The **Global Costs** of an Influenza Pandemic

By Warwick J. McKibbin and Alexandra A. Sidorenko

The deaths of 187 people in 12 countries through May 2007 from Type A (H5N1) avian influenza has raised fears that bird flu could trigger the next influenza pandemic – perhaps even one on the scale of the Spanish flu that swept the world in 1918. While we are in some ways better prepared to deal with a public-health emergency on this scale than we were a century ago, the integrated nature of the global economy – the dependence on global markets for goods, services and capital – may leave us more vulnerable to a pandemic's accompanying economic shocks. We can estimate the economic consequences of pandemics, based on computer simulations incorporating what we know about influenza transmission and the likely response by governments, as well as by markets.

left: iain masterton/alamy; right: john stanmeyer/vii

SOME GRIM FACTS

Influenza pandemics have been recorded for more than three centuries, a period in which there have been 10 probable and three possible outbreaks. The flu is not the deadliest of all infectious diseases – smallpox, various hemorrhagic fevers and rabies kill a much higher proportion of those who contract them. But it is spread more easily, and hence has the capacity to infect a larger proportion of the population. In the parlance of epidemiologists, its "attack rate" is high.

Influenza Type A, the category to which H5N1 belongs, is both the most common and the least stable of the known human influenza viruses. Its evolutionary skills include an ability to change rapidly and to use animals as reservoirs in which to exchange genes. Three known influenza pandemics in the 20th century – the Spanish influenza of 1918-19, the Asian influenza of 1957-58 and the Hong Kong influenza of 1968-69 – were caused by influenza A viruses. The gravity of clinical symptoms of the Spanish flu, which disproportionally killed young adults, made it the "deadliest plague in history," according to John Barry, the author of *The Great Influenza*, an insightful account of the events of 1918.

The natural reservoirs of influenza A are humans and waterfowl. Pigs can be infected by both human and avian strains, providing a mixing bowl for virus "reassortment" – creating a strain that can be passed easily from human to human. The high density of the human population and its proximity to pigs and waterfowl make Asia a likely source of a future pandemic strain.

But efforts to predict flu pandemics have not succeeded. The best one can do is look to the record, which suggests an interval of 10 to 40 years between major outbreaks. Another pandemic, it seems, is overdue.

The emergence of a flu pandemic is virtually as unpredictable as an earthquake. Thus, the most we can do is to be alert and be prepared.

If a pandemic strain does emerge, its spread could be unprecedentedly rapid, thanks to mass travel by airplane. Border-control measures might postpone the arrival of infection, but don't offer much hope of stopping its transmission. An effective vaccine would not be available until months after the onset of the pandemic, since a vaccine accurately targeted for Type A virus can't be prepared ahead of time.

Moreover, flu-vaccine manufacturing capacity is concentrated in a handful of developed countries, and it would be difficult to gear up to the scale required to check a pandemic with billions of potential victims. Current vaccine technology crucially depends on the availability of fertilized chicken eggs, whose supply may be limited during the pandemic. And if the pandemic is caused by a highly pathogenic virus, like H5N1, the technology will be difficult to manage safely.

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Epidemiologists always remind us to expect the unexpected with influenza. The emergence of a flu pandemic is virtually as unpredictable as an earthquake. Thus, the most we can do is to be alert and be prepared.

Since 1970, many countries have invested in the development of national-preparedness plans, along with a global surveillance system that includes a network of laboratories capable of identifying the virus. Challenges surrounding pandemic-preparedness planning include increasing the emergency capacity of critical-care facilities, building antiviral drug stockpiles and, of course, improving the ability to produce massive quantities of vaccine very quickly. All these measures are costly and need to be justified on the grounds of the expected benefits. Which is where economics fits in.

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HOW MUCH DOES A DISEASE COST?

Conventional analysis of the tangible economic costs of death and disability, the sort used by courts to determine damages, goes like this: using estimates of mortality and morbidity, one calculates the loss of future income during a working lifetime. Then one adds in the loss of time and income by spouses or relatives who must care for them, along with the cost of medical care and supporting services.

This approach has always been limited in the sense that it doesn't include the intangible value people place on their own lives. But it is becoming increasingly evident that conventional analysis is inappropriate even on its own terms for infectious diseases that have large numbers of victims and that lack a vaccine. Examples include the HIV/AIDS, Severe Acute Respiratory Syndrome (SARS) and influenza pandemics. The impact of these three diseases provide insight into the wider economic consequences of their spread.

HIV infection mostly affects the young and has a long-term demographic effect through decreased fertility and healthy-life

PREDICTED DEATHS IN EACH REGION (THOUSANDS)

	MILD		MODERATE		SEVERE		ULTRA	
	NUMBER	%POPULATION	NUMBER	%POPULATION	NUMBER	%POPULATION	NUMBER	%POPULATION
US	20.2	0.007%	201.9	0.07%	1,009.3	0.35%	2018.6	0.70%
Japan	21.5	0.017	214.6	0.17	1,073.1	0.84	2146.2	1.68
UK	7.6	0.013	76.0	0.13	380.0	0.64	759.9	1.28
Europe	56.5	0.010	565.5	0.10	2,827.4	0.50	5654.9	1.00
Canada	3.1	0.010	30.9	0.10	154.5	0.49	309.1	0.99
Australia	2.1	0.011	21.4	0.11	107.1	0.54	214.2	1.09
New Zealand	0.5	0.013	5.2	0.13	25.8	0.65	51.5	1.31
Indonesia	114.3	0.054	1,142.5	0.54	5,712.6	2.70	11,425.1	5.39
Malaysia	10.9	0.045	108.9	0.45	544.5	2.24	1,089.1	4.48
Philippines	41.5	0.052	415.5	0.52	2,077.5	2.60	4,155.0	5.20
Singapore	1.4	0.035	14.4	0.35	72.0	1.73	144.1	3.46
Thailand	16.2	0.026	162.1	0.26	810.3	1.32	1,620.5	2.63
China	284.9	0.022	2,848.6	0.22	14,242.8	1.11	28,485.6	2.22
India	242.4	0.023	2,423.6	0.23	12,118.1	1.16	24,236.1	2.31
Taiwan	5.6	0.025	55.9	0.25	279.4	1.24	558.8	2.48
Korea	11.8	0.025	117.5	0.25	587.6	1.23	1,175.2	2.47
Hong Kong	1.6	0.024	16.4	0.24	82.0	1.21	163.9	2.42
LDCs	330.9	0.022	3,308.6	0.22	16,543.1	1.08	33,086.2	2.15
EEFSU	67.1	0.013	670.7	0.13	3,353.7	0.66	6,707.3	1.32
OPEC	181.6	0.035	1,816.3	0.35	9,081.5	1.77	18,163.1	3.54
TOTAL	**1,421.6**	**0.022**	**14,216.5**	**0.22**	**71,082.3**	**1.10**	**142,164.5**	**2.21**

SOURCE: The authors

expectancy. The virus affects households, businesses and governments through lower household incomes, loss of labor supply and increased government spending for health care and support for orphans.

The flu virus is far more contagious than HIV, and the onset of an epidemic is sudden and unexpected. Hence, if the world's response to SARS is any indication, the spread of a strain similar to Spanish influenza in its virulence and the severity of symptoms would almost certainly induce panic.

Indeed, the SARS epidemic in 2003 demonstrated that even in an event with a relatively small number of cases and deaths, the global costs can be large and reach beyond the countries directly affected. Epidemics have significant effects on economies through large reductions in consumption of various goods and services (like tourism and group recreation), increases in business operating costs, and the flight of capital.

Several earlier studies have estimated the costs of hypothetical influenza pandemics. Martin Meltzer, Nancy Cox and Keiji Fukuda of the Centers for Disease Control and Prevention put the figure for the U.S. economy at $73-167 billion. The Asian Development Bank staff produced an estimate of a 2.6 to 6.5 percent loss for Asia's GDP and 0.6 percent for global GDP. Yet another study, by the U.S. Congressional Budget Office, estimated that a mild-to-severe pandemic would reduce U.S. GDP by between 1.5 and 5 percent.

We used our own technical study, published last year by the Lowy Institute for International Policy and the Australian National University's Center for Applied Macroeconomic Analysis, to outline the likely global economic consequences of an influenza pandemic under four possible scenarios:

- A mild pandemic, modeled on the 1968-69 Hong Kong Flu.
- A moderate pandemic, modeled on the Asian Flu of 1957-58.
- A severe pandemic, with mortality and

morbidity similar to that of the Spanish Flu of 1918-1919.
- An ultra pandemic, modeled on high-end estimates of casualties from the Spanish Flu.

THE MODEL

To simulate the economics of a flu pandemic, we used a computer model developed by Warwick McKibbin and Peter Wilcoxen (Syracuse University). It includes 20 countries or regions (the United States, Japan, the United Kingdom, Europe, Canada, Australia, New Zealand, Korea, China, India, Indonesia, Thailand, Taiwan, Hong Kong, Philippines, Singapore, Malaysia, Eastern Europe and the former Soviet Union, OPEC, and other developing economies) with six sectors of production in each economy (energy, mining, agriculture, durable-goods manufacturing, nondurable-goods manufacturing, and services). The equations capture both trade and financial market linkages between and within economies. A more detailed description is available at http://www.brookings.edu/views/papers/mckibbin/200602.htm.

The prediction of shocks associated with the spread of the flu follows the methods developed by McKibbin and Jong-Wha Lee for analyzing the economic costs of SARS, adapted to model the effect of a pandemic on each country. The model captures economic relationships among firms, consumers and governments. The regions in the model are linked by flows of goods and assets. Money supply and demand are also explicitly included in the equations. The impact of the spreading influenza pandemic is fed into the equations through a series of shocks constructed to match each of the four scenarios. The shocks are constructed for the benchmark economy, the United States, then scaled and adjusted by various factors for the other countries.

An influenza pandemic would be expected to lead to:
- A decline in the size of the labor force due to a rise in mortality and disabling illness.
- An increase in the cost of doing business, especially in the service sectors in which human interactions are largest.
- A shift in consumer preferences away from services that require exposure to other people, which is independent of the effects of changes in incomes and prices.
- A re-evaluation of investment risk in light of the responses of governments and their health systems to the influenza pandemic.

Epidemic shocks. We used two indicators to build the mortality shocks for each scenario in each country or region: an index of geographic susceptibility to an influenza pandemic and an index of health policy.

The index of geography reflects the ease with which the influenza virus can enter a country through air travel, and its capacity to spread within the country once introduced. The first (international) component of the geography index is based on air transport data. The domestic component is a measure of population density. The higher the density and frequency of contacts, the faster the spread of the epidemic.

The health policy index measures the likely efficiency of a country's health care system to deal with the pandemic, and is constructed from data on per capita health expenditure and influenza-specific policies in each country.

These two indexes combined create an index of mortality for each country. This translates into an aggregate world scenario defined in terms of total world deaths, with the mild scenario generating 1.4 million deaths (0.022 percent mortality), the moderate scenario 14 million deaths (0.22 percent mortality), the severe scenario 71 million deaths (1.1 percent mortality), and the ultra scenario 142 million

deaths (2.2 percent mortality).

There are substantial differences in mortality rates among countries. The hardest hit are Indonesia and the Philippines: in the "ultra" scenario, more than 5 percent of their population dies. The smallest shocks occur in the United States, Europe and Canada. These differences, together with the underlying structures of economies and the linkages through global trade and capital markets, drive the economic consequences.

GDP LOSS BY REGION (PERCENTAGE CHANGE, 2006)

	MILD	MODERATE	SEVERE	ULTRA
US	–0.6%	–1.4%	–3.0%	–5.5%
Japan	–1.0	–3.3	–8.3	–15.8
UK	–0.7	–2.4	–5.8	–11.1
Europe	–0.7	–1.9	–4.3	–8.0
Canada	–0.7	–1.5	–3.1	–5.7
Australia	–0.8	–2.4	–5.6	–10.6
New Zealand	–1.4	–4.0	–9.4	–17.7
Indonesia	–0.9	–3.6	–9.2	–18.0
Malaysia	–0.8	–3.4	–8.4	–16.3
Philippines	–1.5	–7.3	–19.3	–37.8
Singapore	–0.9	–4.4	–11.1	–21.7
Thailand	–0.4	–2.1	–5.3	–10.3
China	–0.7	–2.1	–4.8	–9.1
India	–0.6	–2.1	–4.9	–9.3
Taiwan	–0.8	–2.9	–7.1	–13.8
Korea	–0.8	–3.2	–7.8	–15.1
Hong Kong	–1.2	–9.3	–26.8	–53.5
LDCs	–0.6	–2.4	–6.3	–12.2
EEFSU	–0.6	–1.4	–2.9	–5.4
OPEC	–0.7	–2.8	–7.0	–13.6

SOURCE: The authors

Impact on labor supply. The morbidity rate captures losses due to absenteeism, including workers who stay out to care for family members. In the mild scenario, this effect dominates the impact on the labor force in the first year, but has no long-term consequences. Deaths, of course, lead to a permanent loss of labor. Under the severe and ultra scenarios, the morbidity shocks are assumed to halve within a year and then disappear altogether in the second year. The mortality shocks are much larger for developing countries.

Sector exposure. Some productive sectors would be particularly vulnerable to a pandemic. We calculate the share of these vulnerable sectors in each country's GDP. Note that there are major differences in the structure of service industries across economies, from less then 2 percent of exposed services in China to more than 35 percent in Hong Kong. These sector-exposure indexes are used to weight the effect of mortality shocks on both production costs and demand.

Risk-premium calculations. The initial "risk premium" added to the cost of capital is calculated for individual countries. In the model, large differences in these risk premiums among countries lead to rapid movement of capital – capital flight – and attendant dislocation in financial markets.

Shocks to costs of production. The shocks to costs of doing business are assumed to vary across sectors, countries and scenarios, and are based on the Lee and McKibbin SARS study. The shocks to service industries are adjusted by the service sector exposure index. This difference shows up starkly in China, where it is small relative to the other countries.

Shocks to demand. The model generates shifts in spending patterns as a result of the changes in tastes, incomes, wealth and relative prices – cable television would presumably fare far better than live concerts. We model this behavior by imposing shocks on the demand for various products, following the spending shifts assumed by Lee and McKibbin for the SARS observations in Hong Kong and Singapore.

Shocks to risk. The risk premium weights discussed earlier are combined with the mortality shocks to produce a risk-premium shock for all countries. This indicator of the degree

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of financial panic suggests that the countries most prone to panic are those in East Asia and other developing areas.

The numbers. As the labor supply contracts because of mortality and morbidity, the return on capital falls in all affected countries – but more so in those countries experiencing larger shocks. Growth slows everywhere as output falls. But the differences among countries imply that financial capital will flow from the developing countries to the United States and Europe, where investors feel safer. In the model, Japan experiences a larger mortality shock than North America and Europe, and takes an extra hit as well from the fact that its economy is more closely tied to East Asia and is thus less of a safe haven than the other rich economies.

In the mild scenario, the labor-force shock is the largest driver of the GDP contraction in most countries. Next most important is the increase in the costs of production. The fall in GDP is significant even in this scenario, ranging from 0.6 percent for the United States to 1.5 percent in the Philippines. The contribution of capital flight and demand shifts are small relative to the supply-side shocks.

In the severe scenario, the world economy is truly hammered by the pandemic. In parts of Asia, GDP contracts by as much one-fourth – a major shock by any measure. The relatively large contraction in Asia compared to the United States and Europe partly reflects the much larger shocks in these economies as well as the flight of capital to North America and Europe. The cost shocks also play a much larger role on the GDP losses in the severe scenario. Financial markets close down as the shocks intensify.

As the pandemic grows more damaging in increasingly severe scenarios, the largest GDP losses are linked to rising production costs. The panic component captured by capital flight appears to have much less effect on GDP than the fundamentals driven by supply shocks. In addition, the effects on wealth and income

are larger in developing countries, and the contraction of demand is therefore much larger than in Europe and North America.

Japan is an intermediate case, since it would experience a larger shock than other industrialized economies but a smaller one than the rest of East Asia. Japan is also more integrated with the collapsing East Asian economies, and bears a secondary burden associated with a decline in regional trade.

The loss of labor through deaths and sickness reduces output in all countries and can be expected to raise inflation in the short run to the extent that output falls by more than demand falls because of contraction of income and wealth. Because the shock is expected to be temporary, households would respond to falling income by reducing savings – and thus consumption would remain relatively strong. The rise in the cost of doing business also tends to push up prices. On the other side of the ledger, the shift in demand away from the most vulnerable productive sectors tends to lower the relative price of those products and services, while the imposed fall in aggregate spending (investment, in particular) also tends to lower prices.

These opposing factors act to create inflation in most economies. The standout exception in the model is Hong Kong, but there is also mild deflation in the Philippines, Malaysia and New Zealand.

The model's assumptions imply that, in most countries, stock prices fall and interest rates fall along with them as investors shift from stocks to bonds. This is not true in Hong Kong and the developing-country block which, by pegging their currencies to the U.S. dollar, are forced to raise interest rates in order to prevent currency depreciation. This tightening of domestic monetary policy increases the output losses from the pandemic, but reduces its inflationary potential. The U.S. dollar appreciates against all currencies except those tightly pegged to it.

Changes in countries' external financial accounts reflect changes in capital flows. As the scenarios worsen, there is a larger fall in equity prices in the more-affected economies; in the safe-haven economies like North America and Europe, stock prices fall less. This reflects capital inflow into these rich, stable economies, which ends up being invested in part in stocks.

Even a "small" pandemic would generate hundreds of billions in losses – and a disproportionate amount of those losses would be borne by developing countries.

Temporary rises in government spending tend to reduce the GDP loss in the most-affected economies, and to raise inflation (as well as short-term interest rates) in those economies. The fiscal response could be a critical determinant of the impact of the pandemic on bond markets.

WHAT IT ALL MEANS

Even a mild pandemic would likely make a noticeable dent in global economic output. The mild scenario, estimated to cost the world 1.4 million lives, would reduce total output by nearly one percent, or approximately $330 billion in the first year. As the assumed scale of the pandemic increases, so, of course, do the economic costs. A massive

global economic slowdown occurs in the "ultra" scenario in which more than 142 million people die and output in some developing economies shrinks by half in the year of the pandemic. The loss in output in this scenario is $4.4 trillion in the first year – 12.6 percent of global GDP. The composition of the slowdown differs sharply across countries, with a major shift of global capital from the affected economies to the less affected safe havens of North America and Europe.

Some robust results – that is, results that are not terribly sensitive to the model's underlying assumptions – do emerge. One is that stock markets fall and bond markets rally, although to differing degrees in different countries. The stock price reactions appear to be reasonably small because the economic hit associated with a pandemic takes place over a brief period and recoveries are quick. In addition, the fall in interest rates also buoys equity prices.

The second robust result is that monetary policy responses play a key role in determining economic consequences. Countries expected to focus on preventing exchange-rate depreciation end up with very tight money, which raises the costs of the pandemic. This is particularly true of Hong Kong, which receives the largest shock of any country thanks to its density and openness, yet has the most rigid exchange-rate regime.

We also find that the more severe the pandemic, the more that developing countries are hurt relative to North America and Europe; Japan is caught in the middle. The differences in the epidemiological outcome generate flows of capital from the most affected developing countries to industrialized economies, worsening the current account positions of the receiving countries and putting downward pressure on developing-countries' exchange rates. World trade would likely contract significantly.

Whether a pandemic causes inflation or deflation depends on the relative size of declines in demand and supply across sectors. Consumption-smoothing – the tendency of households to try to maintain living standards in the teeth of temporary distress – implies that aggregate demand would decline by less than supply. This, together with increases in the costs of doing business, suggests that inflation is a more likely consequence of pandemic than deflation. But a sufficiently strong shift in spending preferences that caused serious economic dislocation could lead to deflation. Countries that try to prevent exchange-rate changes are more likely to experience a deflationary shock as tight monetary policy compounds the economic contraction.

There is plainly a great deal of uncertainty about how individuals and markets would respond to mass illness and significant loss of life. Some things are clear, nonetheless. A 1918-style pandemic would destroy trillions of dollars of potential output along with millions of lives. Even a "small" pandemic would generate hundreds of billions in losses – and a disproportionate amount of those losses would be borne by developing countries, which could least afford the blow. At least one conclusion, then, is crystal clear: it would pay to invest considerable resources now to prevent a flu pandemic and to prepare for the consequences of massive economic jolts if the pandemic does come.

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