As the world emerges from the pandemic, it will also be critical to strengthen the mechanisms for preventing and responding to epidemics before the next one strikes. Less than 5 percent of countries entered this pandemic scoring in the highest tier for their ability to respond to and mitigate the spread of an epidemic (Johns Hopkins University and NTI 2019). Improving these capabilities will require international policy cooperation and coordination, especially given the global reach of such disasters.

ANNEX 3.1 The macroeconomic effects of pandemics and epidemics: A literature review

A growing literature has examined the economic losses from historical and simulated pandemics, taking account of a range of channels, including labor force disruption; a collapse in consumption, trade, and travel; and amplification through confidence and financial market disruptions. These studies have found initial GDP losses that fall in a range of 1-8 percent. However, these estimates generally do not account for containment measures of the scale used during the COVID-19 pandemic, which could significantly increase the economic costs. Other major economic shocks, such as financial or currency crises, have been associated with persistently negative effects on growth, suggesting that there may be long-term scarring effects from COVID-19.

Introduction

SARS-CoV-2 (COVID-19) is the latest in a long series of global disease outbreaks. In just the past century, the world has experienced four influenza pandemics: H1N1 in 1918-19 (Spanish flu), H2N2 in 1957-58 (Asian flu), H3N2 in 1968-69 (Hong Kong flu), and H1N1 in 2009-10 (swine flu). HIV/AIDS, which appeared in the early 1980s, was also eventually classified as a pandemic. In addition, the world has suffered from numerous other disease outbreaks, such as SARS-Cov (Severe Acute Respiratory Syndrome, or SARS) in 2002-03, MERS-Cov (Middle East Respiratory Syndrome, or MERS) in 2012, Ebola in 2014-15 and again in 2018-20, the Zika virus in 2015-16, as well as endemic diseases such as cholera and yellow fever (Table A.3.1.1).

Past pandemics, especially the Spanish flu, have imposed a heavy toll in terms of human lives. The number of fatalities from COVID-19 is rising strongly, and is likely to rise considerably more (Figure A.3.1.1; Atkeson 2020; Ferguson et al. 2020).

Pandemics and epidemics also have significant economic impacts. Even a relatively mild pandemic, in terms of the number of deaths, can generate substantial global output losses in the short term. This annex reviews the relevant literature, addressing the following questions:

- What are the channels through which the global economy is disrupted by pandemics and epidemics?
- What were the economic costs associated with previous pandemics and what do model-based simulations suggest about the costs of pandemics of different severity?
- What are the expected economic costs of COVID-19, based on existing studies?

Channels of economic impact

The macroeconomic impacts of disease outbreaks (epidemics or pandemics) stem from effects on aggregate demand and aggregate supply. Demand-side channels capture the effects on consumption, investment, trade, and travel, while supply channels capture workforce and supply-chain disruptions and the rising costs of doing business.[1]

Demand channels

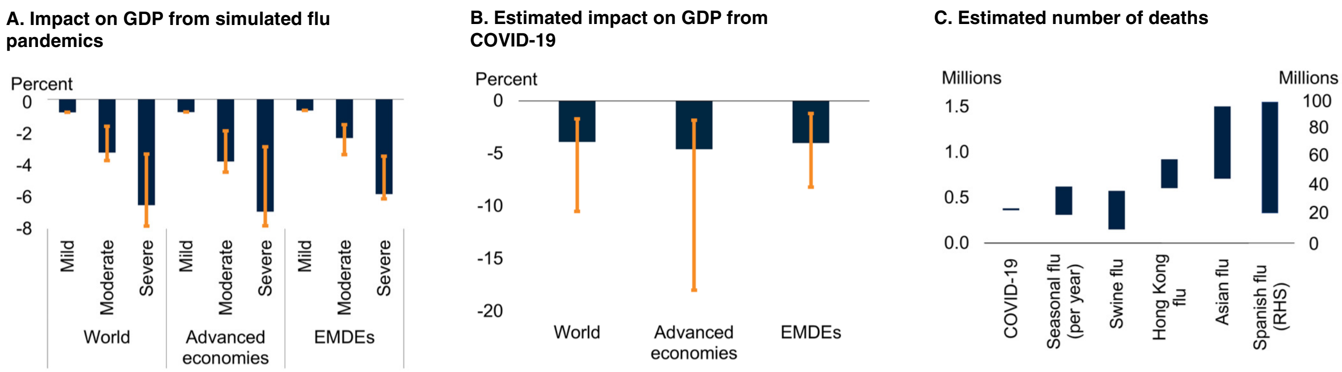
Avoidance, fear, and uncertainty. Infectious disease outbreaks can have a substantial impact on demand as governments, consumers, and firms

Note: This annex was prepared by Gene Kindberg-Hanlon, Yoki Okawa, and Dana Vorisek.

[1] In addition, the supply-side effects can trigger large falls in income which are then magnified by credit constraints and firm failures, reducing demand (Guerrieri et al. 2020).

FIGURE A.3.1.1 Economic impact of pandemics

Model simulations of pandemics of varying severities find that output can be reduced by 2-8 percent in moderate to severe scenarios. The models account for a range of channels affecting the economy, such as work absenteeism, reduced consumption, credit constraints, and financial volatility, but generally do not consider aggressive measures of the sort widely used to contain the COVID-19 pandemic. For this reason, the economic impact of COVID-19 tend to be larger in simulated severe scenarios in recent studies.



Source: Cobos et al. (2016); Dawood et al. (2012); Simonsen (1999); Spreeuwenberg, Kroneman, and Paget (2018); WHO (2018); World Bank.

A. Blue bars show the median of reported GDP shrinkage. Orange lines represent the range of the median estimates of influenza pandemics on first-year (peak impact in all cases) GDP growth from models in McKibbin and Sidorenko (2006); Burns, Mensbrugghe, Timmer (2006); Verikios et al. (2011); and McKibbin and Fernando (2020). In “mild” scenarios, the mortality rate is 2.2 per 10,000 population. In “moderate” scenarios, the mortality rate is 20-50 per 10,000 population. In “severe” scenarios, the mortality rate is 90-110 per 100,000 people.

B. Blue bars show the median reported GDP shrinkage. Orange line represents the range of the simulated impacts of COVID-19 on first-year GDP growth from Baker et al. (2020b); Breisinger et al. (2020); IMF (2020); McKibbin and Fernando (2020); and World Bank (2020b). Baseline estimates from IMF (2020) are changes in forecasts in April 2020 from January 2020. Baker et al. (2020b) and Breisinger et al. (2020) are estimates for only the United States and Egypt, respectively.

C. Number of cumulative daily infections from first day when infections exceeded 100. Data for COVID-19 is as of May 22, 2020.

Click here to download data and charts.

take actions to limit contagion. In some cases, this effect may be magnified by uncertainty. SARS, for example, triggered a substantial reduction in travel, consumption, services exports (including tourism), and even investment, despite causing just 800 deaths. Consumer spending patterns have shifted dramatically during the COVID-19 pandemic. In the United States, the magnitude of changes in spending has been linked to both the severity of local outbreaks, which creates heightened avoidance of contagion risk, and to controls imposed at the city and state level, which halt many normal activities (Baker, Farrokhina et al. 2020). Heightened uncertainty may also be reflected in financial market stress. The market volatility from COVID-19 has been severe. Risk spreads on borrowing costs have widened sharply. Many EMDEs have experienced capital flight. Previous infectious disease outbreaks have had qualitatively similar effects on financial markets (Ma, Rogers, and Zhou 2020).

Supply channels

Labor force effects. Illness and preventive measures to reduce contagion during infectious disease outbreaks reduce available labor supply and labor productivity in the short run, while loss of schooling and job experience, as well as mortality, can have persistent effects. In past pandemics, illness and absences to care for family members reduced labor supply more than mortality (Kilbourne 2004; McKibbin and Sidorenko 2006).[2]

Business closures and supply chain disruptions. Business costs are likely to increase during a pandemic as measures are taken to protect employees and the general population, and closures can exact an even greater toll. Empirical assessments of disease outbreaks have found that high-exposure service sectors, such as travel, accommodation, and food services, are hardest hit during pandemics, even when few restrictions or closures were imposed (Joo et al. 2019; Siu and Wong 2004). Manufacturing can be deeply affected by supply chain disruptions. In some CGE-based estimates of the economic costs of pandemics, rising business costs in affected sectors

[2] In addition, over the long term, the loss of human capital due to fatalities during the outbreak can result in long-term output losses (Fan, Jamison, and Summers 2018).

TABLE A.3.1.1 Estimated mortality and infection rates of pandemics during the past century

	Spanish flu	Asian flu	Hong Kong flu	Swine flu	COVID-19
Period	1918-19	1957-58	1968-69	2009-10	2020
Deaths (% of global population)	1.0-5.7	0.03-0.05	0.02-0.03	0.001-0.004	0.004
Infections (% of global population)	28	42-55	30-57	24	0.07

Source: Cobos et al. (2016); Johnson and Mueller (2002); Johns Hopkins University Coronavirus Resource Center; Simonsen (1999); Taubenberger and Morens (2006).
Note: COVID-19 infections and deaths are as of May 22, 2020.

are responsible for the majority of economic losses (Lee and McKibbin 2003; McKibbin and Sidorenko 2006).

Amplifying and dampening factors

Several factors affect the magnitude of economic losses from disease outbreaks.

Demographic profiles. Large-scale infectious disease outbreaks tend to strike some age segments more than others. For example, the case fatality rate during the Spanish flu was highest for young adults, while during the Asian flu, school-aged children and young adults experienced the largest elevation in mortality relative to the baseline (Gagnon et al. 2013; Viboud et al. 2016). Early experience with COVID-19 shows a disproportionally higher frequency of death for the elderly suggesting that the loss of life may be severe for countries and regions with a high share of older people (Farzanegan, Feizi and Gholipour 2020; Sornette et al 2020; Verity et al. 2020).[3]

Health care systems and social safety nets. Low- and lower-middle-income economies may suffer particularly high loss of life from disease outbreaks as a result of low-quality health care systems and poor access to water and sanitation services (Corburn et al. 2020; Farzanegan, Feizi, and Gholipour 2020; McKibbin and Sidorenko 2006). Weak social safety nets can magnify the economic impacts of pandemics for lower-income households. Because low-income workers typically have limited savings to buffer income shocks, and because telecommuting is not an option for many low-paid service jobs, these workers may be forced to work in environments where the risk of infection is high.

Cross-country spillovers. Simulations have shown that global trade would fall by as much as 14 percent in a medium-scale outbreak of avian flu, even if viral cases were limited to South and East Asia (Bloom, de Wits, and Carangal-San Jose 2006). During the SARS outbreak, the high dependence of Hong Kong SAR, China on tourism and services exports was found to have magnified GDP losses (Siu and Wong 2004). Disruption to global value chains provides an additional channel that can increase the economic cost of pandemics and epidemics. The impact of COVID-19 on global trade has been a major concern in part because countries that collectively account for the majority of global manufacturing production and exports (China, Germany, Italy, Korea, and the United States) have also experienced some of the largest outbreaks (Baldwin and Tomiura 2020).

Macroeconomic policy response. Fiscal and monetary policy support can blunt the adverse economic impacts of disease outbreaks and aggressive mitigation measures. With much of the global economy under lockdown during the COVID-19 pandemic, such support has been essential to offset drastic interruptions to the normal income, credit, and spending patterns among businesses and households. The effectiveness of policy support depends on the credibility of the measures, and the extent of pre-existing vulnerabilities such as high debt levels and large external financing needs, and structural issues. For example, fiscal multipliers are typically lower in economies with high debt (Huidrom et al. 2019). The effectiveness of fiscal policy also depends critically on a well-functioning social security system, and could be complicated by high levels of informality (Box 1.4; Loayza and Pennings 2020). Monetary policy easing also may be less effective in economies with large informal sectors and low financial inclusion (Alberola-Ila and Urrutia 2019).

[3] The U.S. Department of Health and Human Services (2020) estimates that the case fatality rate for patients ages 20-44 is less than one-tenth of the rate for patients ages 65-74.

Estimates of economic losses

The literature has studied the economic impacts of disease outbreaks using both model-based simulations and empirical analysis of historical pandemics.

- **Computable general equilibrium (CGE) models.** Several global CGE models have been applied to estimate losses of simulated pandemics (Lee and McKibbin 2004; McKibbin and Fernando 2020; McKibbin and Sidorenko 2006; Verikios 2011). These models offer rich sectoral disaggregation that allows the consideration of differential effects across industries, estimation of trade spillovers, and endogenous policy responses.

- **Empirical estimates of historical episodes.** Estimates of the impact of actual pandemics have the advantage of taking account of the actual losses experienced (Barro, Ursua, and Weng 2020; Correia, Luck, and Verner, 2020; Keogh-Brown and Smith 2008; Siu and Wong 2004). However, they are often unable to distinguish the effects of the pandemic from other factors.

Simulated outbreaks

Studies of simulated pandemics typically use mortality rates to classify the severity of the event (Table A.3.1.2).[4] Simulations with higher mortality rates tend to generate larger economic losses. Containment and mitigation measures, including social distancing and restriction of movements, are largely absent from the literature on simulated pandemics. However, a study of the United Kingdom reports that a three-week school closure in response to a simulated influenza outbreak reduces GDP by about 0.5 percentage point in the first year, in addition to the 0.8-1.7 percent loss of output directly attributable to infections (Smith, Keogh-Brown, and Barnett 2011).

Mild pandemics. These are defined to have mortality rates of less than 20 per 10,000 people.[5] Historical examples are the Hong Kong flu, with about 2 deaths per 10,000; and the Asian flu, with about 4 deaths per 10,000. In model simulations, their impact reduces GDP by 0.7-0.8 percent in both advanced economies and EMDEs in the first year (Figure 1.1; McKibbin and Sidorenko 2006).

Intermediate pandemics. These are defined to have mortality rates of 20-50 per 10,000 population. Model simulations suggest, during the first year, reductions of 1.6-3.5 percent of GDP in EMDEs, and 2.0-4.6 percent of GDP in advanced economies (Burns, van der Mensbrugghe, and Timmer 2006; Verikios et al. 2011).[6] Relative to mild pandemics, modeled intermediate pandemics show larger losses from reduced labor supply, negative shocks to consumption, financial market disruption, and increases in business costs (Table A.3.1.2).

Severe pandemics. These are defined to have more than 50 deaths per 10,000 population. In model simulations, pandemics on this scale reduce GDP by 3.6-7.0 percent in EMDEs, and 3.0-8.0 percent of GDP in advanced economies (McKibbin and Sidorenko 2006; Burns, van der Mensbrugghe, and Timmer 2006).

Historical outbreaks

Historical analysis of the economic costs of previous pandemics and epidemics is complicated by lack of data and the simultaneous presence of other shocks. For example, the Spanish flu overlapped with World War I, while the swine flu pandemic broke out during the global financial crisis. Empirical investigations of these episodes suggest that the results of the model-based simulations are in the right range (Table A.3.1.3). Thus, the Spanish flu is estimated to have lowered GDP by about 6 percent during 1918-19, with

[4] Mortality rates are more variable than infection rates. Estimates put the mortality rate of the Spanish flu at more than 500 times that of the 2009 swine flu pandemic, and the infection rate only 1.5 times larger.

[5] Here and in the subsequent two paragraphs, the 10,000 figure refers to the whole population, rather than just the infected population.

[6] Pandemics can also be differentiated into those with high mortality but low infection rates and vice versa. A pandemic with a moderate case fatality rate but high contagion could generate economic losses many times higher than a pandemic with a high fatality but low contagion (Verikios et al. 2011).

more cyclical economic sectors, such as manufacturing, experiencing output reductions of up to 18 percent (Barro, Ursua, and Weng 2020; Correia, Luck, and Verner 2020). In contrast, estimates for more moderate episodes of influenza, such as the Asian flu, which killed approximately 1 million people globally, show GDP losses that are largely indistinguishable from normal growth volatility (Henderson et al. 2009). SARS is estimated to have reduced output by 1-4 percent in some of the worst affected economies in the second quarter of 2003, with less clear impacts on growth during the whole of 2003 (Siu and Wong 2004).

COVID-19: Short and long-term losses

Several studies have published initial estimates of the possible economic losses from the COVID-19 pandemic (Table A.3.1.4). Some take account of the economic impacts of the stringent containment and mitigation measures, which could make the economic impacts of this pandemic much more severe relative to past episodes (Boissay and Rungcharoenkitkul 2020).[7]

Short-term economic losses

The existing estimates of the economic consequences of COVID-19 have a wide range, reflecting the large uncertainty surrounding contagiousness, the eventual infection and fatality rates, the stringency and duration of policies to reduce virus transmission, and other factors (Figure A.3.1.1). The first estimates showed small economic losses. Subsequent estimates were higher, as the pervasiveness and severity of the disease, and the containment and mitigation measures, became more apparent.[8]

One study puts output losses from the COVID-19 pandemic at 2-6 percent of GDP in EMDEs in the first year, and 2-8 percent in advanced economies (McKibbin and Fernando 2020). This would be comparable to the estimated 6 percent global economic losses due to Spanish flu (Barro, Ursua, and Weng 2020). Maliszewska, Mattoo, and van der Mensbrgghe (2020) estimate losses of 2.5-4.0 percent in EMDEs, and 1.8-3.8 percent of GDP in advanced economies. This results from a fall in employment, lower consumption, rising trade costs, and reduced travel and tourism. However, these studies do not factor in the full stringency of the controls that were later imposed globally.

Several studies have attempted to separate the losses of output that preventive controls may impose from those of a hypothetical COVID-19 outbreak with no such restrictions. Restrictions on retail, travel, and other services industries could reduce output by 25 percent in OECD economies during their enforcement (OECD 2020a). Were these restrictions to remain in place over three months in 2020, this would imply a 6 percent reduction in annual GDP, equivalent to estimates of lost output in severe simulated pandemics (without explicit containment measures) and empirical estimates of losses from Spanish flu. Other estimates suggest that growth will be approximately 5-8 percentage points lower in advanced economies and EMDEs in 2020 due to the effects of COVID-19 and associated containment measures. The impact on growth would be an additional 3 percentage points if the duration of containment measures is extended to increase the number of lost working days by 50 percent (IMF 2020).

A developing strand of the literature models the economic impact of imposing "optimal" containment measures to limit the spread of COVID-19. In a model of the United States, consumption falls by 22 percent under optimal containment measures, compared to just 7 percent if only the effect on labor supply owing to illness and mortality and consumer behavior is considered (Eichenbaum, Rebelo, and Trabandt 2020).[9] Another model-based approach applied to the United States finds that targeting containment

[7] Keogh-Brown et al. (2010) estimate that extending a four-week school closure to 15 weeks alongside increased levels of prophylactic absenteeism might double economic losses in a medium-scale pandemic but only reduce the rate of infection by 2-15 percent.

[8] For example, ADB (2020) initially estimated a "worst-case scenario" of 0.4 percent of global GDP. A similar scenario with moderate global contagion modeled by the OECD (2020c) estimated that world GDP would be reduced by around 1.5 percent relative to baseline.

[9] The "optimal" containment measures are assumed to reduce deaths as a share of the initial population from 0.4 percent to 0.26 percent.

measures to older age groups results in a 10 percent reduction in output over one year, compared to a 24 percent loss of output with universally-applied lockdown measures (Acemoglu et al. 2020). Age-targeted containment measures may be particularly effective at limiting output losses in EMDEs, which have a smaller share of their population in vulnerable age groups (Alon et al. 2020).

Medium- and long-term impacts

Scarring effects and offsetting policy. Most analysis of the economic costs of pandemics and epidemics focuses on short-term impacts. However, severe economic contractions of the magnitude expected in 2020 have historically cast long shadows, typically lowering potential growth for four to five years (Box Lasting damage of recessions; Martin, Munyan, and Wilson 2015; World Bank 2018). This can result from reduced investment, credit constraints, and slower adoption of new technologies (Anzoategui et al. 2019; Queralto 2019).[10] History suggests that good policy may reduce the adverse effects of severe contractions. Regions implementing significant containment measures during the Spanish flu are found to have experienced faster rates of growth than other regions in the five years following the pandemic (Brainerd and Siegler 2003; Correia, Luck, and Verner 2020).

Debt and insolvency risk. The negative shock from COVID-19 is occurring at a time of heightened vulnerabilities in sovereign and private sector debt. Historically, episodes of rapidly accumulating debt are associated with an increased likelihood of a financial crisis (Kose et al. 2020). The unprecedented scale of the current fiscal stimulus will stretch public sector balance sheets even further in many EMDEs, and in some advanced economies. Private sectors may experience a wave of insolvencies, posing a threat to banking systems in various jurisdictions. One of the lasting effects of the COVID-19 induced recession may be increased financial fragility.

Human capital implications. Schools and universities have been closed across the world as part of the policy response to slow the spread of COVID-19 (UNESCO 2020). The associated learning disruptions, although partially compensated by home schooling and remote teaching, are likely to have the most adverse effects for disadvantaged students, including on health and safety (World Bank 2020d). School closures may cause lasting setbacks to human capital accumulation and earnings potential (Psacharopoulos et al. 2020; Wang et al. 2020). Missed learning opportunities can have larger impacts for low-income families, who often have limited ability to support learning at home (Van Lancker and Parolin 2020). Evidence from the Ebola epidemic in West Africa in 2014 suggests that school closures were associated with higher dropout rates and wider gender gaps in educational attainment (UNDP 2015). Large declines in household income are also associated with increased school dropout rates in EMDEs (Glick, Sahn, and Walker 2016). In addition, closure of workplaces will deprive many people of opportunities to improve skills and productivity through apprenticeships and on-the-job learning.

Poverty implications. The COVID-19 pandemic could have severe effects for the poor through multiple channels, including greater vulnerability to declines in labor and non-labor income, increased risk of infection and mortality, and lower availability of essential items due to market disruptions hit the poor particularly hard (Barnett-FAO et al. 2020; Howell and Mobarak 2020; World Bank 2020d). Although the social assistance measures that have been implemented by many countries may soften the impacts on households, they do not fully offset the income losses from shutdowns. Moreover, the poorest members of society have little capacity to manage negative income shocks. Less than 20 percent of workers are covered by social insurance or assistance programs in low-income countries (LICs), in part due to their large informal sectors (World Bank 2019b). All this suggests that recent progress on the reduction of poverty and inequality will likely be lost (Sumner, Hoy, and Ortiz-Juarez 2020).

[10] Downward pressure on real rates of return following a pandemic may be particularly persistent, lasting for about 40 years (Jordá, Singh, and Taylor 2020).

Structural changes in production, consumer behavior, and work patterns. The fragility of the global trading system, highlighted by disruptions in global value chains, and by shortages of essential goods in many countries during the COVID-19 outbreak, may lead governments and firms to reassess the benefits of low-cost, off-shore sourcing. Onshoring efforts will have costs, however. Domestically, resources may be diverted into capital-intensive import-substitution. Aside from this, efforts to avoid viral contamination may linger long after the pandemic dissipates. This could lead to changes in the structure of production on a much larger scale than those which past recessions have triggered. Certain restrictions, and adjustments in consumer behavior, to reduce the risk of infection may prove highly persistent (Smith et al. 2014). For example, the experience with widespread remote working may permanently change the nature of workplaces. Avoidance of crowds may mean that established business models of popular entertainment are no longer viable. It may take the travel industry years to recoup the tourist losses it has suffered in 2020.

TABLE A.3.1.2 Economic impacts of simulated influenza pandemics

Paper	Total mortality (per 10,000 people)	Channels and shocks	Containment measures and policy response	Time horizon	Method	Peak GDP loss in advanced economies (percent)	Peak GDP loss in EMDEs (percent)
McKibbin and Sidorenko (2006)	2.2-22	- Illness: the labor force is reduced by 1.15% - Mortality: 0.02-2.2% of the labor force is killed by influenza - Tourism and trade reductions - Financial market disruption - Business costs rise, with the largest increase in sectors requiring more social interaction - Costs shocks for the most affected sectors - Demographics and health care quality affect the illness and mortality rates across economies	No explicit containment or policy measures	1 year	DSGE/CGE	0.7-7.1	0.7-6.3
Burns, Mensbrugghe, and Timmer (2006)	108	- Illness and mortality - Reduction of 20% in travel, transport, and restaurant consumption for 1 year	No explicit containment or policy measures	1 year	DSGE/CGE	3.0	3.6
Smith, Keogh-Brown, and Barnett (2011)		- Illness: 35% of working labor force is infected - Case fatality rate of 0.06-0.35%	School closures and prophylactic absenteeism considered in alternate scenarios	1 year	CGE	United Kingdom: 0.3-0.6 considering disease only; 3.4-4.3 with school closures and prophylactic absenteeism	-
Verikios et al. (2011)	20	- Illness and mortality - *unspecified* - School closures add 75% to lost working days - Reduction of tourism and travel of 70%	School closures	Multi-year. Losses largely unwound after one year	CGE	3.9	2.4

Note: Losses are reported relative to a baseline level of GDP or growth rate, which are approximately equivalent. Median of the first year GDP loss in advanced economies or EMDEs are reported, except Burns, Mensbrugghe, and Timmer (2006), which only reports aggregated GDP impact. "High-income countries" in Burns, Mensbrugghe, Timmer (2006) are presented in the tables as advanced economies and "low and middle-income countries" are presented as EMDEs.

TABLE A.3.1.3 Estimates of economic impacts of historical pandemics and epidemics

Event	Study	Estimation technique	Geographical coverage	Estimate of immediate impact	Estimate of subsequent impact
Spanish flu	Brainerd and Siegler (2003)	Growth regressions controlling for the death toll from flu and other factors as explanatory variables in 1918 for per capita growth over the subsequent 10 years	United States (state by state)	n/a	+0.2 percentage points per year growth for 10 years following the pandemic
Spanish flu	Karlsson, Nilsson, and Pichler (2014)	Growth regressions exploiting regional differences in influenza incidence and mortality rates during 1918-19	Sweden	No discernable effect on aggregate earnings or GDP per capita but a large increase in poverty rates	
Spanish flu	Barro, Ursua, and Weng (2020)	Growth regressions controlling for country-specific factors, war-related deaths, and influenza-related deaths to assess the influenza-specific fall in GDP	43 advanced economies and EMDEs	GDP reduced by 6%, consumption reduced by 8%	
Spanish flu	Correia, Luck, and Verner (2020)	Exploits state and city influenza deaths to assess the specific effects on manufacturing output and employment	United States	Manufacturing output reduced by 18% and employment by 23% by 1919	Regions with longer-lasting public health interventions (46 days longer) experienced a 6% rise in manufacturing employment and a 7% rise in output following the pandemic
Asian flu	Henderson et al. (2009)	Event study of industrial production	Canada	1% fall in industrial production at the time of the outbreak	
SARS	Lee and McKibbin (2004)	CGE modeling exercise calibrated following the SARS epidemic	Asia-Pacific	Reduction in 2003 GDP: Hong Kong SAR, China -2.6% China -1.1% Singapore -0.5%	
SARS	Siu and Wong (2004)	Event study of the effects of SARS using sectoral, trade, and tourism data	Hong Kong SAR, China	Initial 15% decline in year-on-year retail sales growth during the peak of the outbreak; tourist arrivals decline 10% at peak; unemployment rate increases by more than one percentage point at peak; tourist arrivals and consumption subsequently recover to pre-SARS levels but no indication that lost growth is recovered	
SARS	Keogh-Brown and Smith (2008)	Event study examining a range of aggregate and sectoral indicators	16 economies, primarily in Asia	One-quarter losses: China -3% Hong Kong SAR, China -4.75% Canada -1% Singapore -1% Losses are concentrated in travel, leisure activities, and tourism; results do not specify whether quarterly impacts are recovered in subsequent quarters	
SARS	Kholodilin and Rietha (2020)	VAR using monthly data on industrial production and index of news about flu-like disease	Eight major economies	News of SARS outbreak reduced industrial production by 2% in China and 10% in Republic of Korea during the peak of the episode	
MERS	Joo et al. (2019)	Event study of tourism, travel, accommodation, and food sectors during 2015	Republic of Korea	Permanent losses in affected sectors equivalent to -0.2% of GDP	

TABLE A.3.1.4 Preliminary estimates of economic impacts of COVID-19

Paper	Total mortality (per 10,000 people)	Channels and shocks	Containment measures and policy response	Time horizon	Method	Peak GDP loss in advanced economies (percent)	Peak GDP loss in EMDEs (percent)
IMF (2020)	Not specified	- Labor supply falls by 5-8% globally in 2020 - Financial market disruption and credit tightening in 2020, fading in 2021. Downside scenario assumes an additional 75 basis point rise in sovereign credit spreads in EMDEs and an additional 50 basis point rise in advanced economies - Commodity prices sharply fall in 2020. Oil prices remain around 15% below baseline in 2021	- Containment measures implemented in 2020Q2 and withdrawn in 2020Q3; more severe case restrictions last 50% longer - Unconventional monetary policy is implemented in advanced economies, alongside fiscal measures	2 years	Baseline WEO forecast and semi-structural DSGE model	7.7 – 10[1]	5.4-8[1]
Maliszewska, Mattoo, and van der Mensbrugghe (2020); World Bank (2020c)	Not specified	-Illness and mortality reduce labor input by 3% in year 1 -Trade costs increase by 25% across all goods and services -Tourism fall implemented with a 50% increase in costs -Demand “reallocated” away from high-risk service sectors	- Effect of containment embedded in assumptions about labor input and consumption reduction	1 year	CGE	1.8-3.8	2.5-4.0
McKibbin and Fernando (2020)	20-90	-Illness and mortality: -0.4 to -4.6% fall in labor supply -Consumer behavior: initial -0.8 to -4.5% fall in total consumption, including targeted tourism and trade reductions -Financial market disruption: 1.1-2.9 percentage point increase in equity risk premium -Costs of doing business: 25-50% increase, varying by sector -Demographics and health care quality indexes vary mortality rates across economies	- No explicit containment measures - 0.2-2.7% positive shock to government expenditure - Endogenous fiscal and monetary response to shocks	1 year (year of shock); reversion to baseline after 1 year	DSGE/ CGE	2.0-8.0	1.6-6.0
WTO (2020)		- Illness and mortality reduce labor supply by 1-4% in year 1 -Tourism declines 20-80% over 3-6 months -Retail activity declines 5-20% over 3-9 months -Manufacturing falls by a maximum of 80% for 3 months and 40% for 6 months -Trade costs increase: 22.5% rise in cost of services transport and specialized equipment transport over 6-18 months, 70% rise in air cargo costs over 6-18 months	-Work from home for 3 months to 1 year and school closures for 3 months	2 years	CGE	4.8-11.1 in year 1 (global)	
Baker et al. (2020b)	Not specified	-Based on U.S. stock return and volatility from February 24 to March 31	n/a		VAR	3-20 (United States)[2]	
Banco de España (2020)	Not specified	-Spillovers from weak global economy -Weak domestic demand due to containment - Discretionary fiscal policy to support the economy	- 8-12 weeks of containment measures, reducing domestic demand	2 years, with strong rebound in year 2	Hybrid macro model	8.5-14.1 (Spain)	

TABLE A.3.1.4 Preliminary estimates of economic impacts of COVID-19 *(continued)*

Paper	Total mortality (per 10,000 people)	Channels and shocks	Containment measures and policy response	Time horizon	Method	Peak GDP loss in advanced economies (percent)	Peak GDP loss in EMDEs (percent)
Breisinger et al. (2020)	Not specified	- Zero internal tourism during crisis - 10-15% reduction in remittance and Suez Canal revenue - Shocks last 3-6 months	n/a	1 year	Social accounting matrix		2.1-4.8 (Egypt)
Çakmaklı et al. (2020)	0.2-96	- Illness and mortality - Changing consumer demand - 18-23% decline in exports due to weaker external demand for final goods and intermediate goods	- 0-35 weeks of lockdown - Only selected industries are active during full lockdown	1 year	DSGE/CGE/ SIR		4.5-11.0 (Turkey)
Duan et al. (2020)	0.24	- Household consumption declines 5-10% in Q1	- Labor supply reduced by 10-50% in Q1 and rebounded in Q2	1 year	CGE		0.6-1.7 (China)
Eichenbaum, Rebelo, and Trabandt (2020)	20-30	-Illness and mortality -Consumer behavior – consumption falls by 7% without containment measures in year 1; consumption falls by 22% with containment measures	- Optimal containment measures at their peak during the year restrict 76% of the population from working	2 years – effects largely dissipate in year 2	DSGE/CGE/ SIR	4.7-14.5 (United States)[3]	

Note: Losses are reported relative to a baseline level of GDP or growth rate, which are approximately equivalent. Median of the first year GDP loss in advanced economies/EMDEs are reported.

1. Calculated as the deviation of the forecast in the IMF's April 2020 *World Economic Outlook* relative to its January 2020 *World Economic Outlook Update*. Upper bound is calculated under the scenario such that containment measures last 50 percent longer than baseline. Upper bound numbers are rounded to nearest integer.

2. 90 percent confidence interval of year-on-year change on quarterly GDP in the worst quarter.

3. Indicates a GDP impact based on the study's cited consumption impact of 7 percent without containment and 22 percent with containment, and assuming that consumption accounts for two-thirds of GDP.