

Li, Xun; Lai, Weizheng; Wan, Qianqian; Chen, Xi

Working Paper

Role of Professionalism in Response to the COVID-19 Pandemic: Does a Public Health or Medical Background Help?

GLO Discussion Paper, No. 1002

Provided in Cooperation with:

Global Labor Organization (GLO)

Suggested Citation: Li, Xun; Lai, Weizheng; Wan, Qianqian; Chen, Xi (2021) : Role of Professionalism in Response to the COVID-19 Pandemic: Does a Public Health or Medical Background Help?, GLO Discussion Paper, No. 1002, Global Labor Organization (GLO), Essen

This Version is available at:

<https://hdl.handle.net/10419/248117>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Role of Professionalism in Response to the COVID-19 Pandemic: Does a Public Health or Medical Background Help?

Xun Li
Wuhan University

Weizheng Lai
University of Maryland

Qianqian Wan
Wuhan University

Xi Chen
Yale University and GLO

Abstract

In response to the outbreak of coronavirus disease 2019 (COVID-19), there have been substantial variations in policy response and performance for disease control and prevention within and across nations. It remains unclear to what extent these variations may be explained by bureaucrats' professionalism, as measured by their educational background or work experience in public health or medicine. To investigate the effects of officials' professionalism on their response to and performance in fighting the COVID-19 pandemic, we collect information from the résumés of government and Party officials in 294 Chinese cities, and integrate this information with other data sources, including weather conditions, city characteristics, COVID-19-related policy measures, and health outcomes. We show that, on average, cities whose top officials had public health or medical backgrounds (PHMBG) had significantly lower infection rates than cities whose top officials lacked such backgrounds. We test the mechanisms of these effects and find that cities whose officials had PHMBG implemented community closure more rapidly than those lacked such backgrounds. Our findings highlight the importance of professionalism in combating the pandemic.

Keywords: COVID-19; Professionalism; Public Health Background; Medical Background; Policy Response

JEL Codes: I18, H12, H75, P41

Acknowledgement: Financial support from the China Central University Special Scientific Fund, the U.S. PEPPER Center Scholar Award (P30AG021342), and a NIH/NIA grant (K01AG053408) are acknowledged. Xun Li and Weizheng Lai are co-first authors for this research. Xi Chen is the corresponding author (xi.chen@yale.edu). The views expressed herein and any remaining errors are the authors' and do not represent any official agency. None of the authors have potential conflicts of interests that could bias this work.

1. INTRODUCTION

Coronavirus disease 2019 (COVID-19) was first reported in the city of Wuhan in Hubei province, China, in early December 2019. It then spread rapidly within China and worldwide, becoming a pandemic and bringing about devastating consequences (Ramteke et al, 2020). To contain the transmission of the novel coronavirus, countries around the world have adopted a wide range of stringent measures to reduce human interactions, such as family outdoor restrictions, closed community management, and large-scale quarantines and isolations.

The exponential viral transmission highlights the importance of a swift response. However, COVID-19 countermeasures vary substantially in the timing of their implementation and their efficacy. For instance, most East Asian countries, with their existing contact-tracing systems and experience of viral outbreaks, could contain COVID-19 in a relatively short time. Western governments, on the other hand, often began with loose regulations and delayed responses, which were followed by blanket lockdown. Countries that responded more quickly, such as Italy, Germany, Austria, and Switzerland, contained the spread of the virus more effectively than countries with a delayed response, including the United Kingdom, Sweden, and the United States (Flaxman et al, 2020; The Economist, 2020). The effectiveness of the pandemic response has varied across countries and regions. For instance, in the initial phase of the pandemic, the case fatality rate (CFR) in Italy was 13.98% (number of deaths per 100 confirmed cases), compared with only 5.40% in China (Chauhan, 2020). Response effectiveness also varied within countries. In China, Hubei province had a CFR of 6.62%, which was much higher than the average value of 0.82% for other Chinese provinces (Peng et al, 2020). In the early stage of COVID-19 transmission, quarantine was often the most effective approach, especially in combination with other prevention and control measures (Nussbaumer et al, 2020). China's early implementation of family outdoor restrictions and closed community management might have avoided a large number of infections and casualties (Qiu et al, 2020a).

There is no doubt that combating the pandemic requires collaboration of the public, scientists, and government officials. The characteristics of officials may be particularly important, as they oversee policy formulation and enforcement to contain the spread of the virus. Their scientific knowledge may affect their perceptions of the underlying risks and corresponding responses. Numerous studies have suggested that a more diverse leadership team tends to be more productive

and creative in problem solving, and leads to higher quality decision-making (Nowak, 2020; Shi et al, 2019). Moreover, leaders' educational backgrounds may shape their ideas and beliefs about policymaking (Li et al, 2020). Leaders' experience may also be a good predictor of their behavior (Avery et al, 2001). The ongoing COVID-19 pandemic offers the opportunity to better understand the role of officials' professionalism in emergency response in a high-stakes context.

Do more professional officials strengthen the efforts to fight COVID-19? To test this hypothesis, we collect data on officials in 294 Chinese cities and examine the effect of the officials' professionalism, as measured by their having a public health or medical background (PHMBG), on epidemic control. A PHMBG is broadly defined as having received education or worked in public health or medicine. Senior officials are central to social management and development in China. Professional leaders with a PHMBG may leverage their unique experience during a public health crisis to demonstrate urgently needed skills in monitoring infectious diseases and organizing an effective policy response.¹ However, only a small proportion of Chinese officials have a PHMBG. We collect the official résumés of principal and deputy (Communist Party) secretaries (secretaries hereafter) and mayors, the officials responsible for managing a city, from which we extract information on their experiences relevant to a PHMBG. We merge this information with data from other sources, including COVID-19 infection and fatality data, a rich set of socioeconomic characteristics, and meteorological and environmental information at city level that may influence virus transmission. We estimate the effects of officials' PHMBG on the COVID-19 infection rates, death rates, and public health measures taken. Our linear regression model at the city level controls for city-level covariates associated with both the officials' profiles and outcome measures, including population density, GDP per capita, the number of doctors per 10,000 population, and the average air quality index (AQI). We also include weather controls, such as the average daily maximum temperature, average wind speed, and average precipitation. Our results indicate that a city leadership with a PHMBG was significantly associated with a lower infection rate, which seems to be driven by the Party secretary's PHMBG. The backgrounds of the Party secretaries seem to play a much bigger role in reducing infections than that of the mayors. We also

¹ The public's scolding the lack of a timely and appropriate response and the consequent outbreaks nationwide led the government to discipline local officials for mishandling the epidemic, partly due to their lack of relevant experience. We offer two anecdotal examples below. First, the top officials in the epicenter Wuhan had no PHMBG. Second, the principal public health official of the city of Huanggang, which had the second largest number of infections in China, was dismissed for incompetence in handling the epidemic. This official in charge had received a law education but had no prior experience of managing public health.

show that having a PHMBG is important for timely implementation of local public health measures, such as community closure and outdoor restrictions, to curb human-to-human virus transmission.

This analysis represents, to the best of our knowledge, the first attempt to empirically test the impact of officials' professionalism on their policy response and performance in combating the COVID-19 pandemic. We contribute to the literature in the following respects. First, we offer novel evidence on how officials' characteristics influence policies, in the context of responding to a major public health crisis. Existing studies have mostly focused on the roles of officials' gender, age, and educational attainment (Braun et al 2018; Elgar 2016; Lahoti 2020; Li et al, 2020; Beaman et al 2009). Second, we add to the literature on the determinants of virus transmission. In addition to socioeconomic factors, environmental conditions, the political system, and compliance with disease control norms (Farseev et al, 2020; Ogen, 2020), the PHMBG of a political team has an important effect on transmission, though this factor has received less attention in the literature.

This paper is organized as follows. The next section introduces the data sources of this paper. Section 3 lays out our empirical strategy. Section 4 reports the findings. The final section presents concluding remarks and recommends future research directions in this field.

2. DATA

This section discusses several data sources this paper exploits. Section 2.1 presents how we construct our sample and define key variables. Some relevant issues or concerns are also discussed. Section 2.2 reports some descriptive features of the sample.

2.1. Our Sample

We use city as the unit of analysis, including prefectural city and direct-administered municipality (i.e., Beijing, Shanghai, Chongqing, and Tianjin). We exclude Wuhan from our analysis as it was the initial epicenter where the virus was first identified. Given its limited knowledge and capacity in the face of this novel virus, infections and deaths data may not be of adequate quality. Some small cities, primarily located in Tibet, Xinjiang, Inner Mongolia, and Hainan, are also excluded due to lack of socioeconomic data. Hong Kong, Macau, and Taiwan are not included due to their different political systems from mainland China. We are left with 294 cities in the sample.

To identify city officials' backgrounds, we collect from posts on official websites and digitize résumés of city leaders – secretaries, deputy secretaries, mayors, and deputy mayors – who were in office before March 2020. These résumés provide comprehensive information on officials' age, gender, education background, and work experience. In particular, we focus on characteristics of a city's two most powerful officials, i.e., secretary and mayor. We define an official as having PHMBG if they completed college/graduate school education in the fields of medicine or public health and/or had experiences working in hospitals, centers of disease control, public health departments, etc. PHMBG is defined as a binary variable.²

Data on COVID-19 infections and deaths at the city level are obtained from Johns Hopkins CSSE Dashboard as of February 29, 2020 (Dong et al, 2020). The main reason for focusing on epidemic control and prevention prior to March 2020 is that the COVID-19 pandemic was largely under control in China (except Wuhan) by the end of February (Chen et al, 2020).

We obtain city level covariates from the China City Statistical Yearbook 2019, including GDP per capita, population density, and number of doctors per 10,000 population. We also include city level five-year average AQI (2015–2019) obtained from the website of China National Municipal Ecological and Environmental Monitoring Center, which proxy people's respiratory health conditions.³ We then link our sample with data on city-level public health measures collected by Qiu et al (2020a; 2000b). Weather conditions are influential for virus spread (e.g., Lowen and Steel 2014; Wang et al 2020). City-level daily meteorological data (from January 19 to February 29, 2020) covering maximum temperature, precipitation, and wind speed are collected from the U.S. Weather National Oceanic Atmospheric Administration. Population flows from Wuhan to each city are constructed based on Baidu Migration Index (see Qiu et al (2020a) for details).

We utilize data on the timing of community closure and family outdoor restrictions collected from Qiu et al. (2020a) and Fang et al. (2020), which aim at keeping social distance and containing both within-city and between-city viral transmission. Qiu et al (2020a)'s sample provides data on

² We do not further distinguish the length of such experiences, because in some cities resume data released are not detailed enough to accurately measure the lengths of related experiences. In addition, given the small number of officials in China with PHMBG, it would not offer us more variations over the intensive margin.

³ Air pollution is harmful to individuals' respiratory system (e.g., Guaita et al 2011), making people more vulnerable to COVID-19 infection. Karen et al (2020) find many countries seriously hit by COVID-19 have very poor air quality.

the timing of restrictive policies that aim at reducing face-to-face contacts within a city, based on official announcements and media reports.

A community closure order limits residents' visits between communities. From January 28 to February 20, 2020, more than 250 prefecture-level cities in China implemented community closure. Under this policy, each community leaves only one entrance/exit open, and only residents of that community can enter or exit.⁴ Meanwhile, body temperature is checked for each entrant. Testing and quarantining cases are implemented immediately for those who exhibit fever, and whose close contacts are traced and quarantined. Moreover, residents who have symptoms of fever or dry cough are required to report to the community and are quarantined and treated in special medical facilities.

The community closure essentially still allows residents to go out freely, whereas the outdoor restriction is a more stringent policy that largely limits outdoor activities. Governments of 127 Chinese cities imposed family outdoor restrictions.⁵ Under such order, residents are required to stay at home and can only go out for necessary needs. For example, in most cities only one household member can go out for groceries every two days, but it may vary from 1 to 5 days across cities in very occasional cases. In some cases, all residents should stay at home with no exception, and the government is responsible for delivering living resources (e.g., food) to them. Exit permits are usually distributed to each family in advance and recollected when residents re-enter the community. Contacts of those infected are also traced and quarantined.

Dummy variables for the presence of community closure and family outdoor restrictions are created. Both policies were announced in city-level government documents and were uniform across areas within each city. As also acknowledged in Qiu et al. (2020a) and Fang et al. (2020), there were a few cities in which only part of their counties declared to start with implementing these policies. However, other counties in the same city quickly learned from them. Thus, as long as one county in a city has implemented community closure or family outdoor restrictions, we treat the whole city as having the policy in place.

⁴ A Chinese community usually has walls and gates to separate it from the outside. Under the community closure order, personnel check visitors' identity to make sure only residents of that community in and out. For communities that are open or semi-open to the outside (there are no walls), roadblock is set to enforce the closure order.

⁵ Here outdoor restrictions mean restricting outdoor activities and travels *within* a city, rather than travels *between* cities. This is different from orders such as Wuhan lockdown on January 23, 2020, which prohibited people from entering or leaving Wuhan, while people within the city could still go out.

Based on information on policy timing, we measure policy adoption speed by the number of days between Wuhan's lockdown (January 23, 2020) and the implementation of a city's community closure or outdoor restriction orders. We use Wuhan lockdown date as a reference point because the lockdown of Wuhan, one of the largest and most populous cities in China, offered a salient signal to city officials in other parts of China that similar restrictive policies can be a key option in their toolkit. Without the experience of Wuhan, officials might not have good justification and resolution to adopt such a stringent policy, especially when the virus outbreak overlapped with the Chinese New Year 2020. Peaceful atmosphere is important during major festivals, but stringent public health measures greatly hinder family and friend union. Nonetheless, the lockdown of Wuhan signals that these measures are unavoidable, and that the stance in the top leadership team is clear and supportive. Alternatively, other dates that represent important events may also be used as a reference point, such as the date when COVID-19 became known to the public. However, to the extent that a reference date is constant across all cities, the estimates would not change with the reference point. Finally, for city-specific reference points, we use the date of each city's first identified case, and results are qualitatively identical (see [Section 4.3](#)).

2.2. Descriptive Analysis

The final sample consists of 294 cities.⁶ Table 1 displays summary statistics of main variables. We divide cities into two groups based on whether anyone in the leadership has a PHMBG. There are 73 cities with leadership having at least one PHMBG official, while 221 cities without. Panel A contains outcomes of interest. Comparing city leadership with and without PHMBG, the former witnessed less infections, a lower death rate, and quicker adoption of community closure, all of which motivates us to more rigorously investigate the role of PHMBG in combating COVID-19. However, no such pattern is found on the speed of implementing outdoor restrictions. We discuss this issue in [Section 4.3](#).

Panels B and C display city covariates and weather conditions in the early stage of the pandemic that can be associated with the pandemic and its control measures. There were large differences in GDP per capita, population flow from Wuhan, AQI, maximum temperature, and precipitation between cities in which the leadership team had *versus* had no PHMBG.

⁶ Qiu et al (2020a)'s sample includes 304 cities. Ten cities are excluded from our analysis due to missing information on their officials' profiles.

Lastly, Panel D of Table 1 reports characteristics of principal leaders, i.e., secretary and mayor. It is apparent that there were very few female leaders. The average age of the secretaries was around 55; on average, they were 3 years older than the mayors. When the pandemic began, the principal officials on average started their third year in office. Educational attainment is coded as a 1–4 scale: 1 denotes junior college, 2 Bachelor, 3 Master, and 4 Doctorate. An average secretary or mayor received graduate education (note all means are well above 2). Notably, there were no large differences in these characteristics between city leadership with PHMBG and those without.

[Table 1]

Figures 1–5 visualize patterns in our data. Figure 1 shows spatial distribution of city leaderships' PHMBG. We categorize the sampled cities into four categories: (1) none has a PHMBG, (2) only deputy officials have a PHMBG, (3) only principal officials have a PHMBG, and (4) both principal and deputy officials have a PHMBG. There seems to be some spatial clustering of PHMBG in southeast and southern China. To address confounding spatial correlations, we control for province fixed effects and explore spatial standard errors in the econometric investigation (see Section 3). Figures 2 and 3 display COVID-19 infections and deaths (per million population) across cities, where darker colors denote more infections or deaths. Infections vary largely across cities. Overall, infections decline as a city is further away from Wuhan. However, this pattern is nuanced, as Figure 2 shows that cities were differentially affected within the same geographical cluster, which encourages us to study the association between leadership PHMBG and infections. By contrast, there are fewer variations in deaths, and the death rate is very low beyond Hubei Province. For this reason, the focus of this paper is on COVID-19 infections.

[Figure 1, 2, 3]

Figures 4 and 5 show adoption speed of community closure and outdoor restriction orders. Darker colors represent more rapid action relative to Wuhan lockdown date, January 23, 2020. In our sample, 240 out of 294 cities eventually implemented a community closure order, whereas for the more stringent policy, outdoor restrictions, only 122 cities implemented. All cities having an outdoor restriction order also had a community closure order. It is evident that cities differ substantially in terms of if and how quickly they implemented these policies. It is worth noting that while Wuhan and other cities in Hubei Province were most severely hit by the pandemic and

took the most rapid action in locking down, they were not the first ones implementing more restrictive measures like community closure or outdoor restriction. In fact, many cities away from Wuhan (e.g., some cities in southwest China, southern China, or northern China) took these measures more quickly, whose leadership team also seemed to have PHMBG.

[Figures 4, 5]

Though from these visualizations it is hard to draw conclusive relationships between PHMBG and COVID-19 outcomes and policy responses, the large variations across cities merit further investigation. In the next section, we discuss our empirical strategy to examine the role of PHMBG in the pandemic.

3. EMPIRICAL STRATEGY

In this section, we describe empirical strategies that we implement to study the effects of officials' PHMBG on different outcomes, including infections, deaths from COVID-19, and policy responses.

3.1. Effects of PHMBG on COVID-19 Pandemic Consequences

We rely on the following linear regression models to explore the effects of officials' PHMBG on pandemic outcomes:

$$(1) y_{ip} = \alpha + \beta^L Z_{ip}^L + X'_{ip} \gamma + W'_{ip} \delta + \lambda_p + \varepsilon_{ip},$$

$$(2) y_{ip} = \alpha + \sum_{O \in \{S, M, D\}} \beta^O Z_{ip}^O + X'_{ip} \gamma + W'_{ip} \delta + \lambda_p + \varepsilon_{ip}.$$

In two equations, i indexes city, and p indexes province where the city locates. For the outcome variable y_{ip} , we use two measures of COVID-19 pandemic consequences, i.e., logged infection rate and death rate as of February 29, 2020.

In equation (1), Z^L is a dummy variable that equals one if any official in a city's leadership has a PHMBG. In equation (2), Z^S and Z^M are dummy variables coding whether city i 's secretary and mayor have a PHMBG, respectively, whereas the dummy variable Z^D denotes if any deputy officials have a PHMBG. X refers to a set of city-level covariates that could also affect the outcomes, as displayed in Panels B and C of Table 1. W refers to other characteristics of principal officials of a city, i.e., the secretary and mayor, which includes their gender, age, tenure, and

educational attainment (i.e., Panel D of Table 1). λ_p accounts for province fixed effects, which removes unobserved heterogeneity across provinces, such as actions taken by the provincial government. ε_{ip} is an error term, clustered at the province level. We also explore other error term structures to account for arbitrary spatial correlations. First, we assume cities' error terms are subject to distance-based correlations unless they are 300km away from each other. Second, error terms in different provinces can be correlated based on their network-based adjacency relationships, which may correspond to the mode of virus transmission. For example, neighboring provinces of Hubei were more seriously hit by the pandemic.

Clearly, β 's are the parameters of interest, capturing how officials' PHMBG is associated with pandemic outcomes. In terms of causality, one may concern that officials with PHMBG could be sent during the pandemic to less developed regions to lead health systems improvement, or promoted to more developed regions due to their good public health performance. However, these concerns can be addressed with the following evidence. The appointments of Chinese municipal leaders are often centralized in higher level governments, and the primary determinants are their ability in boosting economic growth and political ties (e.g., Jia et al 2015). Moreover, these leadership positions require general skills, rather than specific skills in a certain field. Therefore, it is unlikely that PHMBG per se would be particularly emphasized in appointments prior to the pandemic. In addition, to the best of our knowledge, during the pandemic political turnovers that replaced incompetent officials with competent ones to help with epidemic control were largely absent. Most political turnovers before March 2020 (the point at which our sample period ends) were during January 2020, which were routine turnovers passed by local people's congress prior to the pandemic. The mere exceptions include Jinan's secretary Wang Zhonglin being sent to Wuhan as the secretary; and Shanghai's mayor Ying Yong being appointed as Hubei provincial secretary. However, none of them or their successors in Jinan and Shanghai held PHMBG. Therefore, they should not threaten our identification.

3.2. PHMBG and Policy Responses

We also examine how the officials' PHMBG backgrounds affect the decision of policy responses to the COVID-19 outbreak using Equations (1) and (2), where the dependent variable y is replaced with a dummy variable that equals one if city i implemented certain policy, i.e., community closure or outdoor restriction orders, to restrict face-to-face contact. The link between the two sets of

outcomes, i.e., public health outcomes (i.e., COVID-19 infections and deaths) and policy response (i.e., days to implement community closure or outdoor restrictions) has been established.⁷

In addition to PHMBG's effect on whether to implement a restrictive policy, we also examine, how PHMBG influences the speed of implementation among cities that adopted such policies. To answer this question, we replace the dependent variable of Equations (1) and (2) with the number of days between Wuhan's lockdown (January 23, 2020) and the implementation of a city's outdoor restrictions or community closure.

Simply running Equations (1) and (2) would give incorrect estimates of PHMBG's impact on days to policy implementation, because cities self-selected into policy implementation based on their social and economic conditions, pressures of pandemic control, and importantly, leadership characteristics, which result in the sample selection problem. To correct for this bias, we apply the Heckman two-stage method (Heckman 1979). In the first stage, we run a Probit regression of the policy adoption indicator for either outdoor restriction or community closure on average weather conditions (unreported), principal officials' characteristics, and the infection rate as of January 28, 2020.⁸ Therefore, the model predicts a city's necessity and likelihood of adopting a policy based on its epidemic condition and governance style. In the second stage, the inverse Mills ratio, which is derived from the Probit model and explicitly accounts for the probability of policy response, is included in the linear regression as an extra regressor to correct for the sample selection bias.

4. RESULTS

4.1. Effects of PHMBG on Infections and Deaths

Table 2 reports the effects of PHMBG on infection and death rates, and Figure 6 visualizes key estimates. As discussed in Section 3, we report three different standard errors: standard errors clustered at the province level in *parentheses*, distance-based standard errors in *brackets*, and network-based standard errors in *braces*. Clustering at province level appears to offer most conservative inferences. Columns (1) and (2) use logged infections per million as the dependent variable. Column (1) is based on Equation (1), a parsimonious specification that bundles up all

⁷ Qiu et al. (2020a) use city level data and counterfactual analyses to quantify the effects of community closure and family outdoor restrictions on avoided number of infections by the end of February 2020.

⁸ Before January 28, 2020, no cities had implemented either a community closure or an outdoor restriction order.

officials' PHMBG as the leadership variable. The estimate suggests that if anyone in a city leadership has a PHMBG, then infections per million are reduced by about 18 percent. By estimating Equation (2), Column (2) separates the effects of different officials' PHMBG. The leadership's PHMBG effects are mainly driven by secretary and deputy officials, while the mayor's PHMBG demonstrates no significant effects. Having a secretary with PHMBG reduces infections per million by 82 percent, and any PHMBG of deputy officials leads to 17.7 percent lower infections per million. The coefficient for deputy officials is less precisely estimated, therefore, we interpret it only as qualitative evidence. Columns (3) and (4) report the effects of PHMBG on deaths per million. There are no detectable effects of the leadership's, secretary's, or deputy officials' PHMBG. One potential explanation is that lack of variations in death data across cities (see Figure 3) results in random correlations due to over-fitting. However, we also admit the possibility that the results might reflect certain features of the decision-making process within the leadership, which is an open question for future research.

[Table 2, Figure 6]

Table 2 also displays coefficients on other variables, which also provides some interesting insights for understanding factors that influence the pandemic outcomes. Officials' characteristics are of particular interest. Some earlier anecdotal cross-country comparisons suggest that female politicians appeared to perform better than male politicians in handling the COVID-19 crisis (Taub, 2020). However, this pattern is less pronounced in our within-country study. We do not find female secretaries or mayors with PHMBG significantly correlate with fewer infections or deaths. We also find no supporting evidence linking educational attainment to health outcomes. Moreover, officials' age does not have significant influences, though previous literature suggests age matters to Chinese officials' incentives and performance, as it indicates opportunities for promotion (e.g., Li 1998; Chen et al 2005; Li and Zhou 2005). One possible explanation is that, faced with the devastating COVID-19 crisis, pandemic control is the vital obligation of officials, which overwhelms career concerns and leaves no room for slack. Work experience in the mayor position shows a salient effect that mayors who had worked in the city for more than six years prior to the pandemic is associated with lower infection rates.

4.2. Robustness Checks

Our results support that PHMBG of the leadership team, especially that of the secretary, plays an important role in mitigating damages resulting from the pandemic. In this subsection, we provide a set of robustness checks to alleviate potential concerns.

Outliers. — One concern is that regression results can be driven by hotspots whose leadership by chance did not have PHMBG. Instead of only excluding the initial largest hotspot city Wuhan from the analysis, now we exclude all cities in Hubei Province and re-do the analysis in Table 2 to minimize influences of outliers, because all cities in Hubei were early hotspots and their leadership mostly did not hold PHMBG. Full estimates are reported by Table A1 in the Appendix. Figure 7 displays coefficients on officials' PHMBG. Comparing Figures 6 and 7 shows that results are robust after excluding all cities in Hubei: the leadership's PHMBG now reduces the infection rate by 20 percent, slightly higher than the previous estimate (18 percent), and the effect remains driven by the secretary's and deputy officials' PHMBG. Therefore, our results should not be affected by potential outliers. For remaining tests in this paper, we primarily report results after excluding Wuhan, though they are also robust to excluding all cities in Hubei province (see Appendix).

[Figure 7]

Alternative Explanations. — We interpret the association between PHMBG and lower infection rates as showing that officials' professionalism serves as a beneficial input into combating the pandemic. However, one might argue that PHMBG may also pick up a general impact of governing style given their technocratic or scientific background. To address this issue, we run equations (1) and (2), adding indicators for the secretary's, mayor's, and deputy officials' STEM (science, technology, engineering, and mathematics) education experience, based on their highest degree received. Figure 8 displays the estimates. Panel (A) presents effects of the leadership's PHMBG and officials' STEM background. The effect of the leadership's PHMBG is virtually unchanged compared to the baseline estimate in Column (1) of Table 2 (18.4 versus 18.1 percent). Reassuringly, the effects of STEM background are all statistically insignificant and have very small magnitude. Panel (B) shows similar patterns for the effects of officials' PHMBG and STEM background. Results are similar if we repeat this exercise on the sample that excludes all cities in Hubei province (see **Figure A1** in Appendix). Therefore, it is most plausible that our identified

effects of officials PHMBG represent the unique importance of professionalism, rather than general scientific thinking.

[Figure 8]

Coincidence. — One may worry that our findings are just by coincidence. We conduct placebo tests, allowing for a more flexible way to test for our findings. Given that our main findings are on the role of leadership's PHMBG on epidemic control, which is driven by the secretary's PHMBG, we simulate the distributions of the leadership's and the secretary's PHMBG across cities by randomly assigning PHMBG (holding constant the fractions of different types of officials who have PHMBG). For each simulated sample, we re-estimate Equations (1) and (2) and obtain counterfactual effects of PHMBG. We run simulations for 20,000 times. In Figure 9(A), we report the permutation test result for the effect of the leadership's PHMBG. It plots the distribution of counterfactual estimates, while the vertical dashed line denotes the true estimate shown in Table 2. The true estimate lies in the left tail of the distribution, and a t -test does not reject that the mean of counterfactual estimates is zero (p -value = 0.301), indicating that our findings are not just by coincidence. Figure 9(B) tests for the effect of the secretary's PHMBG. According to these placebo test results, it is unlikely that our findings are merely by chance.

[Figure 9]

4.3. Implementation of Community Closure and Outdoor Restrictions

In this subsection, we probe into explanations for the association between PHMBG and lower infections rates. Using a sample of cities almost the same to ours, Qiu et al (2020a) find that community closure and outdoor restriction orders effectively contained viral transmission within Chinese cities. Cross-country evidence also supports the importance of timely measures to enforce social distancing. Countries that responded more quickly, such as Italy, Germany, Austria, and Switzerland, contained the spread of the virus more effectively than countries with a delayed response, including the United Kingdom, Sweden, and the United States (Flaxman et al 2020; The Economist 2020). Along this line, we explore if PHMBG contributes to better policy responses in the first place, which then manifests itself in fewer infections.

Firstly, we look at how PHMBG affects the probability of community closure and outdoor restriction orders being implemented. Figure 10 shows the estimates from linear probability

models specified as Equations (1) and (2) using policy adoption dummies as dependent variables. A secretary with PHMBG makes the city 13.5 percent more likely to enact community closure, while other officials do not have significant contributions. However, for the more stringent outdoor restriction, mayor's PHMBG makes more difference.

[Figure 10]

We then investigate PHMBG's effects on the speed of policy adoption. We estimate Equations (1) and (2) with the days between policy implementation date and Wuhan lockdown date (January 23, 2020), augmented by Heckman two-step method. Figure 11 visualizes the results for cities excluding Wuhan. The left panel shows that a leadership team with PHMBG implemented a community closure order nearly one day earlier, but PHMBG's effects differ dramatically across officials. Secretary's PHMBG significantly accelerated a community closure order by about three days, but the mayor's PHMBG seems to cause a delay though insignificant, and deputy officials' PHMBG had no effect. The right panel turns to investigate the speed of implementing outdoor restriction, none of officials' PHMBG had any salient influences. We also look at results using each city's first case date as the reference point (Figure 12). In general, results are similar to Figure 11: secretary's PHMBG drives the entire leadership to speed up launching community closure, but a distinction is that the mayor's PHMBG now appears to facilitate more rapid outdoor restrictions.

[Figure 11, 12]

In sum, the results deliver a clear message that secretary's PHMBG increases the chance and rapidity of a community closure order. This provides an explanation for earlier finding that secretary's PHMBG reduces infections: quicker community closure effectively reduces face-to-face contacts, thus cuts off many channels through which the virus transmits. Admittedly, the results are mixed in the role of mayor's PHMBG. If anything, on the extensive margin, mayor's PHMBG insignificantly increases the probability of adopting outdoor restriction, but on the intensive margin, it has no impact on the speed of implementing an outdoor restriction if using Wuhan lockdown date as the reference point, but accelerates the policy adoption if using the city's first case date as the reference point. A further question is why PHMBG's effects vary dramatically by position. One conjecture is political hierarchy and differential power attached to each position. This study documents this pattern and leave the exact interpretations for future research.

5. CONCLUDING REMARKS

This study examines the potential influence of city officials' educational or work experience in public health or medicine on their epidemic control and prevention efforts and outcomes. Our results show that the presence of city officials with PHMBG was significantly associated with lower infection rates. Second, cities whose officials had PHMBG implemented a community closure order in a timelier manner.

Our findings may have implications that training background and work experience of the leadership team may play a role in response to epidemics. Given that only 3.27 percent of top-ranked officials in our sampled cities have PHMBG,⁹ enhancing professionalism in leadership team may generate high return in disease control and prevention. For example, the appointment of officials in public health departments may stress on professional skills. Under the Chinese bureaucratic rotation system, a department's leader usually does not have relevant experience in issues that the department oversees. Some training can be helpful. In addition, certain institutional reforms are necessary to empower professionalism in the policy making process in the face of emergencies. For instance, establishing an advisory board that consists of public health or medical scientists can provide professional suggestions to policy makers.¹⁰ This implication for professionalism not only applies to public health emergencies, but is relevant for other public sectors in which the government plays an important role.

In times of crises, people with a public health background may respond differently from those with a medical background, as the former often emphasize preventive measures to protect population-level health, while the latter treat specific patients. However, as only a small proportion of top city officials in China have such background, even when both types of background are combined, future studies will have to wait for a larger number of cities to join this group to obtain the statistical power needed to identify potentially heterogeneous effects. Future studies could also conduct randomized control trials to examine whether providing local officials with training in public health, medicine or other fields could improve professionalism in their duties. Finally,

⁹ Calculated among over 3000 officials in the sample.

¹⁰ Recently, the Chinese government has started some of these efforts. For example, Hubei is set to create a "Chief Public Health Specialist" position in its public health department. https://ctdsbepaper.hubeidaily.net/pc/content/202007/07/content_38466.html

studying the significance of officials' PHMBG during epidemics from a global perspective would be another meaningful extension of this study.

REFERENCES

- Avery, D. R., S. Tonidandel, K. H. Griffith, M. A. Quinones, The impact of multiple measures of leader experience on leader effectiveness: New insights for leader selection. *Journal of Business Research*, 56, 2003, 673-679.
- Beaman, Lori, Raghavendra Chattopadhyay, Esther Duflo, Rohini Pande and Petia Topalova, Powerful Women: Does Exposure Reduce Bias? *The Quarterly Journal of Economics* 124(4), 2009, 1497–1540.
- Braun, S., C. Peus, D. Frey, Connectionism in action: Exploring the links between leader prototypes, leader gender, and perceptions of authentic leadership. *Organizational Behavior and Human Decision Processes*, 149, 2018, 129-144.
- Chauhan, S., Comprehensive review of coronavirus disease 2019 (COVID-19). *Biomedical Journal*, 2020.
- Chen, K., M. Wang, C. Huang, P. L. Kinney, P. T. Anastas, Air pollution reduction and mortality benefit during the COVID-19 outbreak in China. *The Lancet Planetary Health*, 4, 2020, e210-e212.
- Chen, Y., H. Li, L.-A. Zhou, Relative performance evaluation and the turnover of provincial leaders in China. *Economics Letters*, 88, 2005, 421-425.
- Dong, E., H. Du, L. Gardner, An interactive web-based dashboard to track COVID-19 in real time. *The Lancet infectious diseases*, 20, 2020, 533-534.
- Elgar, M. A. Leader selection and leadership outcomes, Height and age in a sporting model. *The Leadership Quarterly*, 27, 2016, 588-601.
- Fang H, L. Wang, Y. Yang, Human mobility restrictions and the spread of the Novel Coronavirus (2019-nCoV) in China. *Journal of Public Economics*. 191:104272, 2020.
- Farseev, A., Y.-Y. Chu-Farseeva, Y. Qi, D. B. Loo, Understanding Economic and Health Factors Impacting the Spread of COVID-19 Disease. medRxiv, 2020.
- Flaxman, S. *et al.*, Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. *Nature*, 584(7820), 2020, 257-261.
- Guaita, R., M. Pichiule, T. Maté, C. Linares, J. Díaz, Short-term Impact of particulate matter (PM2.5) on respiratory mortality in Madrid. *Int. J. Environ. Health Res.*, 21(4), 2011, 260.
- Heckman, J. J., Sample selection bias as a specification error. *Econometrica: Journal of the econometric society*, 1979, 153-161.
- Jia, R., M. Kudamatsu, & D. Seim, Political selection in China: The complementary roles of connections and performance. *Journal of the European Economic Association*, 13(4), 2015, 631-668.

- Lahoti, R., S. Sahoo, Are educated leaders good for education? Evidence from India. *Journal of Economic Behavior & Organization*, 176, 2020, 42-62.
- Li, D. D., Changing incentives of the Chinese bureaucracy. *The American Economic Review*, 88, 1998, 393-397.
- Li, H., L.-A. Zhou, Political turnover and economic performance: the incentive role of personnel control in China. *Journal of public economics*, 89, 2005, 1743-1762.
- Li, J., T. Xi, Y. Yao, Empowering knowledge: Political leaders, education, and economic liberalization. *European Journal of Political Economy*, 61, 2020, 101823.
- Lowen, Anice C., John Steel, Roles of humidity and temperature in shaping influenza seasonality. *Journal of Virology*, 88(14), 2014, 7692-7695.
- Nowak, R., The effects of cognitive diversity and cohesiveness on absorptive capacity. *International Journal of Innovation Management*, 24(02), 2020, 2050019.
- Nussbaumer-Streit, B. *et al.*, Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. *Cochrane Database of Systematic Reviews*, 2020.
- Ogen, Y., Assessing nitrogen dioxide (NO₂) levels as a contributing factor to the coronavirus (COVID-19) fatality rate. *Science of The Total Environment*, 2020, 138605.
- Peng, Y., B. Xu, B. Sun, G. Han, Y. H. Zhou, Importance of timely management of patients in reducing fatality rate of coronavirus disease 2019. *Journal of Infection and Public Health*, 2020.
- Qiu, Y., X. Chen, W. Shi, Impacts of social and economic factors on the transmission of coronavirus disease 2019 (COVID-19) in China. *Journal of Population Economics*, 2020a. 33: 1127–1172.
- Qiu, Y., X. Chen, W. Shi, COVID-19 data set for community closure and lockdown policies used in “Impacts of social and economic factors on the transmission of coronavirus disease 2019 (COVID-19) in China.” 2020b. Download link: <https://www.dropbox.com/s/tufef2sciu28ka0/2019-nCoV.dta?dl=0>
- Ramteke, S., B. L. Sahu, Novel coronavirus disease 2019 (COVID-19) pandemic: considerations for the biomedical waste sector in India. *Case Studies in Chemical and Environmental Engineering*, 2020, 100029.
- Shi, F., Teplitskiy, M., Duede E., & Evans, J., Are Politically Diverse Teams More Effective? *Harvard Business Review*, 2019, 2-5.
- Taub, A., Why Are Women-Led Nations Doing Better With Covid-19? *New York Times*, 15, 2020.
- The Economist, Thinking fast and slow: How speedy lockdowns save lives. *The Economist*, 2020.
- Wang, Mao, Aili Jiang, Lijuan Gong, Lina Luo, Wenbin Guo, Chuyi Li, Jing Zheng et al, Temperature significant change COVID-19 Transmission in 429 cities. *Medrxiv*, 2020.

FIGURES

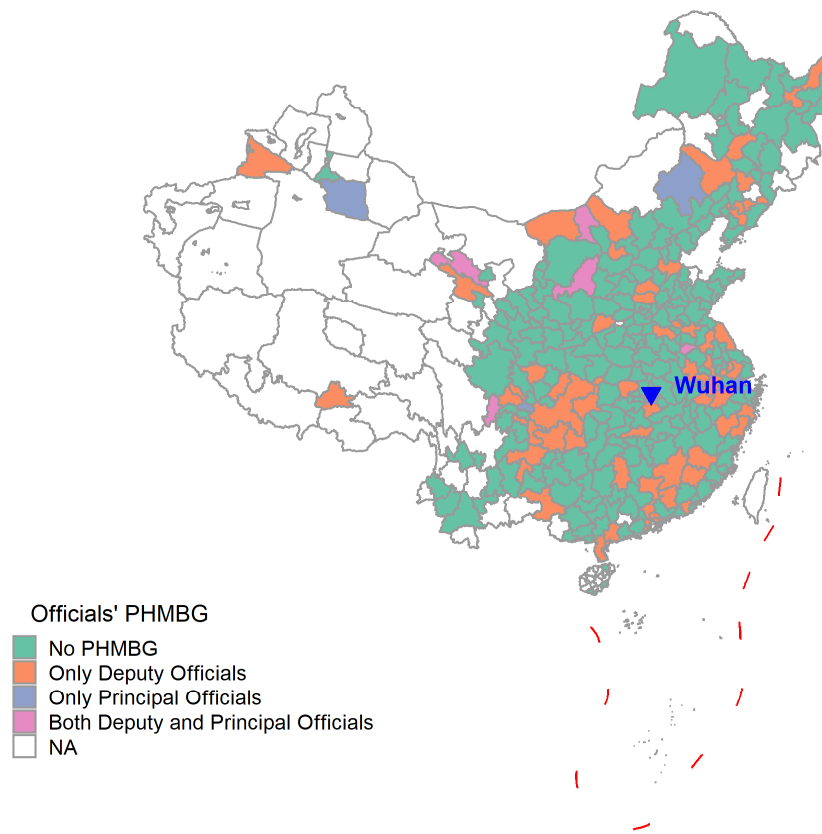


Figure 1. Distribution of Officials' Public Health/Medical Background (PHMBG) Across Chinese Cities

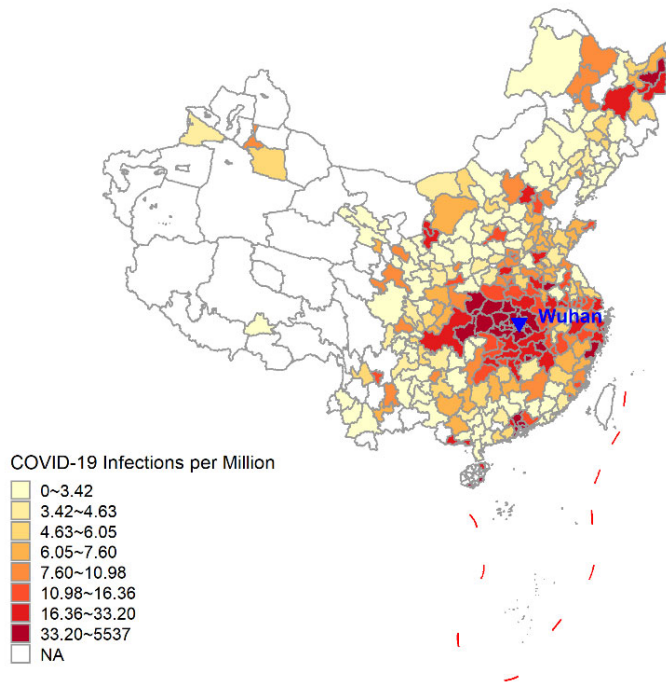


Figure 2. Spatial Distribution of COVID-19 Infection Rates Across Chinese Cities as of February 29, 2020

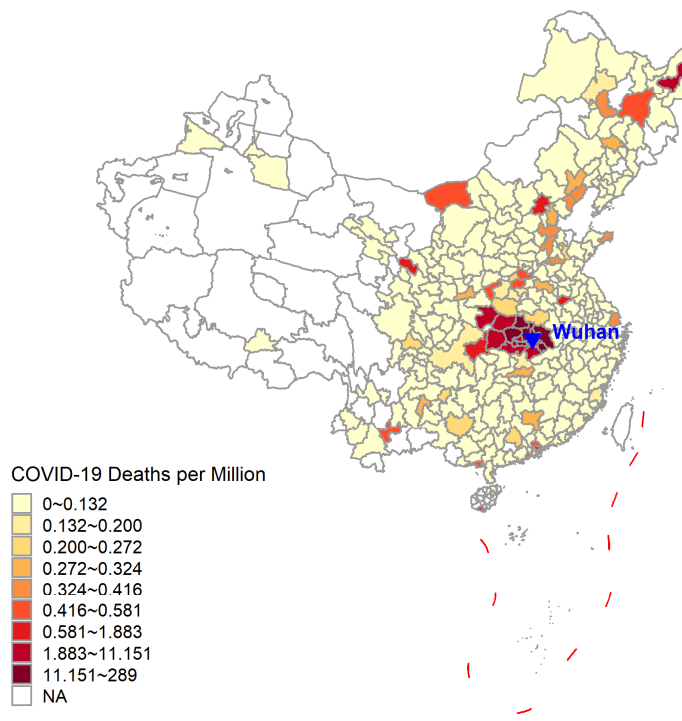


Figure 3. Spatial Distribution of COVID-19 Death Rates Across Chinese Cities as of February 29, 2020

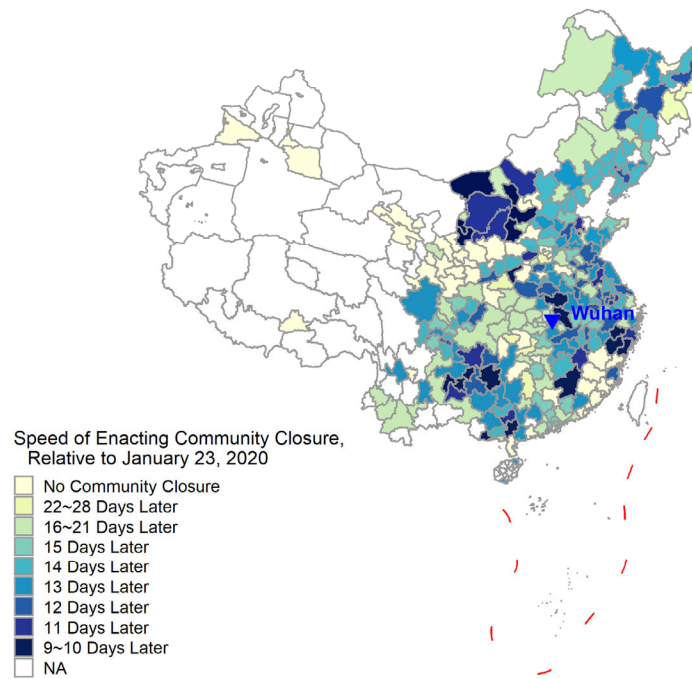


Figure 4. Speed of Community Closure Orders Across Chinese Cities, Relative to January 23, 2020

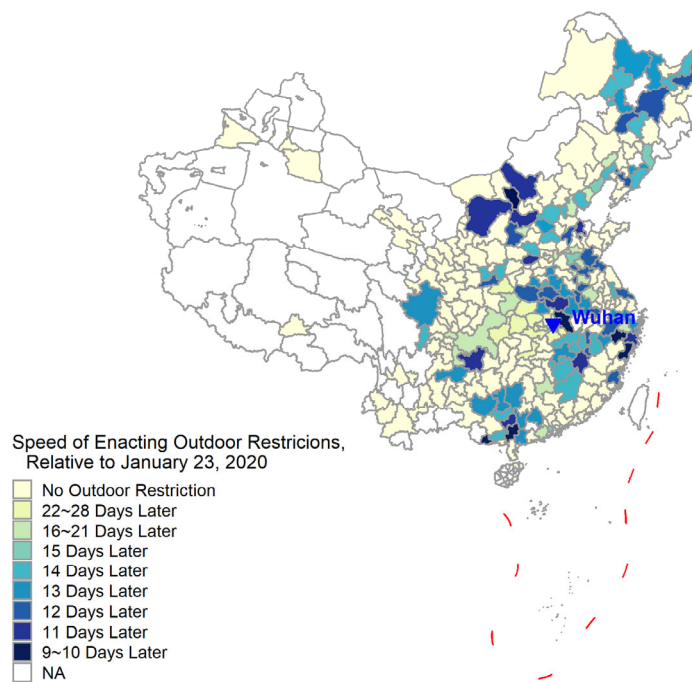


Figure 5. Speed of Outdoor Restriction Orders Across Chinese Cities, Relative to January 23, 2020

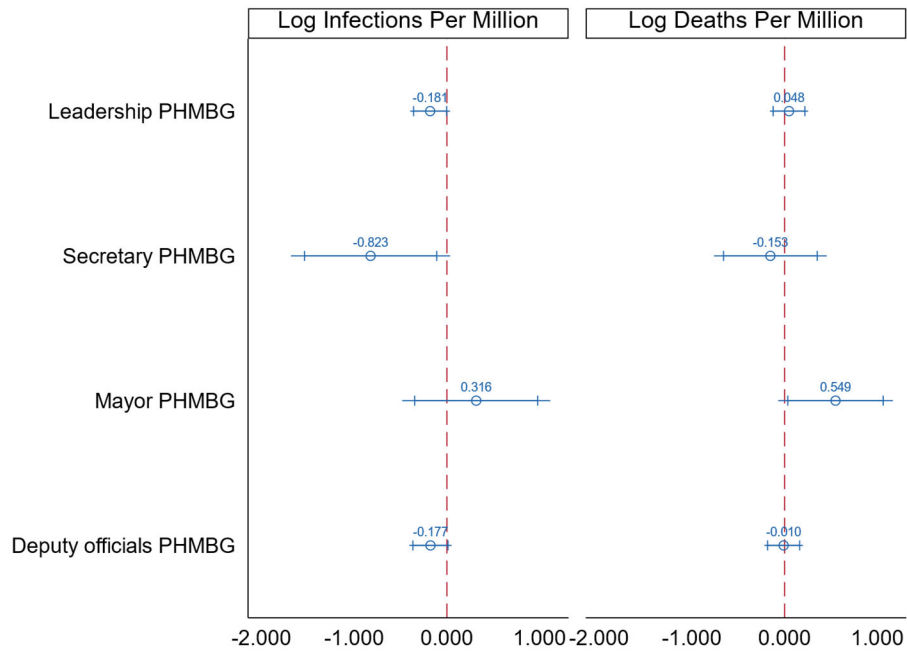


Figure 6. Effects of Leadership PHMBG on COVID-19 Infections and Deaths, Wuhan City Excluded
 Note: Estimates correspond to Table 2. Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed.

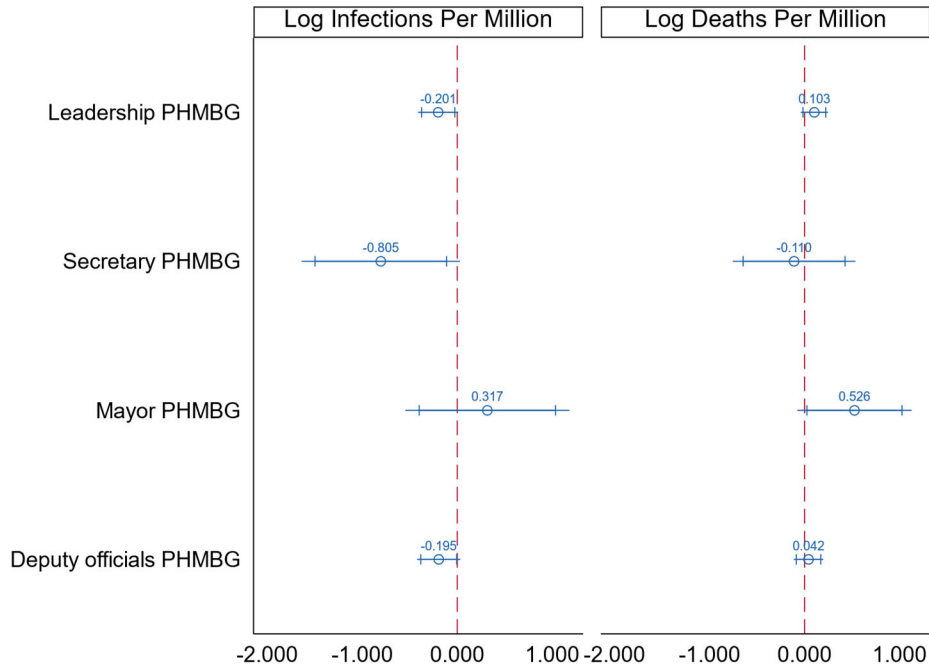
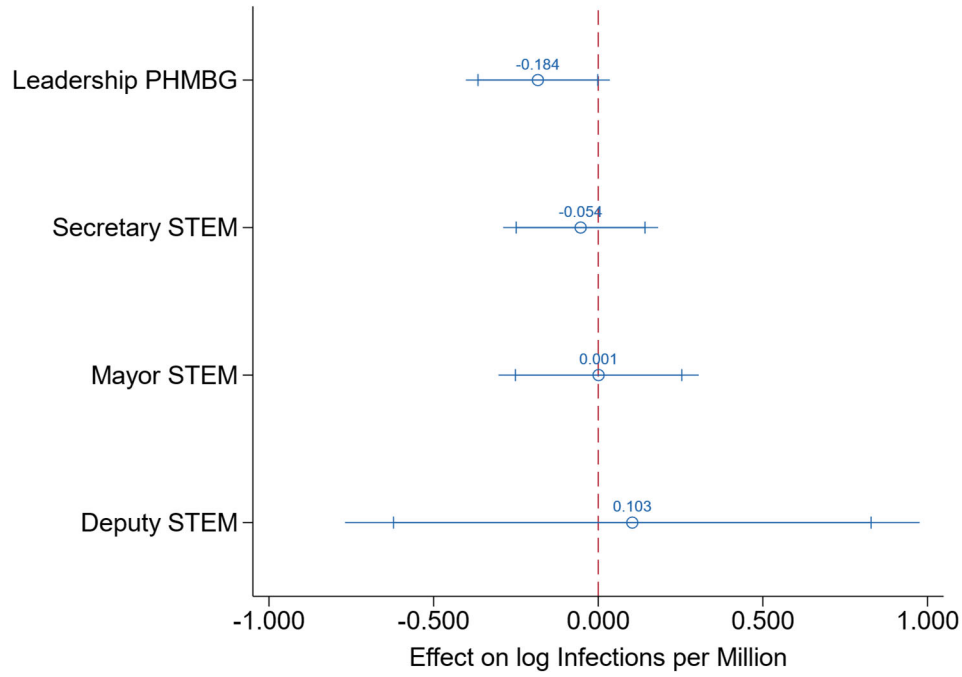
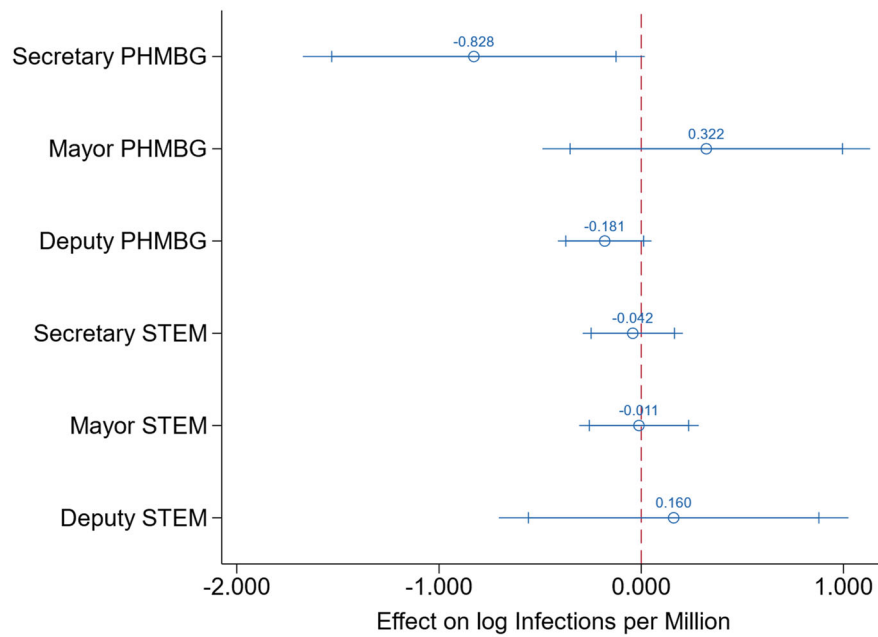


Figure 7. Effects of Leadership PHMBG on COVID-19 Infections and Deaths, Hubei Province Excluded
 Note: Estimates correspond to Table A1. Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed.

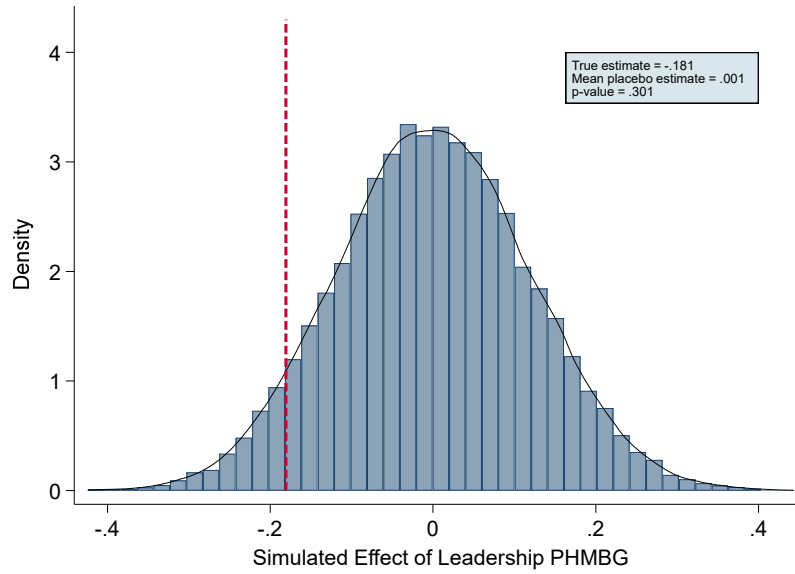


(A) Leadership's PHMBG versus Officials' STEM

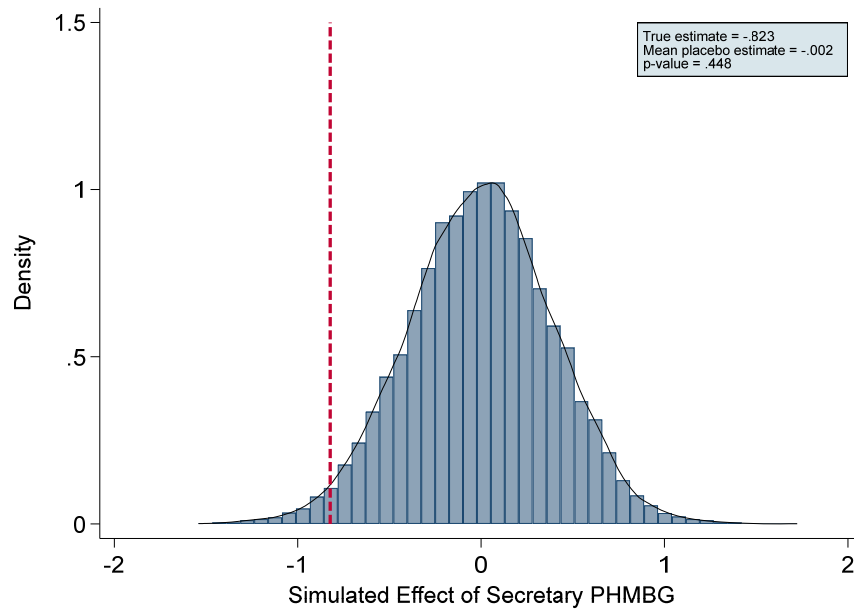


(B) Officials' PHMBG versus Officials' STEM

Figure 8. The Role of PHMBG and STEM Backgrounds in Containing Infections, Wuhan City Excluded
 Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed. Deputy here includes both deputy secretaries and deputy mayors. Either of them having PHMBG is coded as 1.



(A) Permutation Test for Leadership PHMBG's Effects on Infections



(B) Permutation Test for Secretary PHMBG's Effects on Infections

Figure 9. Permutation Tests of Leadership and Secretary PHMBG's Effects on Infections, Wuhan City Excluded
 Note: Counterfactual PHMBG effects are generated by 20,000 simulations. The vertical dashed lines denote true effects estimated in Table 2.

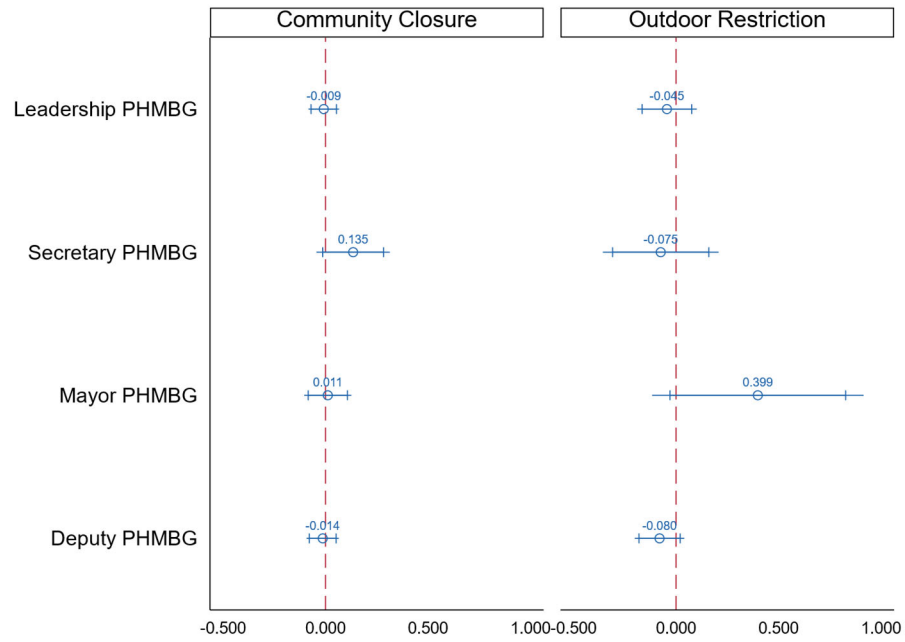


Figure 10. Effects of PHMBG on Policy Adoption, Wuhan City Excluded

Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed. Policy adoption is a binary choice variable. Deputy here includes both deputy secretaries and deputy mayors. Either of them having PHMBG is coded as 1.

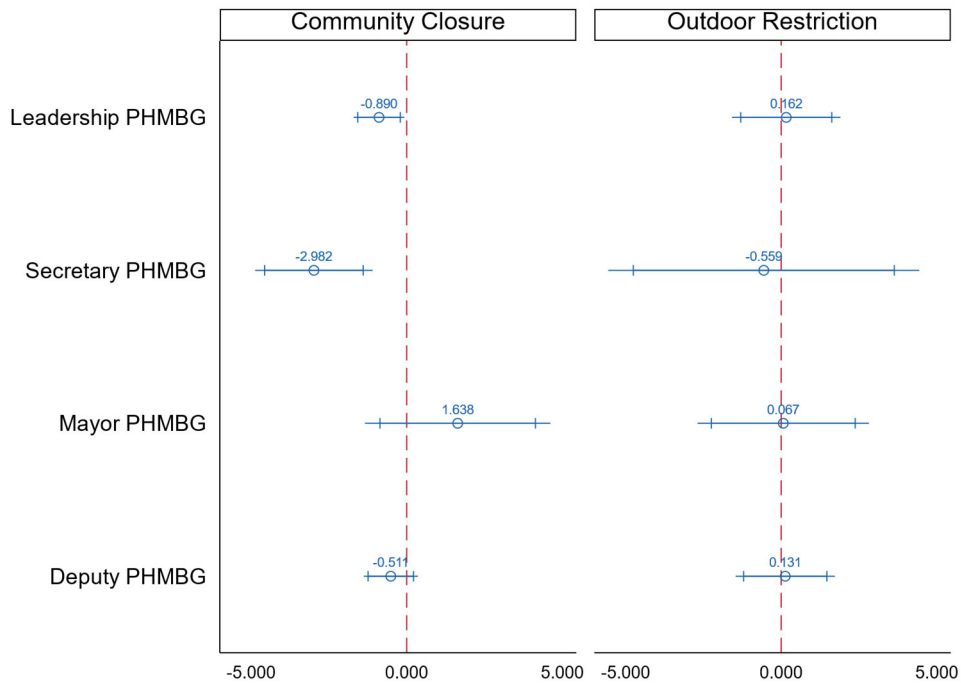


Figure 11. Effects of PHMBG on Policy Speed (Relative to January 23, 2020), Wuhan City Excluded
 Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed. Deputy here includes both deputy secretaries and deputy mayors. Either of them having PHMBG is coded as 1.

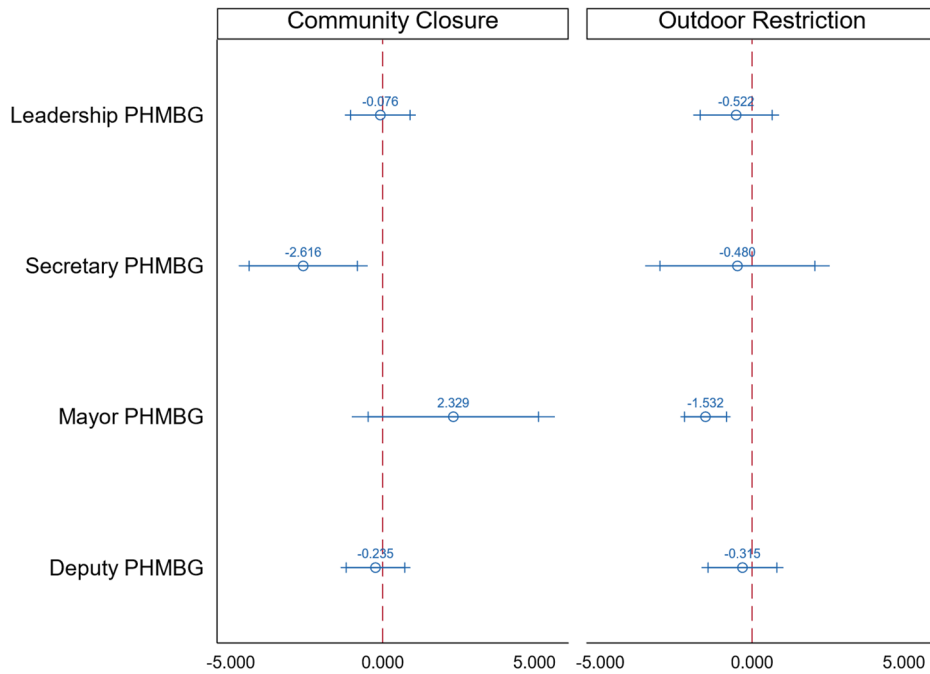


Figure 12. Effects of PHMBG on Policy Speed (Relative to First Case Date), Wuhan City Excluded
 Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed. Deputy here includes both deputy secretaries and deputy mayors. Either of them having PHMBG is coded as 1.

TABLES

Table 1: Summary Statistics

	Leaderships w/PHMBG					Leaderships w/o PHMBG				
	N	Mean	Std. Dev.	Min.	Max.	N	Mean	Std. Dev.	Min.	Max.
Panel A. Outcomes										
Infections per million	73	89.438	183.034	1	1009	221	108.783	365.420	1	3452
Deaths per million	73	0.875	2.218	0.095	13.993	221	1.281	4.621	0.083	54.054
Days to community closure	61	13.803	3.341	5	26	179	14.464	3.420	6	28
Days to outdoor restriction	27	14.667	4.288	10	24	95	14.568	3.844	9	28
Panel B. City Covariates										
GDP per capita	73	63070.277	43986.919	2.389	189568	221	54235.110	32204.516	1.141	181486
Doctors per 10k	73	1.283	1.326	0.017	7.636	221	1.037	1.038	0.138	10.938
Population density	73	432.981	361.147	9.049	1777.670	221	433.423	374.635	10.250	3444.092
Population flow from Wuhan	73	0.247	0.998	0	6.433	221	0.353	1.878	0	19.786
Average AQI 2015-2019	73	65.077	17.129	42.051	117.830	221	68.509	18.669	28.589	113.108
Panel C. Weather Variables										
Wind speed (m/s)	73	2.340	0.821	0.910	4.471	221	2.370	0.739	1.013	5.114
Temperature (°C)	73	11.836	6.879	-7.032	23.440	221	11.071	7.123	-10.455	26.244
Precipitation (mm)	73	0.286	0.615	0	4.197	221	0.200	0.336	0	4.197
Panel D. Leader Covariates										
Female secretary	73	0.055	0.229	0	1	221	0.032	0.176	0	1
Female mayor	73	0.041	0.200	0	1	221	0.072	0.260	0	1
Secretary's age	73	54.904	3.516	40	61	221	56.005	2.645	45	65
Mayor's age	73	53.288	3.541	44	61	221	52.819	3.738	44	60
Secretary's tenure	73	2.425	1.674	0	7	221	2.679	1.719	0	9
Mayor's tenure	73	2.438	1.509	0	7	221	2.588	1.662	0	9
Secretary's education (1-4)	73	2.795	0.440	1	3	221	2.760	0.469	1	4
Mayor's education (1-4)	73	2.781	0.479	1	3	221	2.783	0.455	1	3

Table 2: Effects of PHMBG on COVID-19 Infections and Deaths, Wuhan City Excluded

	log Infections per Million		log Deaths per Million	
	(1)	(2)	(3)	(4)
Leadership PHMBG	-0.181 (0.105) * [0.103]* {0.115}		0.048 (0.101) [0.091] {0.065}	
Secretary PHMBG		-0.823 (0.420) * [0.202]*** {0.281}***		-0.153 (0.297) [0.225] {0.220}
Mayor PHMBG		0.316 (0.391) [0.332] {0.390}		0.549 (0.303) * [0.291]* {0.276}**
Deputy PHMBG		-0.177 (0.112) [0.103]* {0.106}*		-0.010 (0.102) [0.098] {0.060}

Note: This table reports coefficients on key independent variables. All regressions control for province fixed effects. Robust standard errors clustered at province level are reported in the parentheses. For key independent variables, official PHMBG, two additional types of standard errors are reported. Distance-based spatial standard errors are reported in brackets, where cities at a distance over 300km are assumed independent. Network-based spatial standard errors are reported in braces, where province adjacency is modeled to account for spatial correlation.

* p < 0.1, ** p < 0.05, *** p < 0.01

Table 2-Continued: Effects of PHMBG on COVID-19 Infections and Deaths, Wuhan City Excluded

	log Infections per Million		log Deaths per Million	
	(1)	(2)	(3)	(4)
<i>City Covariates:</i>				
log GDP per capita	0.045 (0.032)	0.042 (0.031)	0.029 (0.022)	0.025 (0.022)
Doctors per 10k	0.276*** (0.077)	0.277*** (0.076)	-0.346*** (0.099)	-0.330*** (0.098)
Population density	4.934** (2.358)	5.311** (2.506)	-0.197 (1.437)	-0.021 (1.304)
% Population flow from Wuhan	0.008 (0.023)	0.008 (0.024)	0.036*** (0.012)	0.036*** (0.012)
AverageAQI	-0.008 (0.006)	-0.009 (0.006)	-0.004 (0.005)	-0.006 (0.005)
<i>Weather:</i>				
Wind speed	0.200 (0.124)	0.211 (0.126)	0.151* (0.081)	0.156* (0.082)
Temperature	0.029 (0.031)	0.032 (0.031)	0.017 (0.021)	0.020 (0.021)
Precipitation	-0.051 (0.048)	-0.069 (0.042)	-0.018 (0.060)	-0.030 (0.052)
<i>Leader covariates:</i>				
Female secretary	-0.048 (0.246)	-0.056 (0.245)	-0.155 (0.191)	-0.137 (0.191)
Female mayor	-0.074 (0.193)	-0.068 (0.195)	0.136 (0.107)	0.113 (0.115)
Secretary age (50, 55)	0.092 (0.264)	0.104 (0.272)	0.197 (0.162)	0.181 (0.163)
Secretary age ≥ 55	0.032 (0.358)	0.047 (0.370)	0.100 (0.187)	0.074 (0.196)
Mayor age (50, 55)	0.140 (0.150)	0.127 (0.148)	0.085 (0.091)	0.084 (0.091)
Mayor age ≥ 55	0.141 (0.171)	0.112 (0.173)	0.077 (0.102)	0.057 (0.106)
Secretary tenure (4, 5)	-0.077 (0.130)	-0.067 (0.130)	-0.079 (0.096)	-0.073 (0.085)
Secretary tenure ≥ 6	-0.114 (0.185)	-0.114 (0.185)	-0.239 (0.216)	-0.219 (0.206)
Mayor tenure (4, 5)	0.052 (0.135)	0.042 (0.139)	0.104 (0.098)	0.114 (0.098)
Mayor tenure ≥ 6	-0.685*** (0.210)	-0.713*** (0.209)	-0.185 (0.114)	-0.183 (0.117)
Secretary Bachelor	0.261 (0.233)	0.227 (0.211)	0.131 (0.339)	0.094 (0.319)
Secretary Master	0.198 (0.169)	0.178 (0.155)	0.027 (0.326)	0.013 (0.308)
Secretary Doctorate	-0.102 (0.307)	-0.128 (0.311)	0.461 (0.465)	0.422 (0.451)
Mayor Bachelor	0.131 (0.392)	0.126 (0.395)	-0.282* (0.152)	-0.283* (0.151)
Mayor Master	0.165 (0.338)	0.156 (0.341)	-0.210 (0.157)	-0.218 (0.155)
Observations	294	294	294	294
R squared	0.719	0.724	0.756	0.760

Note: This table continues Table 2 and reports coefficients on other independent variables. All regressions control for province fixed effects. Robust standard errors clustered at province level are reported in the parentheses. Official age is binned into three groups, below 50, between 50 and 55, and above 55 (reference group). Official tenure is binned into three groups, below 3 years, between 4 and 5 years, and above 5 years (reference group). Dummy variables for junior college, bachelor, master, and doctorate education are included for both secretaries and mayors, where junior college is the omitted group. There is no mayor having a doctorate.

* p < 0.1, ** p < 0.05, *** p < 0.01

APPENDIX: RESULTS AFTER EXCLUDING HUBEI PROVINCE

In the main text, we present results excluding Wuhan. In this appendix section, we replicate all analyses excluding all cities in Hubei Province, which leaves us 278 cities.

Table A1: Effects of PHMBG on COVID-19 Infections and Deaths, *Hubei Province Excluded*

	log Infections per Million		log Deaths per Million	
	(1)	(2)	(3)	(4)
Leadership PHMBG	-0.201 (0.103)* [0.101]** {0.129}		0.103 (0.070) [0.084] {0.085}	
Secretary PHMBG		-0.805 (0.407)* [0.187]** {0.254}***		-0.110 (0.316) [0.202] {0.204}
Mayor PHMBG		0.317 (0.422) [0.364] {0.399}		0.526 (0.294)* [0.293]* {0.250}**
Deputy PHMBG		-0.195* (0.111) [0.101]* {0.116}*		0.042 (0.076) [0.091] {0.077}

Note: This table reports coefficients on key independent variables. All regressions control for province fixed effects. Robust standard errors clustered at province level are reported in the parentheses. For key independent variables, official PHMBG, two additional types of standard errors are reported. Distance-based spatial standard errors are reported in brackets, where cities at a distance over 300km are assumed independent. Network-based spatial standard errors are reported in braces, where province adjacency is modeled to account for spatial correlation.

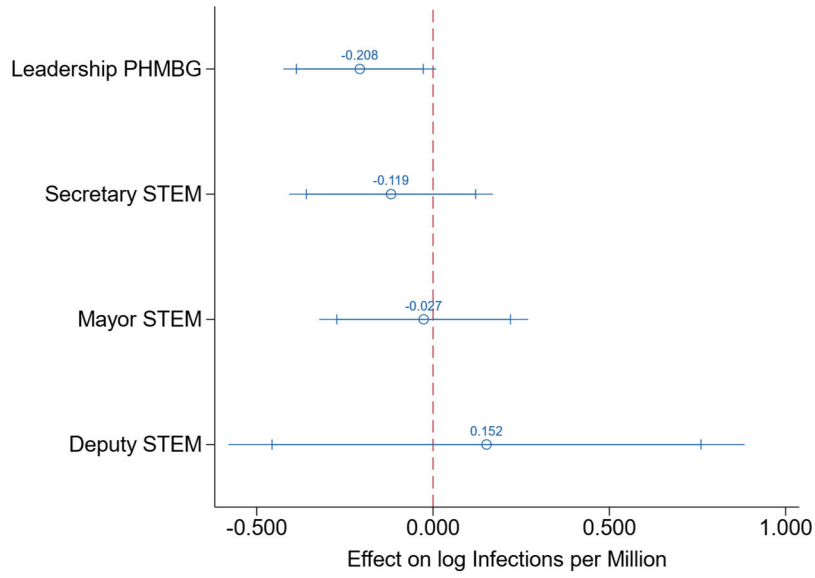
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A1-Continued: Effects of PHMBG on COVID-19 Infections and Deaths, *Hubei Province Excluded*

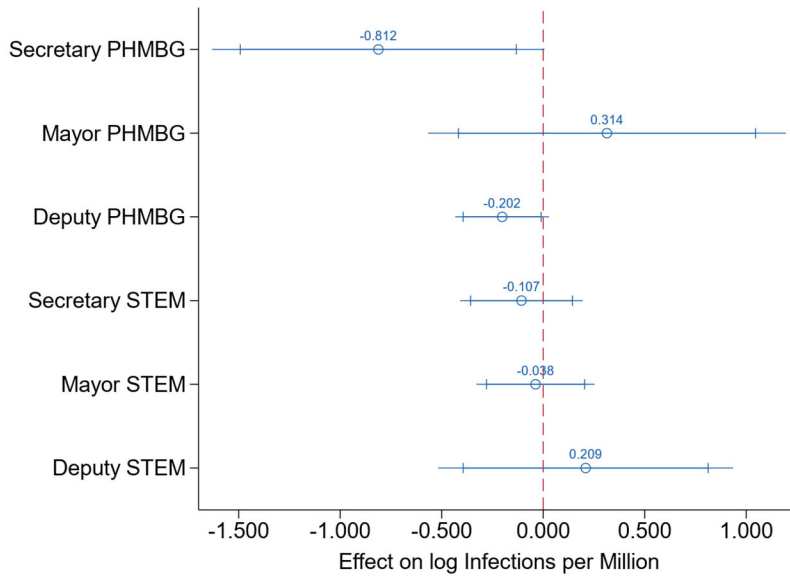
	log Infections per Million		log Deaths per Million	
	(1)	(2)	(3)	(4)
<i>City Covariates:</i>				
log GDP per capita	0.042 (0.040)	0.037 (0.039)	0.023 (0.024)	0.018 (0.024)
Doctors per 10k	0.105* (0.056)	0.107* (0.055)	-0.387*** (0.110)	-0.374*** (0.111)
Population density	4.039 (2.640)	4.425 (2.829)	-0.885 (1.212)	-0.671 (1.083)
% Population flow from Wuhan	3.574*** (0.902)	3.556*** (0.889)	1.130 (1.136)	1.162 (1.149)
Average AQI	-0.005 (0.006)	-0.006 (0.006)	-0.005 (0.004)	-0.006 (0.004)
<i>Weather:</i>				
Wind speed	0.158 (0.114)	0.169 (0.116)	0.112 (0.072)	0.116 (0.073)
Temperature	0.020 (0.028)	0.023 (0.028)	0.016 (0.022)	0.019 (0.022)
Precipitation	-0.047 (0.041)	-0.067 (0.048)	0.002 (0.051)	-0.007 (0.044)
<i>Leader Covariates:</i>				
Female secretary	-0.114 (0.224)	-0.117 (0.225)	-0.245 (0.203)	-0.219 (0.205)
Female mayor	-0.152 (0.173)	-0.148 (0.179)	0.114 (0.110)	0.091 (0.116)
Secretary age (50, 55)	0.154 (0.294)	0.162 (0.305)	0.294* (0.153)	0.273* (0.157)
Secretary age ≥ 55	0.097 (0.357)	0.109 (0.375)	0.209 (0.149)	0.177 (0.167)
Mayor age (50, 55)	0.122 (0.162)	0.109 (0.161)	0.093 (0.085)	0.088 (0.085)
Mayor age ≥ 55	0.135 (0.171)	0.107 (0.176)	0.101 (0.090)	0.080 (0.094)
Secretary tenure (4, 5)	-0.037 (0.138)	-0.026 (0.137)	-0.079 (0.105)	-0.071 (0.093)
Secretary tenure ≥ 6	-0.171 (0.190)	-0.170 (0.193)	-0.377** (0.177)	-0.354** (0.168)
Mayor tenure (4, 5)	0.037 (0.140)	0.026 (0.143)	0.149* (0.084)	0.156* (0.084)
Mayor tenure ≥ 6	-0.695*** (0.221)	-0.724*** (0.224)	-0.176 (0.116)	-0.176 (0.117)
Secretary Bachelor	-0.006 (0.253)	-0.035 (0.233)	0.194 (0.474)	0.168 (0.451)
Secretary Master	-0.022 (0.202)	-0.036 (0.198)	0.117 (0.458)	0.114 (0.438)
Secretary Doctorate	-0.315 (0.323)	-0.337 (0.327)	0.643 (0.562)	0.614 (0.542)
Mayor Bachelor	0.529 (0.638)	0.534 (0.633)	-0.423 (0.310)	-0.413 (0.321)
Mayor Master	0.457 (0.625)	0.458 (0.623)	-0.438 (0.309)	-0.432 (0.322)
Observations	278	278	278	278
R squared	0.537	0.546	0.502	0.510

Note: This table continues Table 2 and reports coefficients on other independent variables. All regressions control for province fixed effects. Robust standard errors clustered at province level are reported in the parentheses. Official age is binned into three groups, below 50, between 50 and 55, and above 55 (reference group). Official tenure is binned into three groups, below 3 years, between 4 and 5 years, and above 5 years (reference group). Dummy variables for junior college, bachelor, master, and doctorate education are included for both secretaries and mayors, where junior college is the omitted group. There is no mayor having a doctorate.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

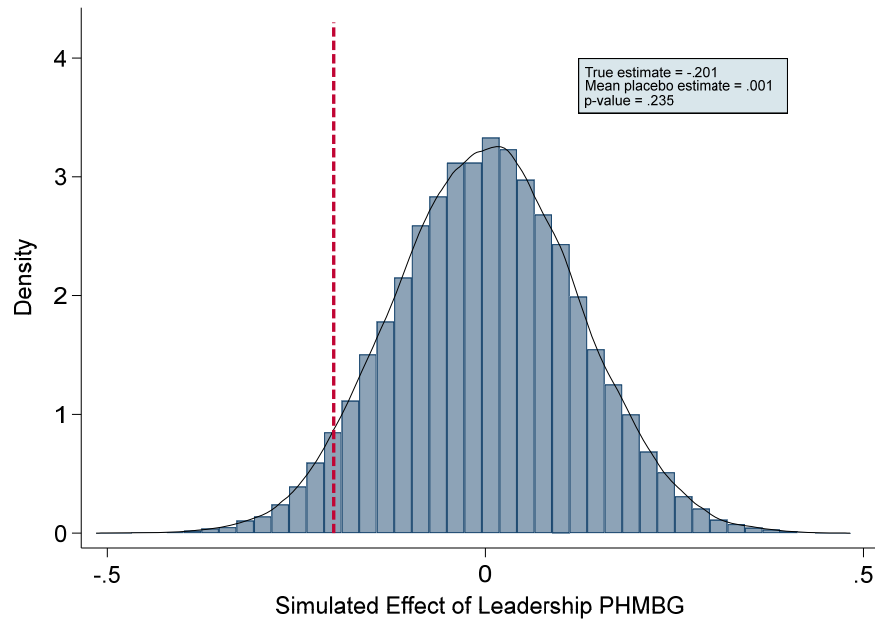


(A) Leadership's PHMBG versus Officials' STEM

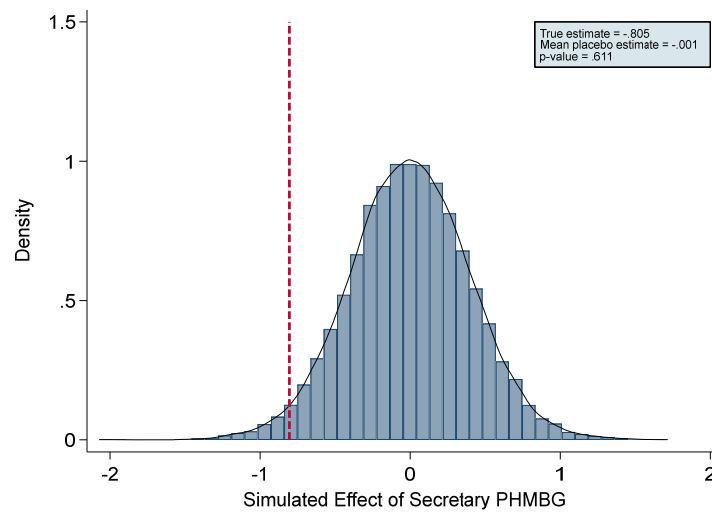


(B) Officials' PHMBG versus Officials' STEM

Figure A1. The Role of PHMBG and STEM Backgrounds in Containing Infections, *Hubei Province Excluded*
 Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed.



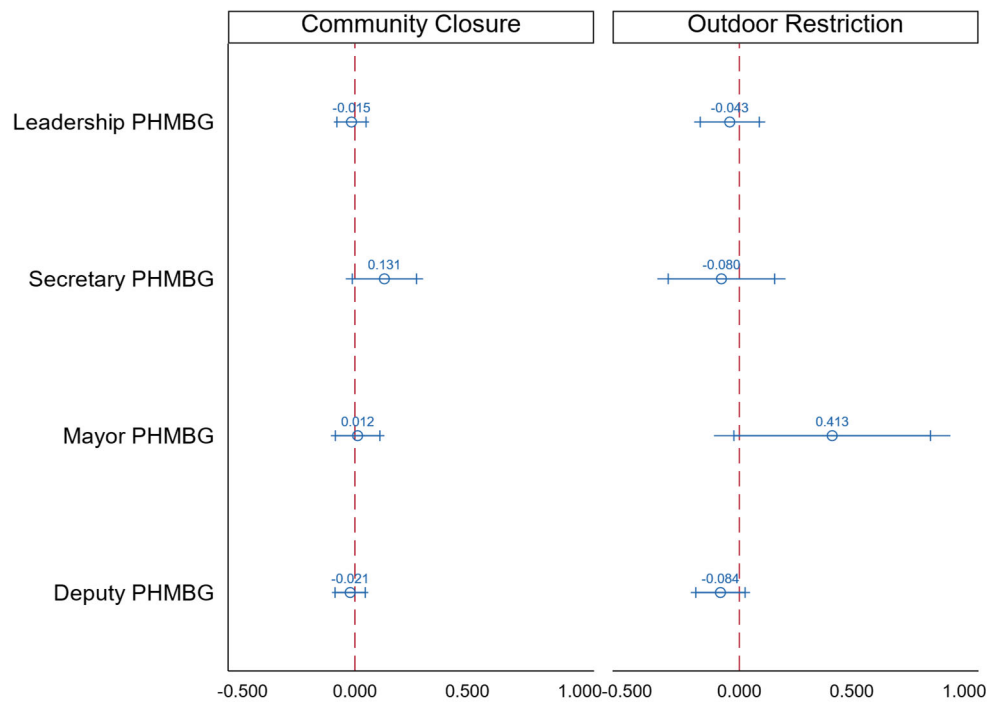
(A) Permutation Test for Leadership PHMBG's Effects on Infections



(B) Permutation Test for Secretary PHMBG's Effects on Infections

Figure A2. Permutation Tests of Leadership and Secretary PHMBG's Effects on Infections, Hubei Province Excluded

Note: Counterfactual PHMBG effects are generated by 20,000 simulations. The vertical dashed lines denote true effects estimated in Table 3.



#

#

Figure A3. Effects of PHMBG on Policy Adoption, Hubei Province Excluded
 Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed.
 Policy adoption is a binary choice variable.

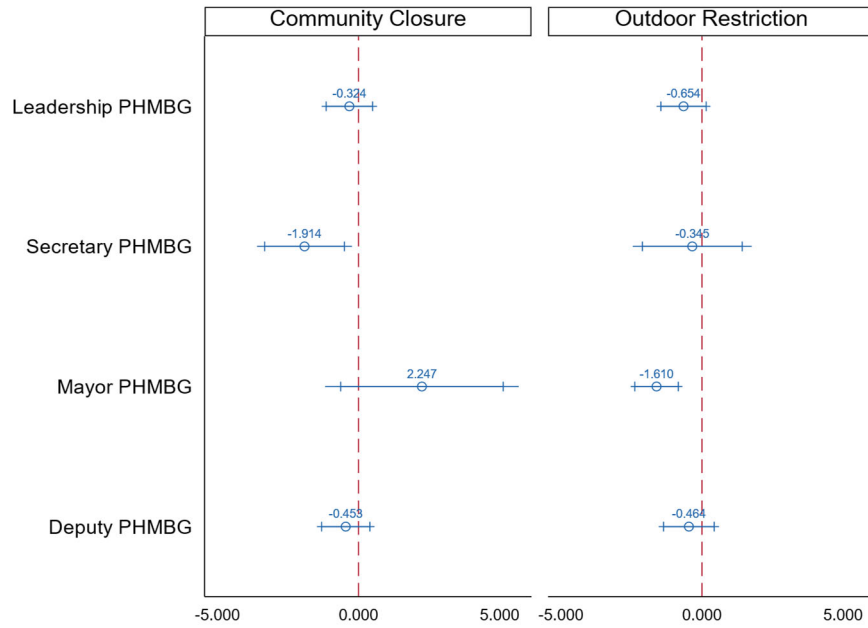


Figure A4. Effects of PHMBG on Policy Speed (Relative to January 23, 2020), Hubei Province Excluded
 Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed.

 #
 #

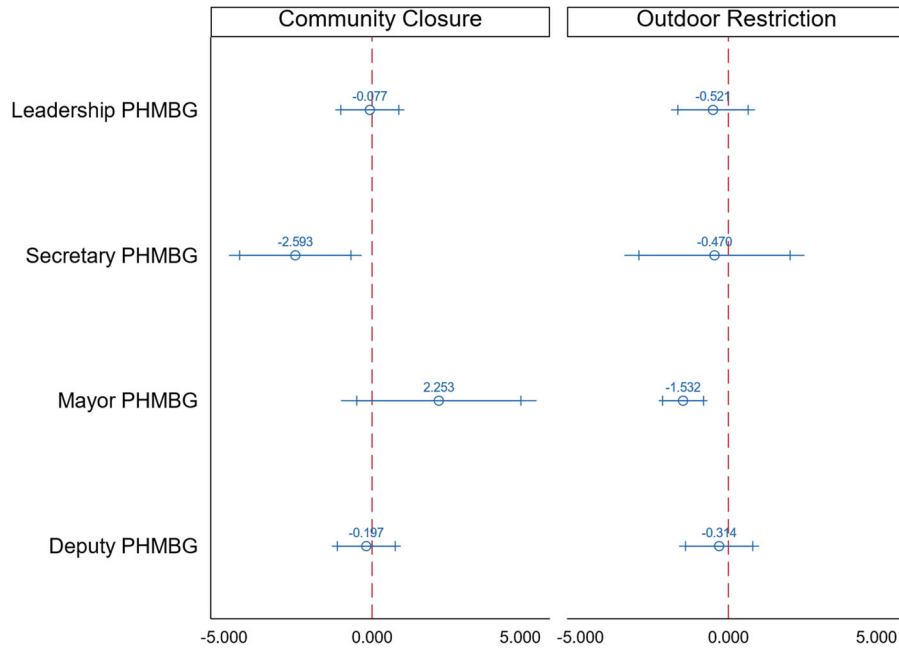


Figure A5. Effects of PHMBG on Policy Speed (Relative to First Case Date), Hubei Province Excluded
 Note: Both 90 (short caps) and 95 percent (long lines) confidence intervals are displayed.