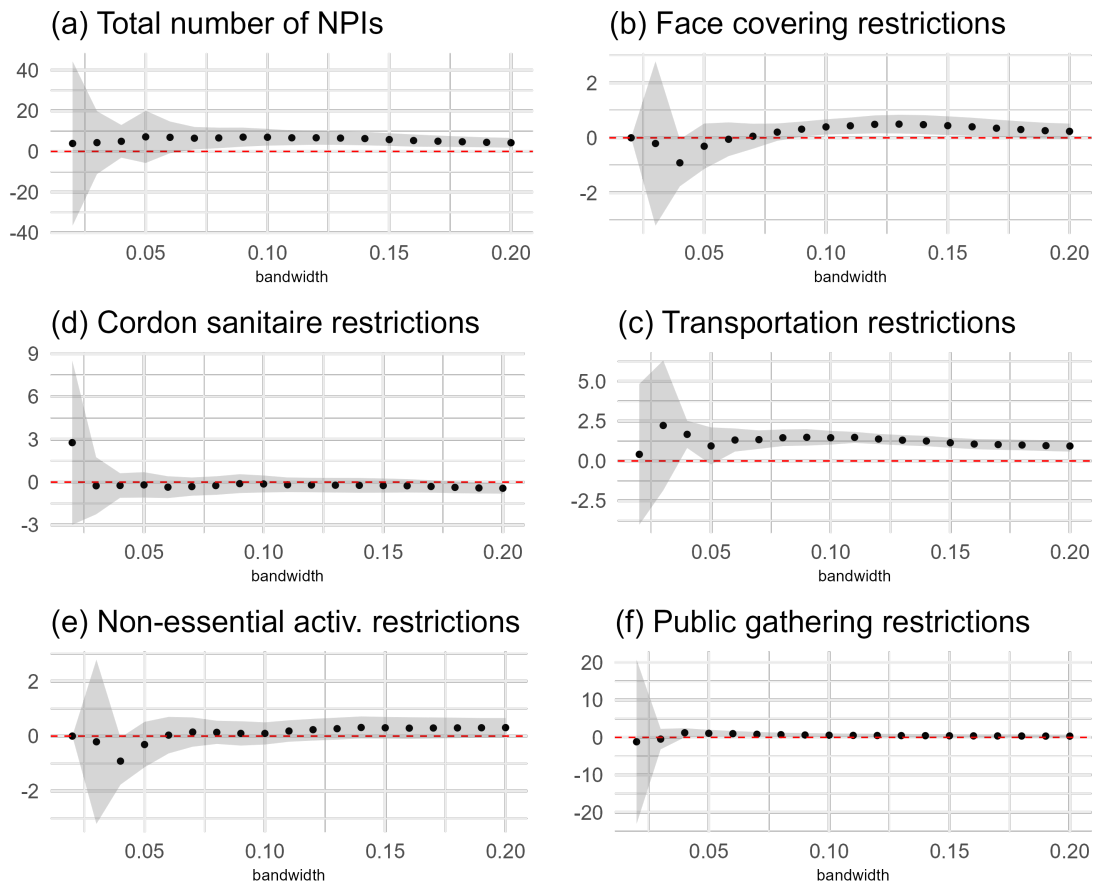
Finally, using our main sample and specification, we test whether a municipality with a STEM mayor has raised the number of NPIs, which is expected to lower the number of hospitalizations and deaths by COVID-19. Following the results of Table 7. We see that STEM mayors caused the adoption of a higher number of non-pharmaceutical interventions. This was done mainly through face-covering restrictions, public gathering restrictions, public transport restrictions and cordon sanitaire restrictions. More specifically, our results show that STEM mayors' caused an increase of 2.19 (p-value 0.00) NPIs. This amount equalizes 55.86 percent of the average number of NPIs among municipalities that elected a non-STEM mayor (the mean rate of NPIs for Non-STEM municipalities inside the 7.3 window margin was 3.92). We also run the same test with different bandwidths to increase the robustness of our estimates, as seen in Figure 9.

Table 7 – Impact of STEM leadership on NPIs - RD estimates

	Total NFI	Masks	Restrictions atv.	Restrictions circu.	Restrictions transp.	Sani barriers
Robust	2.19 [0.72] 0.00***	0.55 [0.18] 0.00***	0.34 [0.21] 0.11	0.47 [0.27] 0.08*	1.16 [0.20] 0.00***	-0.29 [0.28] 0.31
Eff.number.obs.	22	25	26	26	31	24
Window	7.3	7.56	7.98	8.18	10.83	6.49
Bandwidth	CCT Opt.	CCT Opt.	CCT Opt.	CCT Opt.	CCT Opt.	CCT Opt.
Pers.character.	X	X	X	X	X	X

Notes: This figure reports the RD estimated impact of mayors with scientific background on the adoption of non-pharmaceutical interventions (NPIs) in 2020 in Brazilian municipalities. Following the order of the columns, the interventions are: total number of NPIs, face-covering restrictions, non-essential activities restrictions, public gathering restrictions, public transport restrictions and cordon sanitaire restrictions (the control of people entering and leaving the city), as published by de Souza Santos et al. (2021). All specifications use state fixed-effects and triangular kernels and control for mayors' age. We report robust-bias corrected p-values, conventional (non-robust) estimates and standard errors.

Figure 9 – Impact of STEM mayor on non-pharmaceutical interventions (NPIs) using different bandwidths



Notes: This figure reports the RD estimated impact of mayors with scientific background on deaths and hospitalizations by COVID-19 per hundred thousand inhabitants in 2020 in Brazilian municipalities. In the horizontal axis, we test different winning margins (bandwidth) between the elected mayor and the second most voted. These results represent the impact of our main estimation (2) that uses first-degree polynomial, state fixed-effects, triangular kernel, and control for mayors' age.

5.4 Moderators

Reflecting on the concept of "scientific intensity," developed by Novelli and Spina (2022), we examine the moderating effect of the "tenure" variable in our study. This continuous variable measures the number of years individuals were employed in a STEM occupation from 2003 to 2015. Consequently, it is a proxy for exposure to treatment intensity, specifically scientific intensity in our context. It is worth noting that individuals with longer tenure in scientific work may have acquired additional scientific skills that might not be obtained solely through academic education. By analyzing the moderation effect of this variable, we also aim to isolate the impact of scientific education. This enables us to differentiate between mayors who graduated in STEM fields but did not pursue careers in STEM occupations. We anticipate that scientific education will have a mitigating

effect on hospitalizations and deaths caused by Covid, as individuals with such educational backgrounds are likely to possess a greater understanding of scientific principles. However, we also anticipate that tenure, reflecting on-job scientific skills, may exacerbate the impact of science education on these health outcomes.

To capture the concept of "stage of development" in municipalities (Novelli & Spina, 2022) this study will utilize the variable "municipalities revenue". It is widely acknowledged that larger municipalities encounter distinct challenges compared to their smaller counterparts. Scholars have often characterized big cities as "ungovernable," given their multitude of stakeholders, diverse populations, significant inequality, the prevalence of informal sectors, myriad of problems, sprawling suburbs, and diverse economic sectors (Le Galès & Vitale, 2013). These complexities underscore the unique set of issues faced by larger municipalities, necessitating a deeper examination of their governance, social dynamics, and urban management. Among the common challenges faced by large and small municipalities, smaller cities encounter their own set of unique problems. Birkmann, Welle, Solecki, Lwasa, and Garschagen (2016) emphasizes that small and medium-sized cities confront limitations in terms of data availability, political influence, human resources, and financial capacities. As a result, the author understands that the vulnerabilities of these cities often tend to be underestimated in comparison to their larger counterparts.

In our moderation analysis, it is important to note that our primary aim was not to establish causal relationships but rather to explore potential effects. To accommodate this exploratory nature, we adopted a flexible approach in defining STEM mayors, wherein complete college education was not required to define a candidate as STEM. Similarly, for non-STEM candidates, we did not require a college degree but instead utilized years of education as a control variable. Additionally, it is worth mentioning that our analysis focused on a narrow bandwidth of 5%, allowing us to assume that regressions discontinuity assumptions hold, but not checking for robustness. In Table 8 we present the results.

Table 8 – Moderating effects of scientific intensity and cities’ development on the impact of STEM background

	<i>Dependent variable:</i>					
	Deaths (1)	Hospitalizations (2)	NFI (3)	Deaths (4)	Hospitalizations (5)	NFI (6)
STEM Background	−69.791** (25.140)	−251.697** (108.318)	1.198** (0.443)	−51.788** (22.194)	−223.385** (102.318)	1.648** (0.590)
Tenure	1.483 (0.958)	5.047 (4.129)	0.035** (0.015)			
Tenure Moderation Effect	−1.591** (0.601)	2.219 (2.591)	0.031*** (0.009)			
2015 Revenue				0.144 (0.308)	0.920 (1.421)	−0.002 (0.007)
Revenue Moderation Effect				−1.339*** (0.393)	−1.865 (1.811)	0.014 (0.011)
Observations	52	52	34	52	52	34
R ²	0.448	0.386	0.833	0.505	0.370	0.648
Adjusted R ²	−0.223	−0.361	0.498	−0.097	−0.398	−0.055
F Statistic	1.438 (df = 13; 23)	1.112 (df = 13; 23)	4.566*** (df = 12; 11)	1.807 (df = 13; 23)	1.037 (df = 13; 23)	1.689 (df = 12; 11)

*p<0.1; **p<0.05; ***p<0.01

Notes: This table presents the estimated impact of mayors with scientific background on COVID-19 deaths and hospitalizations per hundred thousand inhabitants in 2020 across Brazilian municipalities. The analysis incorporates moderation effects of scientific intensity, measured by tenure, and cities’ level of development, indicated by revenue. The model controls for mayors’ education, political ideology, incumbency, age, gender, and includes state fixed-effects.

The variable "STEM Background" captures the impact of electing a mayor with a STEM education but without previous formal experience in a STEM occupation, particularly in economically disadvantaged cities. The results reveal statistically significant and positive effects of STEM background on non-pharmaceutical interventions while showing statistically significant and negative effects on deaths and hospitalizations. These findings suggest that the development of a scientific approach and evidence-based decision-making may primarily occur during an individual's educational journey, rather than relying solely on work experience in a STEM field. However, it is important to note that these findings imply a correlation, and there is a possibility that other unobserved variables, such as intelligence quotient (IQ), may explain the positive effects observed.

Furthermore, the variable "Revenue Moderation Effect" represents the interaction between STEM Background and municipalities' revenue in 2015 (measured in 10 million reais), reflecting the moderation effect of cities' level of development on the impact of electing a STEM mayor. The results indicate a statistically significant correlation between the revenue moderation effect and deaths, but not for hospitalizations or non-pharmaceutical interventions (NPIs). These findings suggest that wealthier cities benefited more from electing STEM-educated mayors, particularly in terms of reducing deaths, which is a crucial measure of success in effectively managing a pandemic crisis.

Lastly, the variable "Tenure Moderation Effect" captures the interaction between STEM Background and tenure, representing the years of experience in a STEM occupation. It measures the moderation effect of the scientific intensity of a STEM mayor on reducing epidemiological outcomes and increasing the adoption of NPIs. The results table demonstrates statistically significant moderation effects for both deaths and NPIs, although not for hospitalizations. This suggests that cities that elected STEM-educated mayors with job experience were able to implement more NPIs and achieve further reductions in deaths. While cities that elected STEM-educated mayors without prior work experience still managed to decrease deaths and hospitalizations and increase NPIs, the presence of job experience enhanced two of these outcomes.

In sum, the results indicate that electing a STEM mayor, even without prior formal experience in a STEM occupation, has significant positive effects on non-pharmaceutical interventions, as well as negative effects on deaths and hospitalizations. The revenue moderation effect highlights the influence of cities' level of development, with richer cities experiencing greater benefits in terms of reducing deaths. The tenure moderation effect emphasizes the importance of job experience, as cities that elected STEM-educated mayors with prior work experience had better outcomes in reducing deaths and NPIs.

6 FINAL DISCUSSION

In this paper, we examine the impact of mayors with a scientific background on COVID-19 outcomes and address the question: Has a scientific background helped mayors combat COVID-19? Our findings reveal a substantial body of evidence indicating that the election of mayors with a scientific background leads to a significant reduction in COVID-19 hospitalizations and deaths, primarily attributed to an increase in non-pharmaceutical interventions, and enhanced by leaders' work experience and cities' level of development. This constitutes our primary contribution to the literature, as previous studies did not identify a robust impact of scientific background on public administration issues (Bastos & Sánchez, 2021; Goodwin, 2015). Additionally, our research addresses the call from management scholars for further investigation, particularly regarding the cases involving individuals with a science background (Camuffo, Cordova, et al., 2020).

Our second contribution is to connect the existing research on scientific literacy, scientific approach, and evidence-based management, on the one hand, with the STEM literature, on the other. Specifically, our study demonstrates that municipalities that elected STEM mayors were able to significantly reduce hospitalizations and deaths caused by COVID-19 through the adoption of non-pharmaceutical interventions. To do so we theoretically suggest that STEM mayors may have achieved better epidemiological outcomes using their acquired knowledge of evidence and applying it in public administration. Nevertheless, we don't consider that our results ask for more mayors with a scientific background. The impact on epidemiological outcomes may be achieved through other measures, instead of a STEM-related formation, such as reducing information frictions between scientists and politicians by making research information directly and easily available to policymakers (Hjort et al., 2021). Although we cannot directly observe the specific mechanisms through which these interventions were implemented, we build upon this literature to suggest that STEM mayors may have used their evidence-based management skills and scientific approach to decision-making developed during education and work experience. This could involve seeking advice from scientific committees, leveraging their professional social networks, or drawing on their prior knowledge and experience to implement evidence-based strategies. Moreover, our empirical analysis reveals that the level of development within municipalities and the scientific intensity of mayors moderate the effects of electing a STEM mayor in 2016 on epidemiological outcomes in 2020, particularly in terms of reducing mortality rates. Our third contribution is an empirical test of a new definition of STEM in the Brazilian literature, which is still in its infancy and has a vague definition (Machado et al., 2021). To address this issue, we tested Machado's definition of STEM occupation in the context of STEM graduates in non-STEM jobs, specifically in local political positions (Mellors-Bourne et al., 2011). Our analysis find that some occupations characterized as STEM didn't require a STEM education. Besides that,

we show that most Brazilian STEM mayors are civil and agroforestry engineers. This finding is significant because the national public data on mayors from the Electoral Office only state their occupation as "engineer" or reflect occupations that were self-declared at the time of election. This data may fail to account for electoral interest bias, where mayors might not declare their actual profession. For instance, many mayors who worked as engineers declared themselves as "entrepreneurs" and not engineers. This helps explain the low percentage of STEM mayors in the TSE data, as STEM professionals might not be self-declaring as such.

Finally, this particular effect of science as a vocational background has a notable implication for public policies. We consider that the usage of evidence-based management and scientific approach from science-educated leaders may be non-expected externalities from investments in scientific human capital. This concept also aligns with the perspective put forth by Winters (2014), who proposes that investing in STEM education can lead to positive externalities such as higher wages and increased productivity for not only the STEM graduates themselves but also for non-STEM workers in the same industry and region. The authors also found evidence of positive spillover effects on patent activity and innovation in industries with higher levels of STEM graduates. Also, Brunow et al. (2018) suggests that attracting STEM workers is more likely to make German cities "smarter" than focusing exclusively on creative workers. This highlights the potential externalities of STEM in terms of regional economic development and competitiveness. Consequently, besides labor markets' advantages (Black et al., 2021), externalities in private firms' innovation (Brunow et al., 2018) and enhanced performance (Siepel, Camerani, & Masucci, 2021), our results suggest that investments in scientific human capital could also produce other non-expected externalities, such as the use of evidence in public issues. If this is the case, the link between STEM formation and management could have lowered the political willingness to deny scientists' recommendations by discouraging measures that could prevent the virus (Cabral et al., 2021) and then reducing hospitalizations and deaths.

One limitation of our study is the restricted external validity inherent in a regression discontinuity design. As we focus solely on municipalities where a mayor with a science background was elected by a narrow margin, our findings cannot be generalized to all municipalities that elected such mayors. Furthermore, we do not empirically examine the specific components within our STEM proxy that drive the observed impact. This means that we lack a precise understanding of the aspects of a candidate's STEM education or experience that contribute to the increase in non-pharmaceutical interventions and decrease in hospitalizations and deaths. Potential mediation effects could stem from a trained mindset to utilize scientific research and make evidence-based decisions. Future research could leverage Onet data to explore which specific skills within STEM occupations are associated with evidence-based management and scientific approach. Moreover, it is worth investigating whether the earlier selection of a STEM course is correlated with other

personal characteristics, such as cognitive biases (Coenen, Borghans, & Diris, 2021), which may be correlated with both the choice of a STEM education and better management of pandemic outcomes.

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APPENDIX A – LIST OF CBOS CLASSIFIED AS STEM

This table was obtained from (Machado et al., 2021).

code_cbo2002	occupation
1223	Diretores de operações de obras em empresa de construção
1236	Diretores de tecnologia da informação
1237	Diretores de pesquisa e desenvolvimento
1413	Gerentes de obras em empresa de construção
1425	Gerentes de tecnologia da informação
1426	Gerentes de pesquisa e desenvolvimento e afins
2011	Profissionais da biotecnologia
2012	Profissionais da metrologia
2021	Engenheiros de controle e automação, engenheiros mecatrônicos e afins
2030	Pesquisadores das ciências biológicas
2031	Pesquisadores das ciências naturais e exatas
2032	Pesquisadores de engenharia e tecnologia
2033	Pesquisadores das ciências da saúde
2034	Pesquisadores das ciências da agricultura
2111	Profissionais da matemática
2112	Profissionais de estatística
2122	Engenheiros em computação
2123	Administradores de tecnologia da informação
2124	Analistas de tecnologia da informação
2131	Físicos
2132	Químicos
2133	Profissionais das ciências atmosféricas e espaciais e de astronomia
2134	Geólogos, oceanógrafos, geofísicos e afins
2140	Engenheiros ambientais e afins

code_cbo2002	occupation
2142	Engenheiros civis e afins
2143	Engenheiros eletricitistas, eletrônicos e afins
2144	Engenheiros mecânicos e afins
2145	Engenheiros químicos e afins
2146	Engenheiros metalurgistas, de materiais e afins
2147	Engenheiros de minas e afins
2148	Engenheiros agrimensores e engenheiros cartógrafos
2149	Engenheiros de produção, qualidade, segurança e afins
2211	Biólogos e afins
2212	Biomédicos
2221	Engenheiros agrossilvipecuários
2222	Engenheiros de alimentos e afins
2341	Professores de matemática, estatística e informática do ensino superior
2342	Professores de ciências físicas, químicas e afins do ensino superior
2343	Professores de arquitetura e urbanismo, engenharia, geofísica e geologia do ensino superior
2344	Professores de ciências biológicas e da saúde do ensino superior
2513	Profissionais em pesquisa e análise geográfica
3001	Técnicos em mecatrônica
3003	Técnicos em eletromecânica
3011	Técnicos de laboratório industrial
3012	Técnicos de apoio à bioengenharia
3111	Técnicos químicos
3112	Técnicos de produção de indústrias químicas, petroquímicas, refino de petróleo, gás e afins
3115	Técnicos em controle ambiental, utilidades e tratamento de efluentes

code_cbo2002	occupation
3121	Técnicos em construção civil (edificações)
3122	Técnicos em construção civil (obras de infraestrutura)
3123	Técnicos em geomática
3161	Técnicos em geologia
3171	Técnicos de desenvolvimento de sistemas e aplicações
3172	Técnicos de suporte e monitoração ao usuário de tecnologia da informação.
3180	Desenhistas técnicos, em geral
3181	Desenhistas técnicos da construção civil e arquitetura
3182	Desenhistas técnicos da mecânica
3183	Desenhistas técnicos em eletricidade, eletrônica, eletromecânica, calefação, ventilação e refrigeração
3185	Desenhistas projetistas de construção civil e arquitetura
3186	Desenhistas projetistas da mecânica
3187	Desenhistas projetistas da eletrônica
3201	Técnicos em biologia
3212	Técnicos florestais
3253	Técnicos de apoio à biotecnologia
3951	Técnicos de apoio em pesquisa e desenvolvimento
