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Do bigger health budgets cushion pandemics?

An empirical test of COVID-19 deaths across the world

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Abstract: How has government healthcare spending prepared countries for tackling the COVID-19 pandemic? Arguably, spending is the primary policy tool of governments in providing effective health. We argue that the effectiveness of spending in reducing COVID deaths is conditional on the existence of healthcare equity and lower political corruption, because the health sector is particularly susceptible to political spending. Our results, obtained using ordinary least squares (OLS) and two-stage least squares (2SLS) estimation, suggest that higher spending targeted at reducing inequitable access to health has reduced COVID deaths. Consistent with the findings of others, our results indirectly suggest that health spending is necessary, but not sufficient unless accompanied by building resilience against the spread of deadly disease. Equitable health systems ease the effects of COVID presumably because they allow states to reach and treat people. Spending aimed at increasing health system capacity by increasing access thus seems a sound strategy for fighting the spread of disease, ultimately benefiting us all.

Key words: COVID-19, healthcare spending, corruption, healthcare equity, OLS, 2SLS

JEL classification: H51, I14, I18,

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1 Introduction

The COVID-19 pandemic has had governments across the world scrambling to devise effective strategies against the spread of the virus and prevent excess deaths. As some suggest, what we face today is a 'crisis of preparedness' (Chilton et al. 2020). Almost all governments have proclaimed increased spending to tackle the problem—arguably the primary policy instrument for governments when it comes to human health. Global financial institutions, such as the International Monetary Fund (IMF), have made available over US$1 trillion to finance COVID-related spending (IMF 2020). Does public spending on health matter for dealing with health crises, given that such spending could be easily misappropriated? As many report, spending on health does not necessarily translate into better health outcomes (Filmer and Pritchett 1999; Gallet and Doucouliagos 2017; Ray and Linden 2020). We contribute to the literature by investigating how government healthcare expenditure in the very recent past might have cushioned societies against the worst of the COVID pandemic. We suggest that the effectiveness of health spending is conditional on having an equitable healthcare system and lower political corruption, because health spending is vulnerable to rent-seeking (Deaton and Case 2020). While politicians and the public expect government spending to solve the problem, experts on public sector finance often see public spending as wasteful and/or benefiting only the rich through what is known as 'tax churning' (Tanzi 2011). We argue that the degree of effectiveness of health spending in fighting the COVID pandemic might very well be conditional on the degree to which a robust health system, in terms of capacity to reach vulnerable people, exists and on the true purpose and intent of public policy, which might be best assessed by gauging the degree of political corruption.[1]

Using a cross-section of data for 210 countries that have faced the COVID-19 pandemic up until 7 September 2020, we find clear evidence to suggest that spending on its own results in greater numbers of deaths—results that are statistically significant and substantively large. Consistent with our expectations, government spending on healthcare reduces the number of COVID-19 deaths conditional on an equitable healthcare system and lower levels of corruption. In other words, money alone compared with healthcare capacity does not help the fight against a health threat such as the COVID-19 virus. Our results demonstrate that the capacity to reach and treat enabled by equitable access matters more than the size of a country's health budget. Indirectly, thus, our study also suggests that a large healthcare budget may not always signify an effective and resilient healthcare system. The results are robust to alternative testing procedures, including the application of the instrumental-variable technique for addressing endogeneity concerns.

2 Theory and previous research

Arguably, the primary policy lever in the hands of governments for solving public health crises is to increase spending. Scholars have long debated, however, the efficacy of the public sector throwing money at problems (Tanzi 2011). Studies suggest that an increase in government spending alone will not necessarily lead to improvements in healthcare and disease outcomes, while the question of whether private spending does better than public is still debated (Deaton 2013; Filmer and Pritchett 1999; Gallet and Doucouliagos 2017; Linden and Ray 2017). While finance is

[1] We use the measure of political corruption developed by the Varieties of Democracy project (V-Dem), which captures the degree to which neo-patrimonialism, nepotism, and rent-seeking exist within a regime. We discuss the measure in detail below.

necessary to build up a resilient health system that can handle epidemics and pandemics, governments do not always target monies efficiently for such purposes, particularly when future crises can be ignored *ex ante*. Indeed, much health spending could simply be 'pork'—wasteful spending designed to buy political support rather than generate effective public policy.

A recent global study using sophisticated econometric analysis finds that the efficiency of transforming spending into better outcomes varies greatly among countries across the world (Ray and Linden 2020). An increase in spending on healthcare, therefore, is only a necessary but not a sufficient condition for improved health outcomes. If the majority of the population in a country do not have access to healthcare despite high expenditures, this might result in a high number of deaths when a pandemic hits. Similarly, high healthcare spending could reflect high levels of corruption—and corruption kills, particularly the poor and vulnerable (Hanf et al. 2011). Despite high health budgets, contingencies for dealing with crises are likely to be weak. According to the Organization for Economic Co-operation and Development (OECD), a third of OECD citizens and 45 per cent of citizens globally consider their health sectors to be corrupt (OECD 2017). Regardless, theoretically at least, a government that spends well on health is likely to be building the resilience and capacity of a health system to cope with a citizenry's health needs and with future contingencies, such as epidemics and pandemics. The United States' experience with COVID provides a cautionary tale.

The recent outbreak of the COVID pandemic has highlighted once again that high healthcare expenditure need not necessarily reflect better healthcare outcomes. For example, the US spent twice as much on healthcare as other high-income economies in 2016 but had lower health outcomes in terms of life expectancy and infant mortality rates, compared with OECD counterparts (Papanicolas et al. 2018). Indeed, the US is the only country among the industrialized countries that has recently seen its life expectancy decline, mostly due to what some term 'deaths of despair', despite having one of the world's most expensive healthcare systems: much of that expense reflects corporate corruption—political pork-barrel spending—rather than public goods (Deaton and Case 2020). Although health expenditure per person in the US is $9,237, the highest in the world, the US has experienced the largest number of COVID deaths—205,666 as of 3 October 2020 (Brink 2017; WHO 2020). Spending statistics might hide much that is relevant in such a case, however, because disparities in healthcare access can influence pandemic outcomes. Chen and Krieger (2020), in a study of the US, show that the highest COVID-19 death rates are observed for those living in the most disadvantaged counties in terms of poverty—19.3 per 100,000, compared with 9.9 per 100,000 in the most economically advantaged counties (Brink 2017; Chen and Krieger 2020). If a health system reflects inequality in access, then one might assume that a government's ability to reach and treat people, or healthcare capacity to affect the vulnerable, is limited. Similar findings have been documented for other countries. For example, spending on healthcare per person in the UK is US$3,749, but the UK has also experienced a large number of COVID deaths—42,202 per 100,000 as of 3 October 2020 (WHO 2020). The Intensive Care National Audit and Research Centre in the UK has observed that 35 per cent of approximately 2,000 patients were from non-white backgrounds with lower access to healthcare, although they comprised only 13 per cent of the total population of the UK (Booth 2020). Thus, something about reaching and treating the vulnerable (the capacity of a system) must matter.

Evidence suggests that countries that have more equal access to healthcare have been more successful in containing the virus and have experienced fewer deaths (Vadlamannati et al. 2020a). For example, in Taiwan all citizens, and foreigners who are resident in Taiwan for at least six months, are entitled to a government insurance plan. This could perhaps explain the country's low number of deaths. Similarly, Thailand, which has moved towards an universal healthcare system, had experienced only 59 deaths as of 3 October 2020, despite spending only US$400 per person on healthcare (Brink 2017). Similarly, Sri Lanka, which has a fairly well-developed public health system, has handled the COVID crisis much better than many richer countries, with only a handful of deaths and few reported cases. Thus, rather than spending levels alone, the infrastructure for accessing people might be critical to reducing the spread of disease. The recent crisis suggests that having a resilient health system that can effectively access people matters, not just for providing immunization and other everyday health services but also for stopping the spread of deadly disease.

High healthcare expenditure and low health outcomes might also signify high levels of corruption, or a political economy where governance is unresponsive to the needs of ordinary people. It is documented that approximately US$455 billion of the $7.35 trillion spent on healthcare worldwide is lost each year to some form of corruption (National Academies of Sciences, Engineering, and Medicine et al. 2018). Because corruption in the health sector can transpire in various areas, including health facility construction, the purchase of technology and equipment, the purchase of pharmaceuticals, and provision of healthcare services, among others, corruption levels in this sector can be particularly high (Vian 2008). One study reports that 1.6 per cent of annual deaths of children under five globally, which is more than 140,000 deaths, might be explained in part by corruption (Hanf et al. 2011). The IMF estimates that infant and child mortality rates in countries with high levels of corruption are almost double those of countries with low levels of corruption (Gupta et al. 2000). Concerns of a comparable nature have been highlighted by a Berlin-based anti-fraud consulting firm, Nemexis, with regard to the recent COVID outbreak. Nemexis finds that fraud and corruption in healthcare services have contributed to COVID-related deaths in one in three of the 58 countries surveyed (Medcity News 2020).

We argue that health spending is likely to be effective only if healthcare is being distributed equitably. What matters is not specifically equity *per se* but the capacity to access people: by following pro-poor strategies, states are likely to have built up health provision capacity by being able to reach and treat people. We argue, thus, that health spending is likely to reduce the impact of COVID only when conditioned by an effective health system as measured by the degree of equitable access. Similarly, health spending should have the most effective impact when accompanied by low political corruption. We contribute to the literature by showing that: (1) high healthcare expenditure by the government does not necessarily lead to better outcomes in terms of preventing COVID deaths unless accompanied by greater equity in healthcare access, which essentially proxies for health system capacity and reach; (2) high healthcare expenditure could suggest high levels of corruption, leading to a higher number of COVID deaths. The findings of our study will have important implications for policy, as limited access to health services and corruption in politics affect all processes and systems in place to fight disease.

3 Data and methods

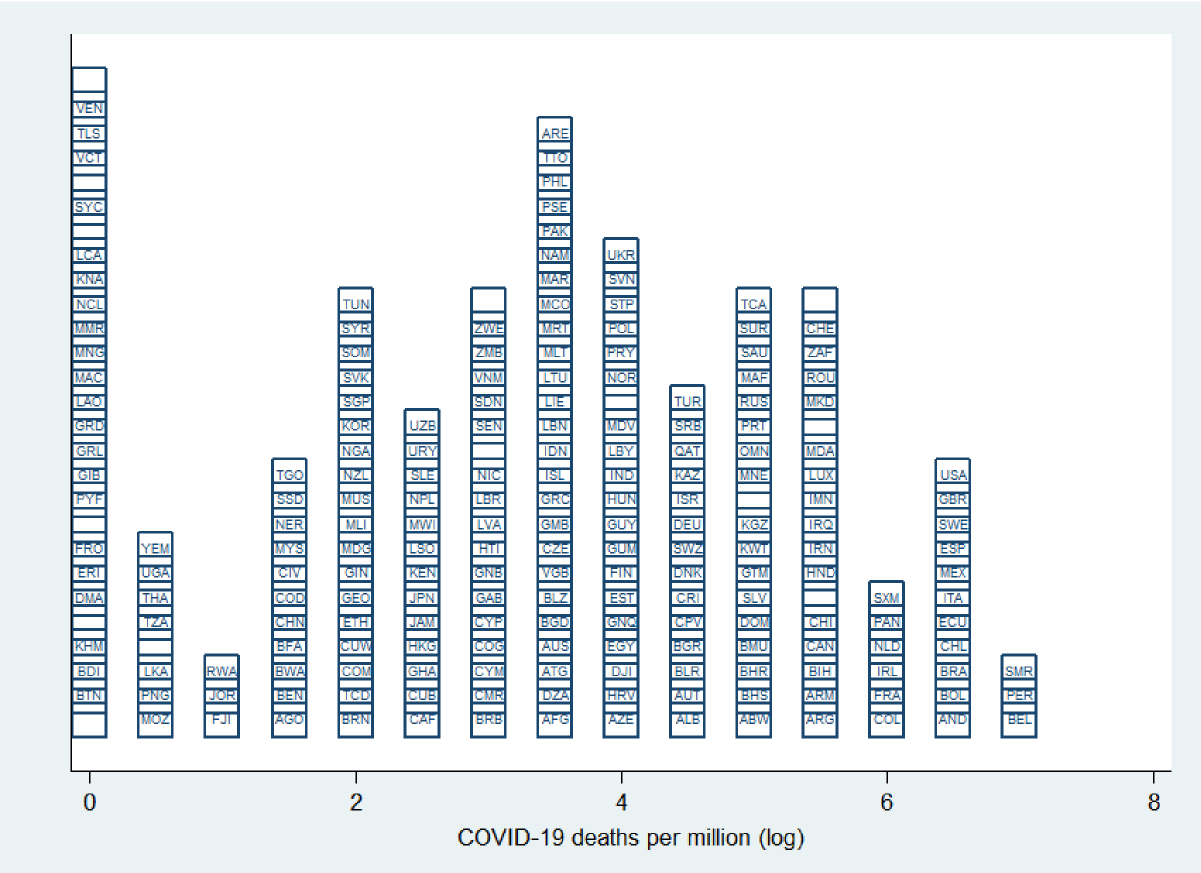
3.1 Model specifications

To examine our theoretical propositions, we utilize a cross-sectional dataset containing 213 countries for which COVID-19 death rates are reported as of 7 September 2020 when we began this study. We estimate:

$$\boldsymbol{ln(Covid)_c = \varphi_c + \beta GHS/GDP_c + \beta Z_c + \lambda_r + \omega_c} \quad (1)$$

wherein $\boldsymbol{ln\ (COVID)_c}$ captures COVID-19 deaths per million (log) in country $\boldsymbol{c}$ as of 7 September 2020 sourced from the Worldometer COVID-19 data, which is an ongoing data collection project, manually sourcing real-time information on the COVID-19 pandemic from various countries across the world.[2] Global COVID-19 live statistics are generated by analysing, validating, and aggregating the data collected from various sources.[3] The mean value of COVID-19 deaths in our sample is 108 per million, while the standard deviation is 187 per million, which shows the wide variation in the way in which this disease has impacted on numbers of deaths. The maximum value of deaths is roughly 1,237 per million and the minimum value 0 per million. Figure 1 captures COVID-19 deaths per million across the world as of 7 September 2020. The strip plot in Figure 1 suggests significant variation in the number of COVID deaths across countries. Appendix Table A2 provides a full list of countries with the number of COVID-19 deaths and deaths per million for each country.

Figure 1: COVID-19 deaths per million (log) globally, as of 7 September 2020



Source: authors' construction based on Worldometer (2020).

The hypothesis variable denoted as ***GHS/GDP$_c$*** measures the level of government spending on healthcare as a share of GDP in country ***c***, sourced from the World Bank's 2019 World Development Indicators (WDIs; see World Bank 2020). Average government spending on health as a share of GDP in our sample is roughly 3.4 per cent, with a minimum value of 0.18 per cent (Venezuela) and a maximum of 9.22 per cent (Sweden).

[2] For the data and information on the methodology adopted in data collection, see Worldometer (2020).

[3] We choose Worldometer COVID-19 data over other sources such as the European Centre for Disease Prevention and Control, the Oxford COVID-19 Government Response Tracker (OxCGRT), or OurWorldInData.org published by Roser et al. (2020) because of its coverage and usage. The COVID data are available for 210 countries and these data are used by governments and prominent news outlets, including the UK government, the BBC, *The New York Times*, and *Financial Times*, among others.

The vector of control variables $\boldsymbol{Z_c}$ includes other potential determinants of COVID-19 outcomes, which we obtain from the literature emerging on the subject (Cepaluni et al. 2020; Chen and Krieger 2020; Vadlamannati et al. 2020a, b). The list of potential control variables is long, and we are aware of the trap of 'garbage-can models' in which numerous variables are lumped onto the right-hand side of the equation, making meaningful interpretation of results difficult (Achen 2005). Therefore, we adopt a conservative strategy of accounting only for key factors that affect COVID-19 outcomes. However, in robustness checks we add several more controls. Accordingly, we include the level of development measured as *per capita income* in US$ 2010 constant prices obtained from the WDI. Income level has a bearing on COVID-19 deaths via its impact on health spending, since richer countries should have higher government spending on healthcare. Next, we also include a measure of *urbanization* (percentage share of urban population), as studies show that transmission of COVID cases is high in urban centres, and the degree of urbanicity could influence the degree of health spending. We also control for *democracy* using the Freedom House index of civil and political liberties (Freedom House 2020). We take the average of civil and political liberties and rescale them on a 1–7 range in which a value of 1 denotes a complete absence of civil and political liberties and 7 denotes the highest score for their presence.[4] Previous studies on COVID-19 have found that democratic countries have experienced deaths on a larger scale and sooner than non-democratic countries, and it is well known that democracies spend more on public goods. Finally, we also include a measure of life expectancy at age 60, which reflects the mortality level of a population in country $\boldsymbol{c}$, sourced from the data platform of the World Health Organization (WHO).[5] This variable captures the vulnerability of the population because elderly populations with comorbidities are less likely to survive the virus (Jordan et al. 2020).

It should be noted that we use the previous-five-year averages (2014–18) of each of these variables. The descriptive statistics are provided in Appendix Table A3 and the details on definitions and data sources are provided in Appendix Table A4. We use an ordinary least squares (OLS) estimation specification with Huber–White-corrected robust standard errors, a method which is robust to heteroskedasticity (Wiggins 1999). We also include geographic regional dummies ($\boldsymbol{\lambda_r}$) to account for differences in susceptibility to viruses based on geographic factors.

3.2 Endogeneity

It is quite plausible that our measure of government health expenditure is an outcome rather than a cause of COVID-19. Even though we use previous-five-year averages, COVID-19 might be more deadly compared with other viruses, potentially biasing any result on the link between spending and deaths. This issue is not trivial, because those who argue that government health spending impacts how the system responds to health pandemics also make causal claims that health spending by governments is an outcome of health pandemics (Lafortune 2020). Furthermore, government health spending could reflect other factors that explain COVID-19 outcomes, such as budgetary constraints, and state capacity in terms of administrative efficiency and reach of the healthcare system. To address the problem of endogeneity, we utilize a two-stage least squares instrumental-variable (2SLS-IV hereafter) estimator including the control variables discussed above along with geographic regional dummies. We use *average public sector health spending as a share of GDP of geographic neighbours of country* $\boldsymbol{c}$ as our instrument. The validity of the instrument depends

[4] Using V-Dem's electoral democracy index and the Polity IV index, which are highly correlated with the Freedom House measure, does not alter our basic results.

[5] According to the WHO, this variable measures the average number of years a person aged 60 could expect to live, if she or he were to pass through life exposed to the sex- and age-specific death rates prevailing at the time when they are aged 60, for a specific year in country c. See WHO (no date).

on two conditions. First, it must pass instrument relevance, which is to say that the selected instrument must be correlated with the explanatory variable. It is customary to accept instrument relevance if the joint F-statistic in the first-stage regression is above 10 (Bound et al. 1995). We also apply a more powerful test, namely the Kleibergen-Paap F-statistic, which offers reliable statistical inferences in a weak instrument setting (Kleibergen and Paap 2006). Once again, the null of weak instruments can be rejected if the F-statistic is above the critical value of 10. Second, the selected instrument should not differ systematically from the error term in the second stage of the equation, i.e. $[\omega_{it} \mid IV_{it}] = 0$, meaning that the selected instrument should not be correlated with the outcome variable of interest—COVID-19 deaths—except through health spending.

We believe our instrument satisfies the exclusion restriction based on the following logic: previous studies find a strong correlation between health spending of a country and that of its geographic neighbours. A rationale for this is that if neighbouring countries have better health outcomes as a result of higher spending on healthcare services, it influences the discourse on the healthcare system in the country in question and presents an opportunity to learn, if not imitate, their neighbours. Research suggests that governments of neighbouring countries often coordinate their health policies to achieve similar goals for their citizens, such as the prevention of contagious diseases (Baltagi et al. 2012; Benos et al. 2019). It should be noted that this instrument has been used in previous studies on government spending on health (Benos et al. 2019; Filmer and Pritchett 1999; Wagstaff and Claeson 2004). If neighbourhood spillover occurs for health spending, deaths from COVID would not necessarily occur similarly due to spillover across borders, given the restrictions on travel and other lockdown measures. The first-stage regression results are reported in Table 1. We find a strong positive effect of our selected instrument on government health spending, which is significantly different from zero at the 1 per cent level. Furthermore, the joint F-statistic from the first stage rejects the null that our selected instrument is not relevant. In fact, we obtained a higher joint F-statistic and a Kleibergen-Paap Lagrange Multiplier (LM) statistic on both estimation models reported in Table 1, which remain significantly different from zero at the 1 per cent level.

3.3 Interaction effects

Next, we introduce interaction terms to examine whether the effect of government health spending on COVID-19 deaths is conditional upon (1) an equitable health system and (2) the degree of political corruption. We estimate the following conditional equations:

$$\boldsymbol{ln(Covid)_c = \varphi_c + \beta(GHS/GDP \times equity)_c + \beta GHE/GDP_c + \beta equity_c + \beta Z_c + \lambda_r + \omega_c} \quad (2)$$

$$\boldsymbol{ln(Covid)_c = \varphi_c + \beta(GHS/GDP \times corrp)_c + \beta GHE/GDP_c + \beta corrp_c + \beta Z_c + \lambda_r + \omega_c} \quad (3)$$

wherein $\boldsymbol{(GHS/GDP \times equity)_c}$ is the interaction term and $\boldsymbol{equity_c}$ measures the extent of equity in healthcare in country $\boldsymbol{c}$. The V-Dem project measures the degree to which any given country at any given time provides access to adequate healthcare for the poor that is comparable with the healthcare accessed by the rich (V-Dem 2019b). The V-Dem data measure several aspects of equity to measure how equally distributed political power is in any given society, in terms of gaining access to government and to resources that empower people politically and enable all people to participate meaningfully (Coppedge et al. 2017). The V-Dem data on equity are generated by asking several country experts to score countries on the following question, scored according to the scale below:

> *To what extent is high-quality basic health guaranteed to all, sufficient to enable them to exercise their basic rights as adult citizens?*
>
> **0**: Extreme. Provision of high-quality basic health is extremely unequal and at least 75 per cent of citizens receive such low-quality health that it undermines their ability to exercise their basic rights as adult citizens.
> **1**: Unequal. Provision of high-quality basic health is extremely unequal and at least 25 per cent of citizens receive such low-quality health that it undermines their ability to exercise their basic rights as adult citizens.
> **2**: Somewhat equal. Basic health is relatively equal in quality but 10 to 25 per cent of citizens receive such low-quality health that it undermines their ability to exercise their basic rights as adult citizens.
> **3**: Relatively equal. Basic health is overall equal in quality but 5 to 10 per cent of citizens receive such low-quality health that it probably undermines their ability to exercise their basic rights as adult citizens.
> **4**: Equal. Basic health is equal in quality and less than 5 per cent of citizens receive such low-quality health that it probably undermines their ability to exercise their basic rights as adult citizens.

The V-Dem Project codes health equality by consulting numerous country and regional experts, who make subjective judgements about the level of access to healthcare of the poorest segments of society compared with the richest segments. This expert coding is then subject to rigorous scrutiny and testing using item response theory, which reduces uncertainty in the coding and assigns a single value to each country for each year (Pemstein et al. 2018). The data are coded as health equality ranging from −3.99 to +3.16, where higher values capture greater equity. Once again, we use the five-year average (2014–18).

In the second interaction model in Equation 3, we examine the role of political corruption ($\boldsymbol{corrp_c}$) in COVID-19 deaths per million (log). Accordingly, we use the corruption index developed by the V-Dem Project, which measures the degree of corruption within a government, measured by the existence of neo-patrimonial and clientelist predispositions within the regime taken as a whole (executive misappropriations, executive bribes, legislature and judiciary) and corruption specific to the government sector (McMann et al. 2016; Støver Toft and de Soysa 2020; V-Dem 2019a, b). The V-Dem data, as mentioned previously, are based on expert opinion, where country experts answer specific questions on corruption, such as:

> *To what extent do political actors use political office for private or political gain?*

The expert coding is then subjected to Bayesian factor analysis, specifically item response theory, to reduce intercoder bias and increasing accuracy. According to V-Dem, regime corruption is defined in the following manner:

> In systems of neo-patrimonial rule, politicians use their offices for private and/or political gain. This index relates closely to V-Dem's political corruption index (v2x_corr) but focuses on a more specific set of actors—those who occupy political offices—and a more specific set of corrupt acts that relate more closely to the conceptualization of corruption in literature on neo-patrimonial rule. (V-Dem 2019a: 274)

The corruption index is coded on a 0–1 scale in which a higher score denotes more regime corruption and a lower score denotes less corruption. As before, we use the five-year average of this index (2014–18). Again, we employ the OLS estimator robust to heteroscedasticity, including the geographic regional fixed effects, to estimate Equations 2 and 3. We generate marginal plots to assess the interaction effects and their significance (Brambor et al. 2006).

4 Empirical results

Table 1 reports the impact on COVID-19 deaths of government spending on health. While Columns 1–2 show the results estimated with OLS with basic control variables and controlling for geographic regional dummies, Columns 3–4 presents findings using the 2SLS-IV estimator to address endogeneity concerns. Table 2 presents the results of the interaction effects.

As seen in Column 1, Table 1, a higher share in GDP of government spending on health has a positive effect on reducing COVID-19 deaths, which is significantly different from zero at the 1 per cent level.

Substantively, a standard deviation increase in the spending share in health increases COVID deaths per million (logged) by roughly 22 per cent of a standard deviation of deaths per million. This effect is not inconsequential because it suggests that an additional 40.4 people per million die for each percentage-point increase in health spending. In Column 2, when we enter the controls, the positive and statistically significant effect of government spending holds, albeit at the 95 per cent level of significance. The substantive effects are reduced only slightly. These results suggest that government spending on healthcare has had the opposite effect to cushioning the pandemic. With respect to the control variables, only urban population share shows a positive and significant effect on COVID-19 deaths—results consistent with the findings of others (Chen and Krieger 2020). The results are robust across the columns in Table 1. Interestingly, income per capita, the level of democracy, and life expectancy after the age of 60 remain statistically not significant.

In Columns 3–4, we present the instrumental-variable (IV) estimations. We correct for endogeneity of health spending and deaths using an instrument to explain health expenditure. While Column 3 reports the results without any controls, Column 4 includes other control variables. There are three observations to draw from these results. First, the IV estimation results on the effect of government spending on healthcare as a share of GDP on COVID-19 deaths per million in Columns 3–4 are similar to those reported in our baseline estimates in Columns 1–2. We find a strong positive and statistically significant effect on COVID-19 deaths of health spending as a share of GDP, after controlling for endogeneity concerns. Secondly, the substantive impact after instrumenting for spending is much larger. Holding the controls constant, a standard deviation increase in government spending on health as a share of GDP is associated with an increase in COVID deaths per million (log) of over 50 per cent of a standard deviation of COVID deaths (logged), or in real terms, roughly 96 deaths per million. The instrumented effects are roughly double the impact of the standard linear regression effects (Column 2). Thirdly, notice that the additional statistics provided in Columns 3–4 of Table 2 suggest that the selected instrument is valid. The joint F-statistic from the first stage rejects the null that the instrument selected is not relevant. In fact, we obtained a higher joint F-statistic and Kleibergen-Paap statistic on both estimation models reported in Columns 3–4 of Table 1, which remain significantly different from zero at the 1 per cent level. Taken together, our results on the impact of government spending on health as a share of GDP remain robust to alternative estimation techniques and potential endogeneity. The results of control variables are roughly the same as those reported in Columns 1–2 of Table 1.

Table 1: Government spending on health and COVID-19 deaths per million (log)

	(1)	(2)	(3)	(4)
	Deaths	Deaths	Deaths	Deaths
Government health/GDP	0.193***	0.176**	0.485***	0.459*
	(0.0667)	(0.0846)	(0.139)	(0.258)
Per capita GDP (log)		−0.0709		−0.122
		(0.156)		(0.168)
Urban population share		0.0285***		0.0272***
		(0.00780)		(0.00825)
Democracy index		−0.0649		−0.145
		(0.0777)		(0.137)
Life expectancy		−0.0194		−0.107
		(0.0698)		(0.0944)
Constant	4.433***	3.872**	2.096***	4.770***
	(0.956)	(1.662)	(0.776)	(1.847)
Estimator	OLS	OLS	2SLS-IV	2SLS-IV
Regional fixed effects	Yes	Yes	Yes	Yes
First-stage F-statistics			41.14***	20.67***
Kleibergen-Paap F-statistic			22.87***	12.08***
Cragg-Donald Wald F-statistic			51.48***	25.05***
No. of countries	178	173	178	173
R-squared	0.399	0.494	0.332	0.459
First-stage regressions				
Neighbours' government health/GDP			0.676***	0.462***
			(0.105)	(0.101)
Control variables			No	Yes
Regional fixed effects			Yes	Yes
No. of countries			178	173

Note: standard errors in parentheses; statistical significance: ***p<0.01, **p<0.05, *p<0.1.

Source: authors' construction based on data described in Section 3 above.

In Table 2, we introduce interaction terms between government spending on health as a share of GDP and various other measures.

Table 2: Conditional effects of health spending on COVID-19 deaths per million (log)

	(1)	(2)	(3)	(4)
	Deaths	Deaths	Deaths	Deaths
Government health/GDP × Healthcare equity	−0.0392	−0.0705*		
	(0.0393)	(0.0382)		
Healthcare equity	−0.0884	−0.282*		
	(0.145)	(0.149)		
Government health/GDP × corruption			0.0614	0.195
			(0.176)	(0.172)
Corruption			0.792	1.741**
			(0.731)	(0.794)
Government health/GDP	0.310***	0.245**	0.252**	0.0828
	(0.0929)	(0.0961)	(0.0996)	(0.106)
Per capita GDP (log)		0.266		0.292*
		(0.164)		(0.166)
Urban population share		0.0202**		0.0155*
		(0.00796)		(0.00804)
Democracy index		0.0414		0.146*
		(0.0754)		(0.0847)
Life expectancy		0.0357		0.0303
		(0.0684)		(0.0685)
Constant	3.631***	−0.377	3.034***	−2.012
	(0.429)	(1.521)	(0.625)	(1.820)
Estimator	OLS	OLS	OLS	OLS
Regional fixed effects	Yes	Yes	Yes	Yes
No. of countries	165	165	165	165
R-squared	0.500	0.564	0.500	0.561

Note: standard errors in parentheses; statistical significance: ***p<0.01, **p<0.05, *p<0.1.

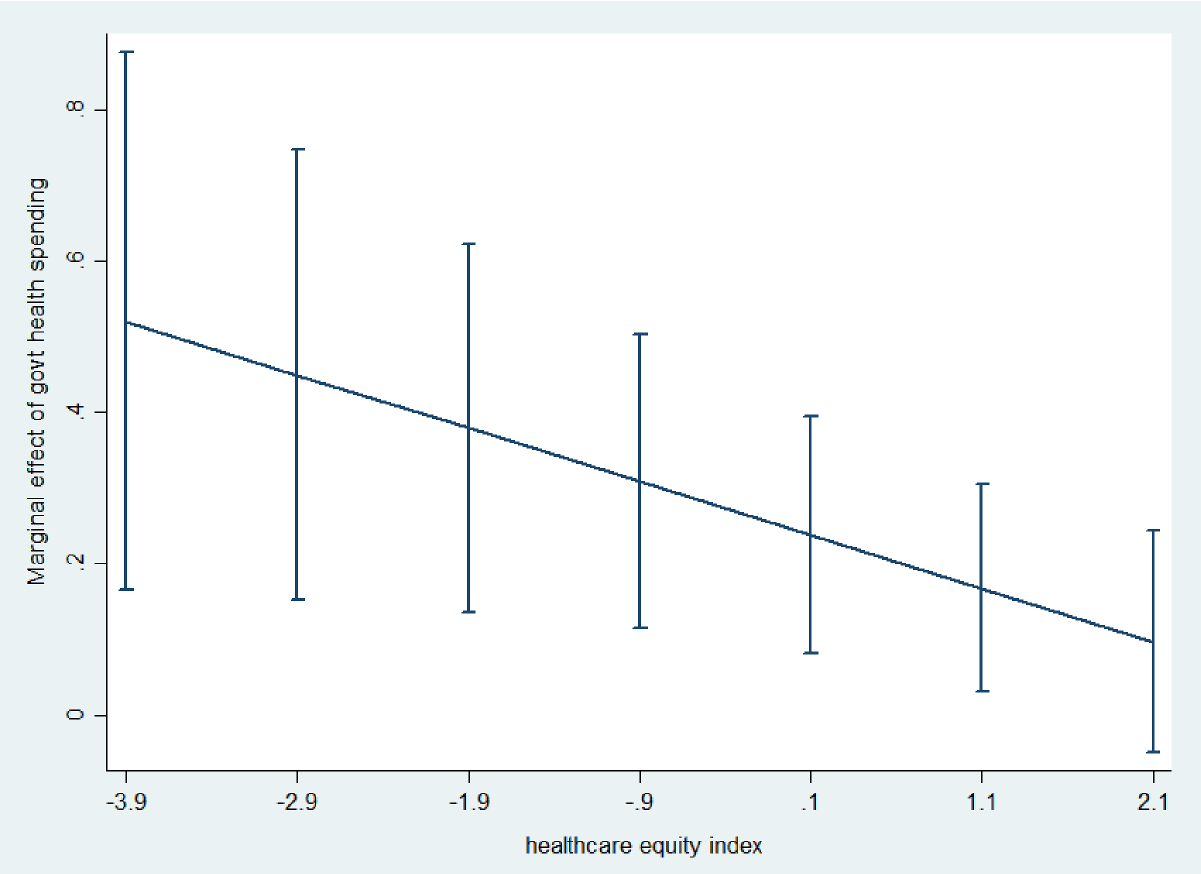
Source: authors' construction based on data described in Section 3 above.

In Columns 1–2 of Table 2 we show the conditional effects of healthcare spending share in GDP and the equitable access to healthcare index, while Columns 3–4 report the interaction effects for healthcare spending and regime corruption and COVID-19 deaths per million. As seen in Column 1, without any controls the interaction term is negative but statistically not different from zero. Notice that the interaction term becomes statistically significant at the 10 per cent level in Column 2, where we also include other control variables. Interestingly, healthcare spending as a share of GDP on its own, i.e., when the health equity index is 0, has a positive and statistically significant effect on COVID-19 deaths per million. It is also interesting to note that the access to healthcare equity index on its own, when health spending/GDP is 0, has a negative effect on COVID-19 deaths per million. This is not surprising and is in line with previous studies showing equitable access to healthcare to matter (Vadlamannati et al. 2020 a, b). It seems that the capacity to reach and treat captured by equitable access matters more than just the financing power of health spending.

The interpretation of the interaction terms even in linear models is not straightforward. Consequently, a simple t-test on the coefficient of the interaction term is not sufficient to examine whether the interaction term is statistically significant (Ai and Norton 2003). We rely on margin plots which depict the magnitude of the interaction effect and their significance levels along the scale of the conditioning variable given increases in the variable of interest.

To calculate the marginal effect on COVID-19 deaths of government health spending as a share of GDP, we take into account both the conditioning variable (healthcare equity index) and the interaction term and display graphically the total marginal effect conditional on healthcare equity coded as a scale between −3.99 and +3.16. The y-axis of Figure 2 displays the marginal effect of government spending on healthcare/GDP, and the marginal effect on the healthcare equity index is evaluated on the x-axis. Note that we include the 90 per cent confidence interval.

Figure 2: Government health spending, healthcare equity, and marginal effect on COVID-19 deaths per million

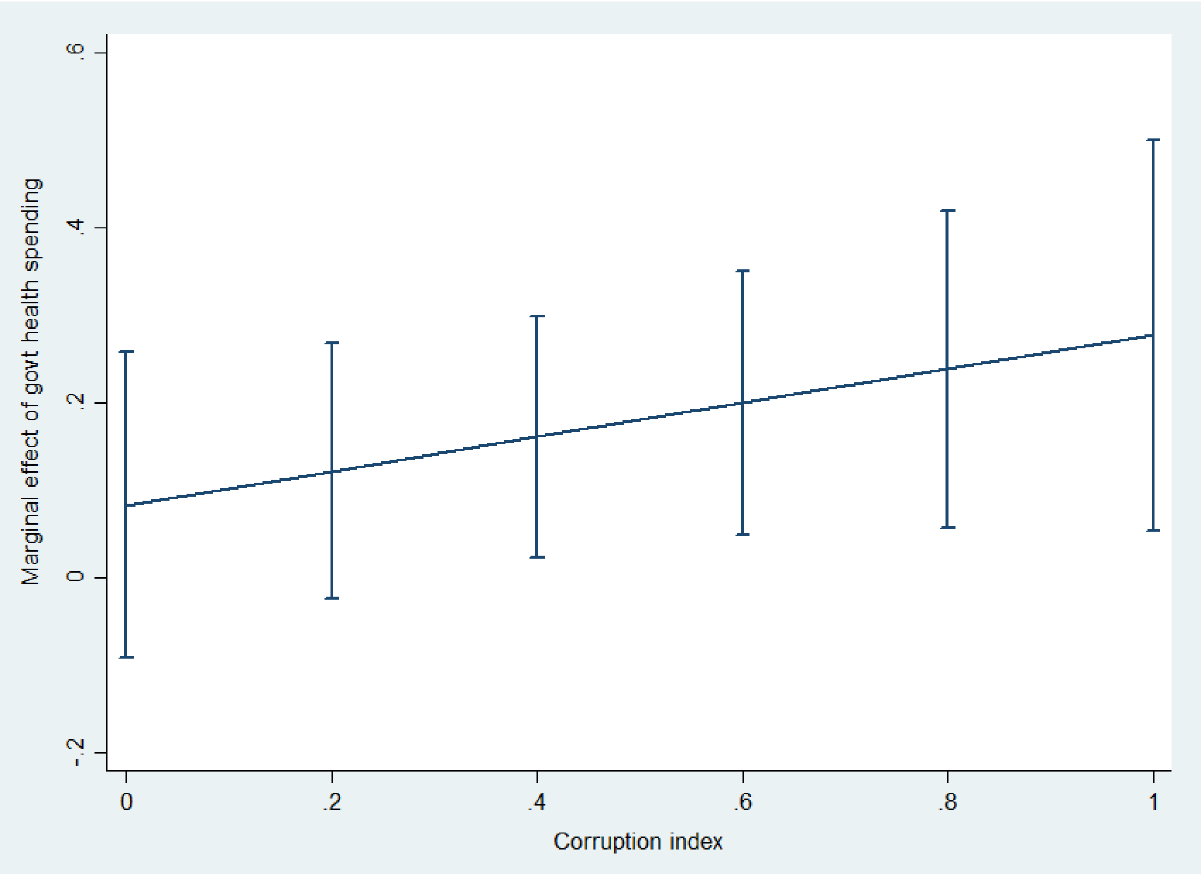


Source: authors' construction based on own regression estimations.

As seen in Figure 2, and in line with our theoretical expectations, government spending on health as a share of GDP actually reduces COVID-19 deaths per million when the healthcare equity index increases from −3.99 to +3.16. For instance, the marginal effects suggest that government spending on health as a share of GDP is associated with an increase in COVID-19 deaths per million (log) of only 16 per cent when the healthcare equity index is at a score of 2, compared with 53 per cent in a country where access to health is completely unequal. This result is significantly different from zero at the 5 per cent level. These results suggest that countries with a robust health system that are able to provide their citizens with equal access to healthcare increase their capacity to deal with a pandemic. Thus, government spending on healthcare could generate positive outcomes if such expenditure goes towards improving equity and greater access to healthcare facilities for a country's citizens, or in other words, increasing capacity to reach and treat.

We turn next to the conditional effect of healthcare spending and corruption presented in Columns 3–4 of Table 2. Once again, we resort to a marginal plot to provide a graphical interpretation of the magnitude of the interaction effect. On the y-axis of Figure 3 we show the marginal effect of an additional unit of health spending as a share of GDP, while on the x-axis we show the regime corruption index at the point at which the marginal effect is evaluated. As before, we include the 90 per cent confidence interval in Figure 3.

Figure 3: Government health spending, corruption, and marginal effect on COVID-19 deaths per million



Source: authors' construction based on own regression estimations.

The conditional plot in Figure 3 reveals that an additional unit of healthcare spending as a share of GDP increases COVID-19 deaths per million (log) when the corruption index is above 0.2 (on a scale of 0–1). For instance, health spending increases COVID-19 deaths per million (log) by 30 per cent when corruption is very high (i.e., an index score of 1), a result which is statistically significant at the 5 per cent level. Once again, the gains realized in the fight against COVID-19, as shown in Figures 2 and 3, occur not when government spending on healthcare is high *per se* but when spending is accompanied by greater access to healthcare and low regime corruption. Overall, our results from the interaction effects suggest that the negative effect on COVID-19 deaths is largely accruing from the 'structural effect' of having a robust health system, i.e., it is dependent on capacity and reach rather than mere spending on healthcare by governments. In a way, our results are also in line with the results of those who argue that the unequal burden of the COVID-19 pandemic between countries might be traced to dilapidated public health infrastructure and inequitable access (Chen and Krieger 2020; Quinn and Kumar 2014; Van Dorn et al. 2020).

4.1 Robustness checks

We examine the robustness of our findings in several ways. First, we use alternative operationalizations of health spending. We replace health spending as a share of GDP with a per capita health spending (log) measure. The denominator, GDP, which is somewhat volatile, might affect the share. Our results remain robust to using the per capita (log) measure. Second, we use alternative instruments. First, we use *average public sector health spending as a share of GDP of geographic region of country* ***c*** as our instrument along with *geographic neighbour*. Next, we use *CO_2 emissions per capita (log)* as an alternative instrument, as studies show that CO_2 emissions significantly increase healthcare expenditure (Gündüz 2020; Ullah et al. 2019). Our results remain robust to using these alternative instruments. These variables pass the instrument relevance test, with joint F-statistics above the threshold of 10. Third, we include a range of other control variables into the model, including *trade as a share of GDP (log)*; a discrete variable measuring a country's *debt burden as a share of GDP* which takes a value of 1 if debt is over 50 per cent of GDP and 0 otherwise; a dummy measure for a *new democracy* which takes a value of 1 if a country has transitioned to democracy during the 2015–20 period; and a measure of *egalitarian democracy* sourced from the V-Dem Project.[6] The inclusion of these other controls in alternative models makes little difference to the original results presented in Tables 1 and 2.

5 Conclusion

Governments across the world have committed to spending on health as a way to deal with the COVID pandemic, presumably to build resilience against any such future pandemic. Global financial institutions are making available vast amounts of money to alleviate the pain from COVID-related economic and social crises. While spending is a primary tool for governments to address crises, such as health crises, it is not at all certain that a large healthcare budget alone matters in terms of achieving intended outcomes. Our results show that higher levels of public spending on health have not necessarily cushioned societies from the worst outcomes of the COVID-19 pandemic. Instrumental-variable analyses to address potential endogeneity suggest that the relationship is most likely to be causal. Compared with spending, having an equitable health system reduces COVID deaths, suggesting that what matters is having an infrastructure capable of reaching and treating people, or conducting effective public action to prevent the spread of the virus among the truly vulnerable. Conditionally, higher spending seems to matter for reducing deaths only among societies with equitable health access and accompanied by lower regime corruption.

International and local policies aimed at building resilient health systems against future pandemics might do well to focus less on quantities spent and more on the details of building equitable systems that allow greater access, paying attention to targeted ways in which viruses might be combated, especially among the vulnerable. If issues of governance and equity are not addressed, they will place an increasing burden on those from lower-income groups, further aggravating inequalities and health outcomes into the future. Countries that currently focus more on other priorities over health should adopt more targeted mechanisms to transform public health spending towards delivering more effective health systems, especially when considering issues of resilience against the next deadly epidemic. Paying particular attention to governance issues in order to

[6] V-Dem codes 'egalitarian democracy' as a democracy that provides equal opportunities for all citizens (classes, groups, genders, etc.) to meaningfully participate by having access not just to rights but also to political resources and public goods on equitable terms.

minimize waste and rent-seeking would truly save lives. Otherwise, in this integrated world of rapid spread of deadly disease, corruption in the health sector anywhere thus becomes everyone's burden.

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Appendix

Table A1: List of countries

Afghanistan	Denmark	Kuwait	Romania
Albania	Djibouti	Kyrgyzstan	Russia
Algeria	Dominica	Laos	Rwanda
Andorra	Dominican Republic	Latvia	Saint Kitts and Nevis
Angola	Ecuador	Lebanon	Saint Lucia
Anguilla	Egypt	Lesotho	Saint Martin
Antigua and Barbuda	El Salvador	Liberia	Saint Pierre and Miquelon
Argentina	Equatorial Guinea	Libya	San Marino
Armenia	Eritrea	Liechtenstein	São Tomé and Príncipe
Aruba	Estonia	Lithuania	Saudi Arabia
Australia	Eswatini	Luxembourg	Senegal
Austria	Ethiopia	Macao	Serbia
Azerbaijan	Faeroe Islands	Madagascar	Seychelles
Bahamas	Falkland Islands	Malawi	Sierra Leone
Bahrain	Fiji	Malaysia	Singapore
Bangladesh	Finland	Maldives	Sint Maarten
Barbados	France	Mali	Slovakia
Belarus	French Guiana	Malta	Slovenia
Belgium	French Polynesia	Martinique	Solomon Islands
Belize	Gabon	Mauritania	Somalia
Benin	Gambia	Mauritius	South Africa
Bermuda	Georgia	Mayotte	South Korea
Bhutan	Germany	Mexico	South Sudan
Bolivia	Ghana	Moldova	Spain
Bosnia and Herzegovina	Gibraltar	Monaco	Sri Lanka
Botswana	Greece	Mongolia	St-Barth
Brazil	Greeland	Montenegro	St Vincent and the Grenadines
British Virgin Islands	Grenada	Montserrat	Sudan
Brunei	Guadeloupe	Morocco	Suriname
Bulgaria	Guatemala	Mozambique	Sweden
Burkina Faso	Guinea	Myanmar	Switzerland
Burundi	Guinea-Bissau	Namibia	Syria
Cabo Verde	Guyana	Nepal	Taiwan
Cambodia	Haiti	Netherlands	Tajikistan
Cameroon	Honduras	New Caledonia	Tanzania
Canada	Hong Kong	New Zealand	Thailand
Caribbean Netherlands	Hungary	Nicaragua	Timor-Leste
Cayman Islands	Iceland	Niger	Togo
Central African Republic	India	Nigeria	Trinidad and Tobago
Chad	Indonesia	North Macedonia	Tunisia
Channel Islands	Iran	Norway	Turkey
Chile	Iraq	Oman	Turks and Caicos
China	Ireland	Pakistan	UAE
Colombia	Isle of Man	Palestine	Uganda
Comoros	Israel	Panama	UK
Congo, Dem. Rep.	Italy	Papua New Guina	Ukraine
Congo, Rep.	Ivory Coast	Paraguay	Uruguay
Costa Rica	Jamaica	Peru	USA

Croatia	Japan	Philippines	Uzbekistan
Cuba	Joran	Poland	Venezuela
Curaçao	Kazakhstan	Portugal	Vietnam
Cyprus	Kenya	Qatar	Yemen
Czechia	Kosovo	Réunion	Zambia
			Zimbabwe

Source: authors' construction based on Worldometer (2020).

Table A2: COVID-19 deaths by countries as of 7 September 2020

Country	Deaths	Deaths per million	Country	Deaths	Deaths per million	Country	Deaths	Deaths per million
Afghanistan	1,420	36	French Polynesia	0	0	Nicaragua	144	22
Albania	322	112	Gabon	53	24	Niger	69	3
Algeria	1,581	36	Gambia	99	41	Nigeria	1,067	5
Andorra	53	686	Georgia	19	5	North Macedonia	634	304
Angola	124	4	Germany	9,409	112	Norway	264	49
Anguilla	0	0	Ghana	283	9	Oman	751	146
Antigua and Barbuda	3	31	Gibraltar	0	0	Pakistan	6,359	29
Argentina	10,457	231	Greece	293	28	Palestine	192	37
Armenia	905	305	Greenland	0	0	Panama	2,107	487
Aruba	15	140	Grenada	0	0	Papua New Guinea	5	0.6
Australia	781	31	Guadeloupe	18	45	Paraguay	463	65
Austria	747	83	Guatemala	2,890	161	Peru	30,123	911
Azerbaijan	555	55	Guinea	63	5	Philippines	3,986	36
Bahamas	63	160	Guinea-Bissau	38	19	Poland	2,147	57
Bahrain	203	119	Guyana	48	61	Portugal	1,849	181
Bangladesh	4,593	28	Haiti	214	19	Qatar	205	73
Barbados	7	24	Honduras	2034	205	Réunion	13	15
Belarus	726	77	Hong Kong	99	13	Romania	4,018	209
Belgium	9,912	855	Hungary	628	65	Russia	18,135	124
Belize	16	40	Iceland	10	29	Rwanda	20	2
Benin	40	3	India	74,613	54	Saint Kitts and Nevis	0	0
Bermuda	9	145	Indonesia	8,336	30	Saint Lucia	0	0
Bhutan	0	0	Iran	22,669	269	Saint Martin	6	155
Bolivia	7,097	606	Iraq	7,657	190	Saint Pierre and Miquelon	0	0
Bosnia and Herzegovina	675	206	Ireland	1,781	360	San Marino	42	1,237
Botswana	9	4	Isle of Man	24	282	São Tomé and Príncipe	15	68
Brazil	128,119	602	Israel	1,053	114	Saudi Arabia	4,165	119

British Virgin Islands	1	33	Italy	35,577	589	Senegal	293	17
Brunei	3	7	Ivory Coast	119	4	Serbia	728	83
Bulgaria	692	100	Jamaica	36	12	Seychelles	0	0
Burkina Faso	56	3	Japan	1,377	11	Sierra Leone	72	9
Burundi	1	0.08	Jordan	19	2	Singapore	27	5
Cabo Verde	42	75	Kazakhstan	1,634	87	Sint Maarten	19	442
Cambodia	0	0	Kenya	607	11	Slovakia	37	7
Cameroon	415	16	Kosovo		262.8	Slovenia	135	65
Canada	9,154	242	Kuwait	552	129	Solomon Islands	0	0
Caribbean Netherlands	0	0	Kyrgyzstan	1,061	162	Somalia	97	6
Cayman Islands	1	15	Laos	0	0	South Africa	15,086	254
Central African Republic	62	13	Latvia	35	19	South Korea	344	7
Chad	79	5	Lebanon	212	31	South Sudan	49	4
Channel Islands	48	276	Lesotho	31	14	Spain	29,628	634
Chile	11,702	611	Liberia	82	16	Sri Lanka	12	0.6
China	4,634	3	Libya	324	47	St-Barth	0	0
Colombia	21,817	428	Liechtenstein	1	26	St Vincent and the Grenadines	0	0
Comoros	7	8	Lithuania	86	32	Sudan	833	19
Congo, Dem. Rep.	260	3	Luxembourg	124	197	Suriname	91	155
Congo, Rep.	114	21	Macao	0	0	Sweden	5,842	578
Costa Rica	531	104	Madagascar	206	7	Switzerland	2019	233
Croatia	206	50	Malawi	176	9	Syria	140	8
Cuba	104	9	Malaysia	128	4	Taiwan	7	0.3
Curaçao	1	6	Maldives	31	57	Tajikistan	218	15
Cyprus	22	18	Mali	127	6	Tanzania	21	0.3
Czechia	444	41	Malta	14	32	Thailand	58	0.8
Denmark	628	108	Martinique	18	48	Timor-Leste	0	0
Djibouti	61	62	Mauritania	160	34	Togo	34	4
Dominica	0	0	Mauritius	10	8	Trinidad and Tobago	39	28
Dominican Republic	1914	176	Mayotte	40	146	Tunisia	96	8
Ecuador	10,701	605	Mexico	68,484	530	Turkey	6,837	81
Egypt	5,560	54	Moldova	1,096	272	Turks and Caicos	5	129
El Salvador	770	119	Monaco	1	25	UAE	393	40
Equatorial Guinea	83	59	Mongolia	0	0	Uganda	46	1
Eritrea	0	0	Montenegro	112	178	UK	41,594	612
Estonia	64	48	Montserrat	1	200	Ukraine	2,979	68
Eswatini	96	83	Morocco	1,453	39	Uruguay	45	13

Ethiopia	949	8	Mozambique	28	0.9	USA	194,499	587
Faeroe Islands	0	0	Myanmar	12	0.2	Uzbekistan	364	11
Falkland Islands	0	0	Namibia	93	36	Venezuela	0	0
Fiji	2	2	Nepal	312	11	Vietnam	444	16
Finland	337	61	Netherlands	6,246	364	Yemen	35	0.4
France	30,794	472	New Caledonia	0	0	Zambia	576	19
French Guiana	62	207	New Zealand	24	5	Zimbabwe	300	16

Source: authors' construction based on Worldometer (2020).

Table A3: Descriptive statistics

Variables	**Mean**	**Standard deviation**	**Minimum**	**Maximum**	**Observations**
COVID-19 deaths per million	108.380	186.906	0.000	1,237.000	213
COVID-19 deaths per million (log)	3.255	1.956	0.000	7.121	213
Government health/GDP	3.419	2.194	0.188	10.475	178
Health care equity	0.474	1.510	−3.174	3.000	172
Per capita GDP (log)	8.736	1.530	5.438	12.081	192
Urban population share	59.480	23.648	11.801	100.000	201
Democracy index	4.546	2.007	1.000	7.000	185
Life expectancy	19.788	3.005	13.350	26.390	181
Neighbours' government health/GDP	0.515	0.306	0.008	0.970	172
Corruption	3.642	2.181	0.787	8.962	183

Source: authors' construction based on data described in Section 3 above.

Table A4: Data sources and definitions

Variables	**Data definition and sources**
COVID-19 and deaths per million (log)	Number of COVID-19 deaths per million (log) recorded for country c as of 7 September 2020, sourced from Worldometer (2020).
Government health/GDP	Average government spending on healthcare as a share of GDP in each country for 2014–18, sourced from World Bank (2020).
Health equity index	V-Dem health equality index measures high-quality basic health guaranteed to all, sufficient to enable them to exercise their basic rights as adult citizens. The index ranges from −3 to +3, wherein 3 captures that basic health is equal in quality and less than 5% of citizens receive low-quality health that probably undermines their ability to exercise their basic rights as adult citizens. We use the five-year average of this index for 2014–18.
Per capita GDP (log)	Average of GDP per capita (log) for 2014–18 measured in US$ 2010 constant prices, sourced from World Bank (2020).
Urbanization	Five-year average of percentage share of urban population for 2014–18, sourced from World Bank (2020).
Democracy index	We use the Freedom House index of civil and political liberties wherein we take the average of both indices and rescale them on a 0–1 scale wherein higher value denotes higher levels of civil and political liberties and we use the five-year average of this index for 2014–18.
Life expectancy	The average number of years a person aged 60 could expect to live, if s/he were to pass through life exposed to the sex- and age-specific death rates prevailing at the time they are aged 60, for a specific year in each country.

Corruption index	Measures the degree of corruption within a regime using a subset of indicators, namely executive embezzlement, executive bribes, legislature and judiciary, and corruption in the public sector. Using Bayesian factor analysis, an index is constructed which is coded on a 0–1 scale in which a higher score denotes more regime corruption. We use the five-year average of this index for 2014–18.

Source: authors' construction.