RESEARCH

Special Series on COVID-19

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Severe Epidemics in Modern History: Growth, Debt and Civil Unrest

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This note examines the economic and political consequences of past severe epidemics since the beginning of the 20th century to shed light on the potential impact of the COVID-19 crisis. The new epidemics database constructed for this analysis covers more than 200 countries for the period of 1900-2019. Epidemics are often related to trade openness. Although severe epidemics are rare, they have significantly negative effects on growth and debt that last for at least a decade. In the initial onset year, severe epidemics lower real GDP growth by about 5%. Even 10 years later, the level of GDP still does not recover to the pre-epidemic trend. Following the outbreak, public debt (as a share of GDP) also rises, peaking in the sixth year at 20% higher than the level it would have been had the epidemic not taken place and does not return to its pre-epidemic trend for a decade. Severe epidemics also tend to be followed by heightened risks of civil unrest (e.g. riots and major government crises), particularly over the medium term.

I. CONTEXT

Severe pre-industrial epidemics (frequently referred to as "plagues") are often identified as crucial turning points in history that sometimes led to the collapses of existing institutions and reshape the path of economic development (Diamond 1997; Acemoglu et al, 2003; Nunn and Qian 2010). Advances in medicine and epidemiology, alongside globalization processes, have altered the way modern epidemics are experienced. Rare but widespread severe epidemics, such as the current COVID-19 pandemic, have caused significant illness, death, and disruption. Drawing on a new database on epidemics since the beginning of the 20th century, this note looks to the past for insights on the epidemic consequences---particularly in terms of their impact on growth, debt and civil conflicts.

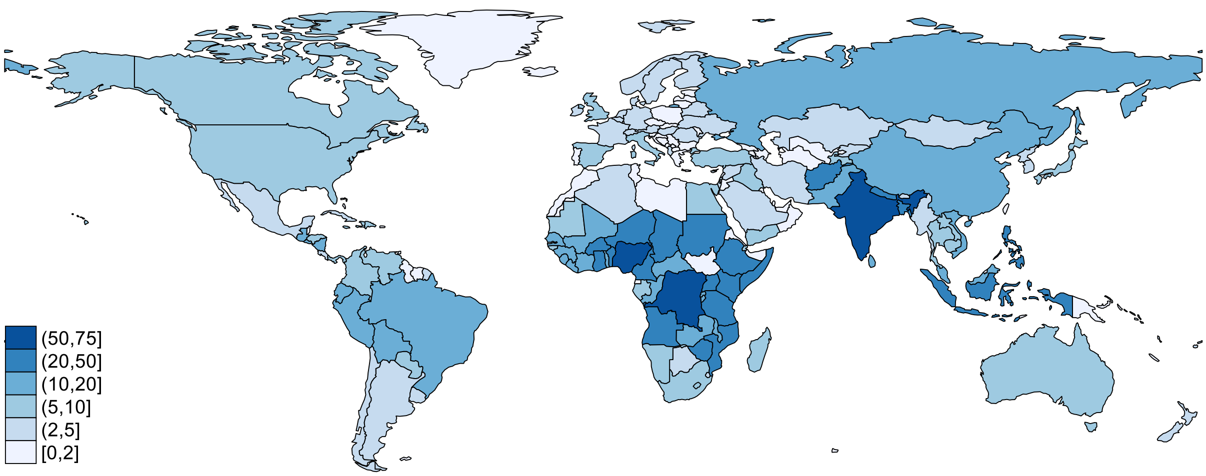
[1] We thank Gustavo Alders, Gita Gopinath, Futoshi Narita, Chris Papageorgiou and Antonio Spilimbergo for helpful discussions. We are grateful to Julia Estefania Flores and Hanbo Qi for help with collecting detailed information on epidemics and other data. For more information, contact Nan Li at nli@imf.org.

II. GLOBALIZATION AND EPIDEMICS

We first build a comprehensive data set of epidemics for more than 200 countries between 1900 and 2019, drawing on an array of sources including WHO, US/European CDC, EM-DAT database by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain, and publications in journals of infectious diseases. The data set provides information on the type of disease (e.g. viral, bacterial, parasitic diseases), the event name (e.g. Cholera, Spanish Influenza, Asian flu, Ebola outbreaks etc.), start/end years, and confirmed or estimated mortality.[2] Prolonged epidemics, such as HIV/AIDS pandemic (1981-present), and the sixth Cholera outbreak (1899-1923), are not included unless the peak year can be identified.

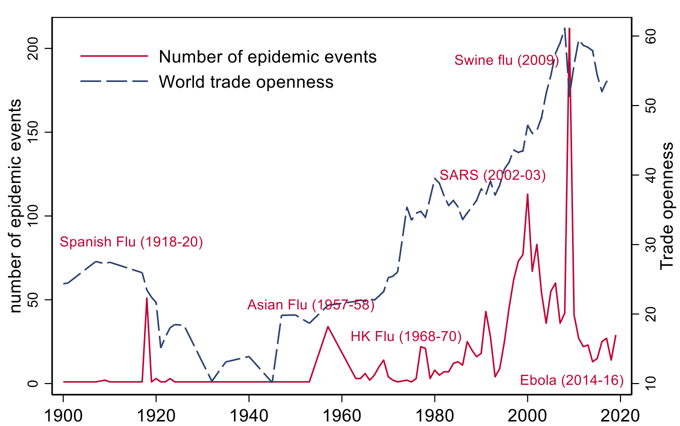
A total of 1,717 epidemic events are recorded in the database, with higher occurrences in low income countries than in high income countries (Figure 1). The prevalence of total events generally rises over time, driven both by improved recording of mild epidemics as well as a genuine increase in the frequency of occurrence of epidemics (Figure 2).

FIGURE 1. Total Number of Epidemics across Countries, 1900-2019



Source: EM-DAT, WHD, ECDC/ CDC, Journals of Infectious Diseases.

FIGURE 2. Globalization and Frequency of Epidemics



Source: EM-DAT, WHD, ECDC/ CDC, Journals of Infectious Diseases, Klasing and Milionis (2014), WDI, PWT.

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[2] The number of people affected is sometimes available but not included in the data base as such information is highly unreliable.

Epidemics are usually transmitted along the dominant lines of movement and communication. In the past, spread of disease was mainly along military passages or important trade routes, but globalization processes associated with higher human mobility and trade openness have increased the threat of epidemic emergence and accelerated global disease transmission (Figure 2). As a country opens to trade, epidemic risks and associated mortality also increase, although the rising income level and progresses in healthcare improve the ability to respond to epidemic outbreaks and mitigates such risks.

TABLE 1. Epidemic Likelihood, Mortality and Trade Openness

	Dependent variables	
	Epidemic (=1)	**Mortality Rate**
	Logit	OLS
log CGDPpc (t-1)	-0.161***	-0.363***
	(0.045)	(0.071)
Log Population (t-1)	0.775***	-0.003
	(0.060)	(0.107)
Openness (t-1)	0.272***	0.685***
	(0.067)	(0.070)
Observations	8,479	8,361
Number of countries	161	161
country FE	YES	YES

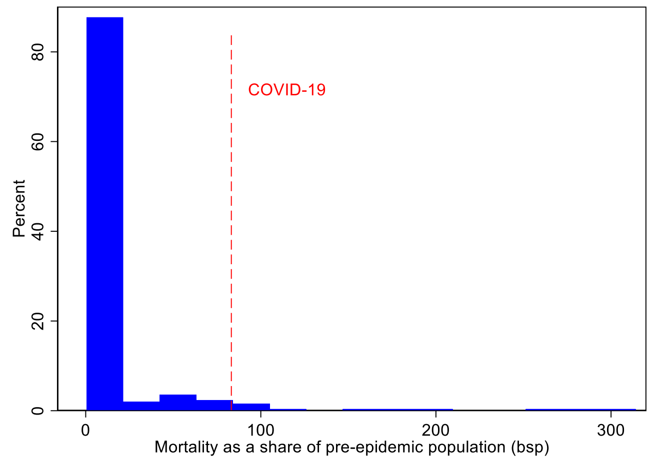
Source: IMF staff calculation.
Note: The dependent variable in Column (1) is an epidemic indicator which equals 1 if an epidemic starts in year t or zero otherwise and a logit regression is adopted. The dependent variable in Column (2) is the mortality rate calculated as number of people killed by the event divided by pre-event population. Independent variables for both columns include PPP-based Real GDP per capita, population and trade openness as measured by the sum of exports and imports as a ratio of GDP. Robust standard errors are reported in parentheses. *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively.

Identifying severe epidemics

Many of the recorded epidemics do not correspond to the notion of severe epidemics that one has in mind for the potential effect of COVID-19 on the macroeconomy. We are interested in severe epidemics where "severity" is defined from a global perspective as measured by mortality rate. Mortality is a relatively reliable and observable statistic that correlates with the nature of the epidemics, the agents that cause them, and the characteristics of pathogens, all of which are of important relevance to assess their economic implications. Here, the mortality rate is constructed as the number of deaths caused by the epidemic as a share of the population size in the year prior to the epidemic. Since the distribution of mortality rates is highly skewed (Figure 3), we use a percentile-based definition of severe epidemics by considering the 95th, 75th and 50th percentile of the world distribution of mortality rates as cutoff values to define a severe epidemic.

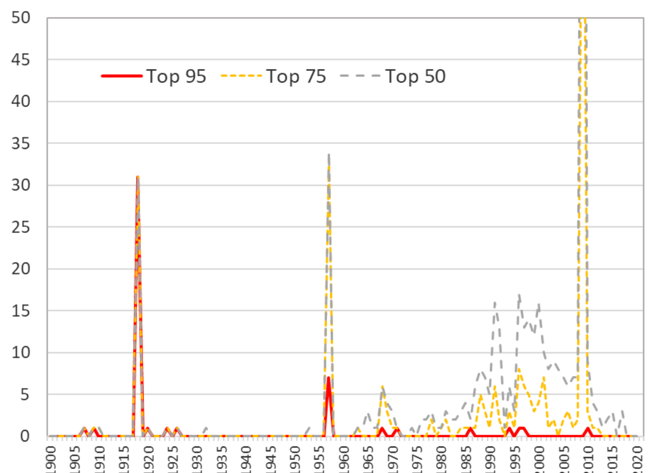
There are 50 severe epidemic events (country-year) based on the 95th percentile and half of them were caused by the 1918 Spanish Flu, the most lethal pandemic in the modern history (Barro, et al 2020). Many more (252) epidemics cause mortality rate above the 75th percentile cutoff and are much more evenly distributed over time (Figure 4).

FIGURE 3. Mortality Distribution of 75 percentile



Source: WHO, US/European CDC, EM-DAT, Infectious Disease Journal Publications
Notes: The Figure shows the share of outbreak events associated with different mortality rates (deaths over population) for epidemics that cause death rate above the 75 percentile of world mortality distribution of epidemics.

FIGURE 4. Number of Outbreak Events by Mortality



Source: WHO, US/European CDC, EM-DAT, Infectious Disease Journal Publications
Notes: The Figure presents the global incidence of outbreak events for each year between 1900 to 2019 for 95th (red), 75th (orange) and 50th (grey) percentile in terms of mortality rates.

The 95th cutoff is equivalent to an event that kills more than 5 people per 10 thousand population. The average mortality rate for the 95th percentile is 63 deaths per 10 thousand (i.e. basis points; henceforth bsp. Although the casualty seems high, the current COVID-19 pandemic is estimated to be close or even exceed this rate. Clearly, mortality rates are not clinical parameters as it can be affected by public health policy decisions and people's behavioral responses and thus cannot be estimated with high precision. The current estimates point to a mortality rate of 80 bsp with a wide range between 20 to 400 bsp.[3] These put COVID-19 squarely in the 95th percentile of the world mortality distribution of epidemics in modern history.

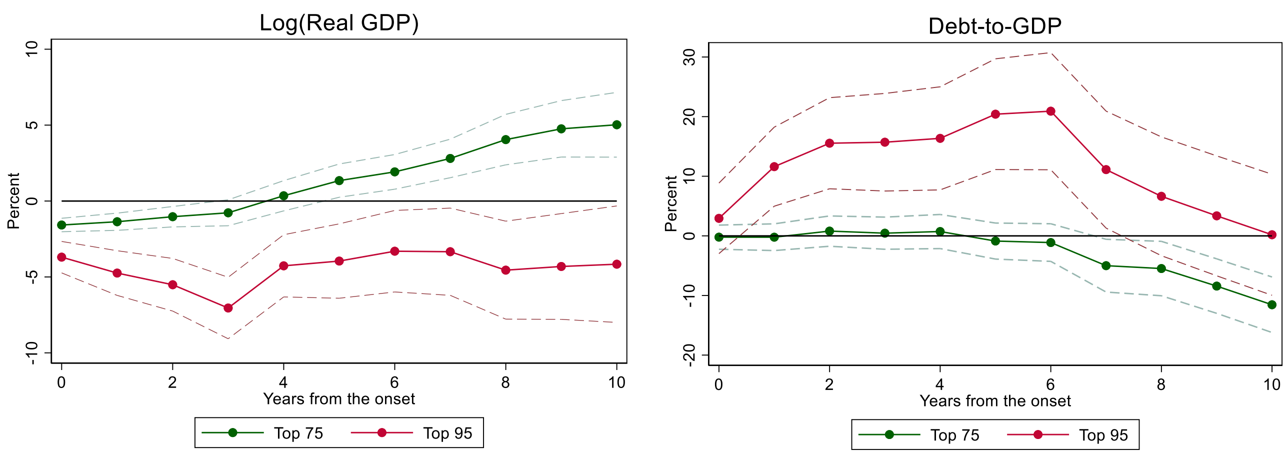
[3] Fernandez-Villaverde and Jones (2020) estimates it at 80 to match the latest evidence from NYC. The model-based approach in Ferguson et al. (2020) generates an estimate of 53.6. A simple back-of-the-envelope calculations, based on potential infection estimates (40-70%) and the asymptomatic ratio (40% according to the Diamond Princess cruise ship study), and the case fatality rate between 0.67% (Verity et al., 2020) to 10% (Italy and UK), would predict a range of mortality rate between 22 and 400 in bsp.

III. GROWTH AND DEBT CONSEQUENCES OF SEVERE EPIDEMICS

We start with a simple local projection method without additional controls to visualize the dynamic effects of severe epidemics. Figure 5 displays the average response of Real GDP (in log) and debt-to-GDP ratio to a severe epidemic as identified by the 95 percentile (red) and the 75 percentile (green), 1 to 10 years from the initial onset year. Notably, severe epidemics (95 percentile) have long lasting effects. In the first year of the event, Real GDP drops by about 4%, and keeps declining for the next three years, reaching its nadir at 7% below the expected level had the epidemic not taken place. GDP recovers somewhat but does not return to the pre-epidemic trend even 10 years later. Part of the reason that GDP declines continuously beyond the onset year is because majority of the severe epidemics lasted for 2-3 years.

Following a severe epidemic, debt/GDP rises gradually and peaks at almost 20% higher than the expected level had the epidemic not occurred. It takes an entire decade for debt/GDP to return to the pre-epidemic trend.

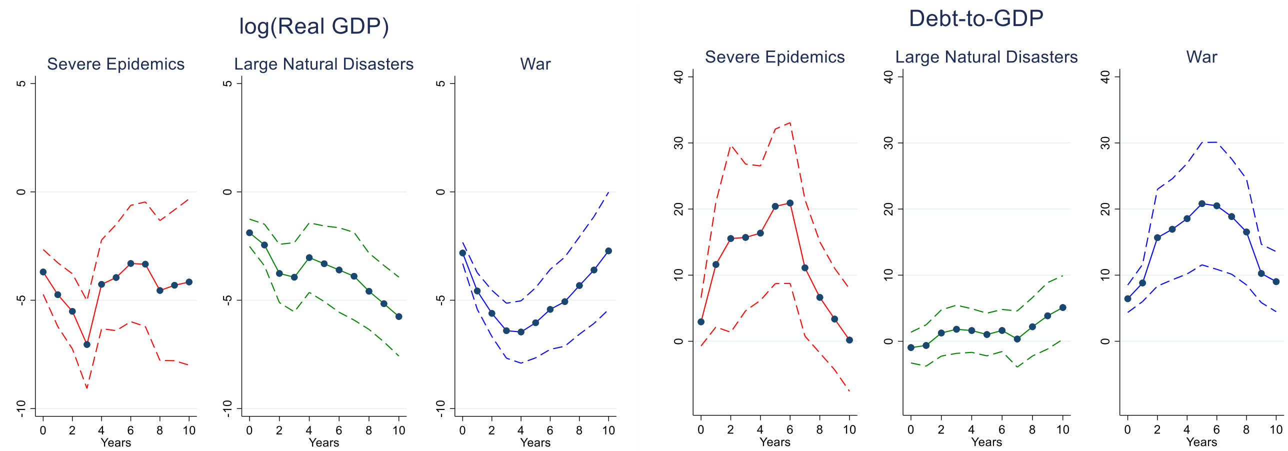
FIGURE 5. Response of Real GDP and Debt-to-GDP following Severe Epidemics



Source: Staff estimation, WHO, US/European CDC, EM-DAT, Correlates of War Project, Maddison Project, IMF-HPDD.
Note: This figure displays local projections estimates of GDP growth (left) and Debt-to-GDP (right) based on the following regression: $y_{i,t+h} - y_{i,t-1} = \beta E^{95}_{i,t} + \sum_{l=1}^{4} \alpha_h \, y_{i,t-l} + c_i + \varepsilon_{i,t}, h = 1, 2, \ldots, 10$, where $E^{95}_{i,t}$ is the epidemic indicator that equals one if t is the start year of a severe epidemic that causes mortality rate above the 95 percentile of the distribution of world epidemic mortality; it is zero otherwise. y responds to log real GDP or debt/GDP respectively. c_i stands for country fixed effects. Standard errors are clustered at the country level. One standard error bands around response estimates are presented.

These results suggest a staggering "L-shaped" or "Swoosh-shaped" recovery from a severe epidemic, and serious debt overhang risks. To put these negative consequences of severe epidemics in context, we compare these estimates with the impacts of catastrophic natural disasters (e.g. earthquake, flood, hurricane, storms) and major armed conflicts such as civil wars, WWI and WWII. Figure 6 shows that the effects of severe epidemics are comparable to those of wars and can be more acute than those of large natural disasters, especially in terms of its impact on debt accumulation. Further investigation using debt restructuring data (e.g. default, restructuring events, or haircut estimates) show no significant association of severe epidemic with default, but destructive natural disasters are often followed by default or debt restructuring.

FIGURE 6. Responses of GDP and Debt to Severe Epidemics, Natural Disasters and Wars



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Source: Staff estimation, WHO, US/European CDC, EM-DAT, Correlates of War Project, Maddison Project, IMF-HPDD.
Note: This figure displays local projections estimates of real GDP growth (left) and Debt-to-GDP (right) based on the following regression $y_{i,t+h} - y_{i,t-1} = \beta I_{i,t} + \sum_{l=1}^{4} \alpha_h \, y_{i,t-l} + c_i + \varepsilon_{i,t}, h = 1, 2, \dots, 10$, where I is the event indicator that equals one if year t is the first year of the event and zero otherwise for severe epidemics (left) or devastating natural disasters (right). The latter is defined as a disaster that causes mortality rate above the 95 percentile of the world distribution of disaster mortality (middle). The event indicator equals one for every year during a civil war, WWI and WWII right). y responds to log real GDP or debt/GDP respectively. c_i stands for country fixed effects. Standard errors are clustered at the country level. One standard error bands around response estimates are presented.

The local projection impulse responses simply trace the responses of GDP and debt to severe epidemic events without controlling for other shocks or events occurring at the same time. Table 2 shows results from panel regressions controlling for additional concurrent shocks. First, regression controlling for global shocks---global inflation, real interest rate, and commodity prices---shows a significant drop of 5% in growth in the onset year (Column 1). The growth impact is milder when less severe epidemics are included (Column 2). Taking into account other devastating large disasters and war events lowers the point estimates of the impact of epidemics but not by much (Column 3). However, the large growth impacts appear to be mostly driven by the 1918 Spanish flu pandemic (Column 4), which is often compared to the current COVID-19 pandemic and referred to as an upper bound for outcomes under the COVID-19 both in terms of deaths rate and economic effects (Barro et al, 2020). Since the start of the Spanish flu synchronizes with the end of the first World War, it is important to control simultaneously for the effect of the war events. According to our estimation, the Spanish flu pandemic is associated with growth reduction of 6% in the first year of the outbreak. Excluding the Spanish flu, other severe epidemics are still associated with a significant drop in growth of about 3.5%in the first two years.

Public debt as a share of GDP rises by 7 to 9 percent in the same year of the outbreak and continues climbing up in the first five years. Milder epidemics are followed by less accumulation of public debt (Column 2) and controlling for other devastating natural disasters and wars dampens somewhat the debt effect of epidemics (Column 3). The buildup of debt/GDP over medium-term is not driven by the 1918 Spanish flu, as shown by Column (4). In fact, excluding the 1918 pandemic, the other severe epidemics are associated with an even more significant debt overhang, with accumulated debt/GDP 40% higher than it would have been had the epidemic not taken place in three years.

TABLE 2. Panel Regression Estimates with Additional Controls

	Real GDP growth				ΔDebt/GDP			
Mortality rate	Severe 95 pctl	Milder 75 pctl	Severe 95 pctl	Severe 95 pctl	Severe 95 pctl	Milder 75 pctl	Severe 95 pctl	Severe 95 pctl
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Epidemic (t)	-5.010***	-1.525***	-4.485***	-0.821	9.428***	-1.937	7.276**	1.962
	(1.069)	(0.470)	(1.060)	(1.386)	(3.315)	(1.242)	(3.210)	(9.964)
Epidemic (t-1)	-0.622	-0.184	-0.767	-2.862*	11.11*	2.863***	9.272	13.15
	(1.568)	(0.387)	(1.586)	(1.644)	(6.594)	(1.023)	(6.774)	(10.025)
Epidemic (t-2)	-0.771	-0.0927	-0.936	-0.411	11.71	2.242**	8.451	27.06**
	(0.932)	(0.310)	(0.906)	(1.032)	(8.353)	(0.983)	(8.629)	(11.605)
Epidemic (t-3)	-1.755*	-0.338	-1.950**	1.409	3.903	1.461	2.505	2.057
	(0.926)	(0.349)	(0.908)	(1.348)	(2.653)	(0.931)	(2.948)	(10.723)
Epidemic (t-4)	3.773***	0.778*	3.391***	0.155	3.003	1.045	1.468	-2.247
	(0.915)	(0.400)	(0.930)	(0.997)	(2.339)	(1.239)	(2.573)	(10.709)
Epidemic (t-5)	0.221	0.301	0.103	0.511	5.007*	0.928	4.622*	4.282
	(0.982)	(0.261)	(1.013)	(1.217)	(2.970)	(1.296)	(2.716)	(11.534)
Spanish Flu (t)				-6.052***				8.001
				(1.809)				(12.618)
Spanish Flu (t-1)				3.286				-6.827
				(2.837)				(12.351)
Spanish Flu (t-2)				-1.150				-26.28*
				(1.979)				(13.655)
Spanish Flu (t-3)				-5.106**				-0.123
				(2.089)				(12.888)
Spanish Flu (t-4)				4.956***				5.528
				(1.424)				(12.776)
Spanish Flu (t-5)				-0.667				0.786
				(1.723)				(13.445)
Observations	12,118	12,118	12,118	12,118	6,595	6,595	6,595	6,595
R-squared	0.060	0.058	0.074	0.076	0.288	0.288	0.295	0.296
Number of countries	169	169	169	169	158	158	158	158
country FE	YES	YES	YES	YES	YES	YES	YES	YES
War and other disasters	No	No	YES	YES	No	No	YES	YES

Source: Staff estimation, WHO, US/European CDC, EM-DAT, Correlates of War Project, Maddison Project, HPDD, GFD, BOE.

Note: The Table presents estimation results of the following regression specification $y_{i,t} - y_{i,t-1} = \sum_{l=0}^{5} \beta E_{i,t-l} + \sum_{l=1}^{4} \alpha_l \; y_{i,t-l} + \sum_{l=0}^{5} \gamma_l' X_{i,t-l} + c_i + \varepsilon_{i,t}$, where E is the epidemic event indicator that equals one if year t is the onset of a severe epidemic that causes mortality rate above the 95 percentile (Column 1, 3, 4) or the 75 percentile (Column 2) of the world distribution of epidemics mortality. y responds to log real GDP or debt/GDP respectively. Other controls, X, include global inflation, oil prices, and global real interest rates, event indicators of the onset year of other large natural disasters and every year during wars. Standard errors are clustered at the country level and reported in parentheses. *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively.

IV. CIVIL UNREST

Epidemics can also generate social disruption, as they cause job losses, economic hardship and poor health, all of which lowers the opportunity costs of violence and encourages risk-taking and short-termism. They also demand timely and effective public health and policy responses, the lack of which may invoke dissent among the population.[4] The 2014 Ebola outbreak in Western Africa is a case in point---"as the numbers of death has surged, so has the violence" (Washington Post, 19 September 2014). It has been documented that Ebola outbreak has led to an increase in civil violence by more than 40% one year later and its effects on social unrest persist several years after the outbreak ended (Gonzalez-Torres and Esposito, 2020).

Exploiting within-country variation over time shows that major government crises (i.e. any rapidly developing situation that threatens to bring the downfall of the present regime) becomes more likely in the short term following a severe epidemic event. Severe epidemics also increases the risks of riots and anti-government demonstration in the medium term.[5]

TABLE 3. Probit regression: domestic conflicts and severe epidemics

	Major Government Crises	Riots	Anti-Govt Demonstration
Epidemic (t)	0.168*	0.0546	-0.0819
	(0.0966)	(0.0970)	(0.104)
Epidemic (t-1)	0.177*	-0.0297	-0.0114
	(0.0911)	(0.0942)	(0.0968)
Epidemic (t-2)	-0.149	0.0663	0.118
	(0.103)	(0.0914)	(0.0935)
Epidemic (t-3)	-0.254**	0.273***	0.178*
	(0.108)	(0.0874)	(0.0923)
Epidemic (t-4)	-0.163	0.198**	0.208**
	(0.104)	(0.0888)	(0.0919)
Epidemic (t-5)	0.0495	0.483***	0.316***
	(0.0963)	(0.0850)	(0.0905)
Observations	9,367	9,367	9,367
Number of countries	159	159	159
country FE	YES	YES	YES

Source: Domestic conflict event data (1919-2018) are obtained from Cross-National Time Series Database (CNTS, 2019 version).
Note: The Table presents estimation results of the following regression specification $Z_{i,t} = \sum_{l=0}^{5} \beta E_{i,t-l}^{75} + \sum_{l=0}^{5} \gamma_h' X_{i,t-l} + c_i + \varepsilon_{i,t}$, where $Z_{i,t}$ denotes various measures of social conflicts, $E_{i,t}^{75}$ is the epidemic event indicator that equals one if year t is the onset of a severe epidemic that causes mortality rate above the 75 percentile of the world distribution of disaster mortality. Other controls, X, include real GDP and population. Standard errors are clustered at the country level and reported in parentheses. *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively.

V. IMPLICATIONS FOR THE COVID-19 PANDEMIC

No epidemic events are exactly alike, but insights gathered from past experiences can inform policy makers on the depth, the duration of impact and the likely path of recovery. Epidemics are inherently uncertain, the pre-epidemic economic conditions are different for each episode, and policy responses obviously shape outcomes.

[4] Also see the Social Unrest Section of "Policy Challenges in Response to the COVID-19 Crisis" by Barrett, Sophia Chen and Deniz Igan for additional discussions.

[5] Riots are defined as any violent demonstration or clash of more than 100 citizens involving the use of physical force. Anti-government Demonstrations refers to any peaceful public gathering of at least 100 people for the primary purpose of displaying or voicing their opposition to government policies or authority, excluding demonstrations of a distinctly anti-foreign nature.

To some extent, there are reasons to believe that the estimates based on the historical events are likely to provide a lower bound for the effect of the global COVID-19 crisis. Except for the 1918 Spanish flu, COVID-19 has a higher death rate than any other epidemics since 1900. The containment measures and travel bans implemented around the world are also unprecedented. Even during the 1918 Spanish flu, non-pharmaceutical interventions (NPI) were limited. In the U.S., major cities eventually all adopted NPIs to promote social distancing, case isolation and public hygiene, but most of the measures were taken either too late or lasted for a short period of time (4 weeks). The “Great Lockdown” and its direct economic impact are truly without parallel. In addition, the importance of global supply chains and their amplification effects imply a sharper decline in global growth. On the other hand, aggressive monetary and fiscal interventions may help to prevent a deep and prolonged recession. The ultimate outcome will also depend on the changing characteristics of the disease and advances in pharmaceutical interventions and surveillance (such as availability of safe and effective vaccines and testing kits).

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