



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Assessment of economic vulnerability to infectious disease crises

Peter Sands, Anas El Turabi, Philip A Saynisch, Victor J Dzau

Infectious disease crises have substantial economic impact. Yet mainstream macroeconomic forecasting rarely takes account of the risk of potential pandemics. This oversight contributes to persistent underestimation of infectious disease risk and consequent underinvestment in preparedness and response to infectious disease crises. One reason why economists fail to include economic vulnerability to infectious disease threats in their assessments is the absence of readily available and digestible input data to inform such analysis. In this Viewpoint we suggest an approach by which the global health community can help to generate such inputs, and a framework to use these inputs to assess the economic vulnerability to infectious disease crises of individual countries and regions. We argue that incorporation of these risks in influential macroeconomic analyses such as the reports from the International Monetary Fund's Article IV consultations, rating agencies and risk consultancies would simultaneously improve the quality of economic risk forecasting and reinforce individual government and donor incentives to mitigate infectious disease risks.

Introduction

Pandemics can devastate human lives and livelihoods on a scale only matched by wars, financial crises, and environmental disasters. Infectious disease crises can cause immense economic disruption. The west African countries of Guinea, Sierra Leone, and Liberia have suffered a cumulative economic loss of at least 10% of gross domestic product (GDP) as a result of Ebola virus disease.^{1,2} Zika virus is already having a substantial effect on the Caribbean tourism industry as young couples go elsewhere for their honeymoons. In its report titled *The Neglected Dimension of Global Security: A Framework to Counter Infectious Disease Crises*, the US National Academy of Medicine's Commission on A Global Health Risk Framework for the Future (the Commission)³ suggested that average expected economic losses from infectious disease crises might amount to over US\$60 billion per year.⁴ This figure included only the direct economic costs. Fan and colleagues⁵ suggest that on a more inclusive basis, taking into account mortality costs, annual expected losses might amount to \$490 billion, a staggering figure. Given the scale of these costs, pandemic prevention and response must be treated as a matter of human and economic security, not purely as a health issue.

Such estimates are immensely uncertain, given the inherent difficulties of predicting pandemics and the associated economic impact. However, there is no room for complacency. The rate of emergence of new infectious diseases appears to be increasing,⁶ a function, presumably, of growth in human population and consequent increase of animal–human interaction. Globalisation, as reflected in ever-increasing trade and travel, makes it easier for outbreaks to become epidemics and, potentially, pandemics.

Medical advances mean we now have many more tools to contain the morbidity and mortality effect of such infectious disease crises. By contrast, we appear to have become more vulnerable to the economic impact of such

outbreaks. In a media-saturated world, fear spreads faster than any disease, and it is fear that drives behavioural change and in turn, economic impact.⁷ Fear of infection prompts tourists to cancel holidays, businessmen to cancel meetings, and politicians to close borders. The same fear of contagion leads governments to close schools, individuals to avoid cinemas, and restaurants and consumers to avoid buying goods from afflicted countries.

Both history and present analysis would suggest that infectious disease crises are one of the biggest risks to economic growth for individual countries, regions, and the world as a whole. Yet a look at the most authoritative analyses of the risks to economic growth and stability shows barely any reference to infectious diseases. Typically, the risks infectious diseases pose to economic growth and stability are only mentioned when the outbreak has already occurred, such as the impact of Ebola virus disease on west Africa,¹ Zika virus on Brazil,⁸ or HIV/AIDS across Africa.⁹ There are few substantive, forward-looking analyses of infectious disease vulnerability incorporated into overall assessments of economic growth and stability. This is true of the reports produced by major multilateral entities such as the International Monetary Fund (IMF), World Bank, or Organisation of Economic Cooperation and Development, and the regional development banks such as the African Development Bank, Inter-American Development Bank, and Asian Development Bank. It is also true of most private sector analysts, such as rating agencies, investment banks, or country risk specialists, as well as academics.

The gap in risk assessment can be seen by examining how often thematic terms such as infectious disease, epidemic, or pandemic, or the names of specific diseases, such as Zika or Ebola are used in reports assessing macroeconomics prospects and risks for specific countries or regions, and whether these are used prospectively or only after the outbreak has occurred.

Lancet 2016; 388: 2443–48

Published Online

May 19, 2016

[http://dx.doi.org/10.1016/S0140-6736\(16\)30594-3](http://dx.doi.org/10.1016/S0140-6736(16)30594-3)

Harvard Kennedy School (P Sands MPA), and Harvard Graduate School of Arts and Sciences (A El Turabi MPhil), Cambridge, MA, USA; Harvard Business School, Boston, MA, USA (P Saynisch BA); and National Academy of Medicine, Washington, DC, USA (Prof V J Dzau MD)

Correspondence to:

Dr Victor J Dzau, National Academy of Medicine, Washington, DC 20001, USA
VDzau@nas.edu

Using text-mining software, we screened some of the more well known or authoritative sets of reports, including the reports of IMF's Article IV consultations, Standard & Poor's sovereign rating assessments, and reports from the Economist Intelligence Unit (EIU). We compared reports published in the 24 months before the first public declaration of a substantial infectious disease outbreak with reports published in the 24 months after. Where the search filters identified the use of at least one of the target search terms, we did a manual review to understand the context of the results returned.

The dichotomy between prospective assessment of risk and post-event analysis of impact can be illustrated by

See Online for appendix

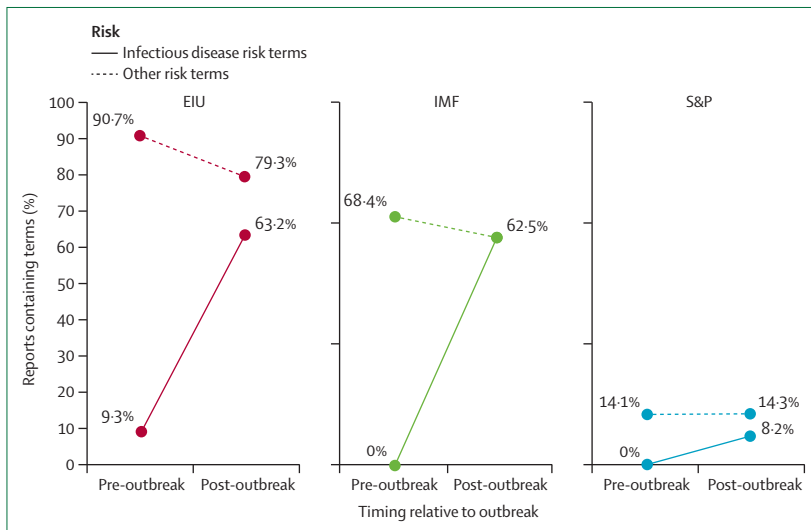


Figure 1: Changes in prevalence of infectious disease and other risk search terms in 24 months before and after major infectious disease outbreaks (2001–16)

EIU=Economist Intelligence Unit. IMF=International Monetary Fund. S&P=Standard & Poor.

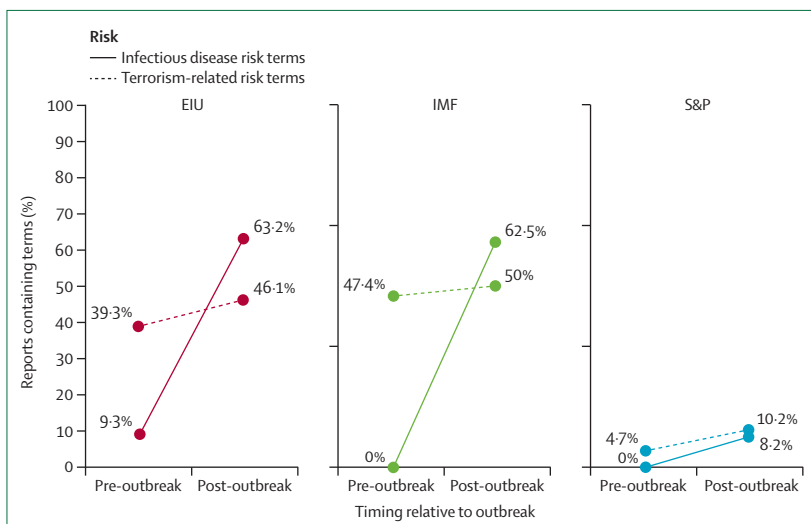


Figure 2: Changes in prevalence of infectious disease and terrorism-related terms in 24 months before and after major infectious disease outbreaks (2001–16)

EIU=Economist Intelligence Unit. IMF=International Monetary Fund. S&P=Standard & Poor.

looking at economic risk analyses of countries that have been afflicted by infectious disease outbreaks, such as Hong Kong with severe acute respiratory syndrome (SARS), Korea with Middle East respiratory syndrome (MERS), or most recently, Brazil and Colombia with Zika virus (figure 1). For example, looking at the IMF Article IV reports for the 15 countries most affected by four of the most substantial infectious disease crises in recent years (SARS, MERS, Ebola, and Zika), none mentioned the risk to economic growth posed by potential infectious disease crises before the outbreaks occurred, whereas most commented on the outbreaks' impact on economic growth after the event took place. In the EIU reports published before the relevant infectious disease outbreaks, only 23 (9%) of 247 reports mentioned the relevant search terms. However, manual review of these 23 instances reveals that most of these mentions referred to the use of terms such as epidemic in a non-infectious disease sense (eg, epidemic of violence).

Comparison of our infectious disease risk term results with those for the risk term terrorism was instructive. Using the same reports described previously, we compared the percentage of reports that contained any infectious disease risk term with the percentage containing a terrorism risk term. In reports from the group of 15 countries chosen because they experienced infectious disease outbreaks, the term terrorism was mentioned much more frequently before the outbreak took place, and almost as frequently after the outbreak (figure 2). Further detail on the analysis used to generate these figures is included in the appendix.

This is not to say that no assessment of the economic risks of potential pandemics takes place. For example, the World Bank has estimated the costs of an influenza pandemic akin to the 1918–19 Spanish influenza to be at about 5% of global GDP, or more than \$3 trillion.¹⁰ Major reinsurers, such as Swiss Re and Munich Re also publish reports on the risks of pandemics. Yet these are almost invariably high-level assessments of global risk, rather than more granular analyses at a country or regional level taking into account specific drivers of vulnerability or varying levels of preparedness.^{11–15} Moreover, the results of such thematic analyses are rarely, if ever, reflected in overall assessment of economic prospects.

Why have risks of infectious disease crises not been incorporated in economic risk assessments? First, economic analysts are not immune to the broader human tendency to struggle with low probability, high-impact risks that Kahneman¹⁶ and Taleb¹⁷ have described so vividly. We either wildly overestimate such tail risks or grossly underestimate them, to the point of ignoring them, depending on factors such as how recently the risk has been experienced (the availability heuristic), whether it triggers a fear response (eg, terrorism), or how it is framed (eg, is it brought to life in stories of individuals?).

A second factor might be the relevant timeframe. Much macroeconomic risk analysis is written with a focus on

the next 12 months, because that is the timeframe of relevance to most recipients, whether in government or the financial markets, given the policy or investment decisions they need to make. This means there might be a limited demand for such analyses to incorporate assessments of certain types of risks, such as high probability, but longer term issues (such as climate change) or low probability, high-impact events (such as pandemics), because the likelihood of them occurring in the timeframe of relevance to the reader is extremely low.

Finally, economists seem to be most comfortable assessing risks for which there is good input data and an abundance of theory. Anecdotal evidence suggests that the absence of readily digestible input data is a major reason for the absence of infectious disease risks from mainstream economic analysis. Economists who concede that such risks should be included in their macroeconomic analyses often explain their absence by saying they do not have the expertise or information to include them. To their credit, the IMF have recognised this weakness and are now talking explicitly about the need to incorporate non-economic factors such as climate change and health risks into their overall macroeconomic analyses. So how should the IMF, World Bank, and others go about including the risks from potential pandemics in their regular assessments of countries' economic stability and prospects and of the appropriateness of government policies? We propose an approach comprising four components.

1) A robust and comparable assessment of the intrinsic vulnerability of individual countries to infectious disease threats

This component of our approach focuses on four indicators of vulnerability: first, a country's history of infectious disease outbreaks should be considered. This is not to claim that the historical record is a strong predictor: such data gives an indication of vulnerability, particularly to specific pathogens that have already been observed in a country, but provides less help with new pathogens, or ones that might turn up from elsewhere. However, as Jones and colleagues⁶ describe, emerging infectious disease events show "non-random global patterns"; in other words, history of incidence provides some guide to the future. Moreover, much good work has already been done in recent months to develop more robust historical data, at least for certain pathogens, in the context of the World Bank's Pandemic Emergency Facility, because the triggers and pricing have been informed by detailed analysis of WHO's outbreak data.¹⁸

Second, environmental indicators of vulnerability to specific disease threats should be taken into account. For example, the presence of the mosquito vector *Aedes aegypti* is an obvious determinant of a country's susceptibility to Zika or chikungunya virus.

Third, drivers of susceptibility to infectious disease threats arising from human factors, range from social

practices, such as food production or burial rites, to societal trends, such as urbanisation, and to politics and policy. For example, sources of meat production, from reliance on bush meat to the prevalence of intensive but informal poultry producers, can influence vulnerability to zoonotic transmission. Rapid urbanisation or migration leading to overcrowding and overburdened sanitation systems is a determinant of vulnerability to infectious diseases like cholera.

Fourth, a broad assessment of the strengths and weaknesses of the overall health system, particularly public health and primary care should be done. Although the Commission recommended external assessment of specified capabilities and infrastructure for pandemic preparedness and response, it also recognised that these operate as part of, and rely on, the overall health system. For example, weaknesses in delivery of primary care will undermine the ability of the public health system to do disease surveillance and respond effectively to outbreaks. Likewise, deficiencies in infection control procedures in hospitals can turn such institutions into inadvertent accelerators of contagion.

WHO already generate forms of intrinsic risk assessments, as do individual countries' public health agencies and various universities and institutes, but not in a way that is easily comparable across countries and across pathogens, and thus readily usable as an input into economic analysis. There are analyses of different countries' susceptibilities to specific pathogens. For example, the World Bank produced a preliminary analysis of the potential impact of Zika virus across Latin America and the Caribbean in February, 2016.⁸ Some national public health agencies, such as the US Center for Disease Control, or in the UK, Public Health England, produce analyses of their own vulnerability to different infectious disease threats. But all of these analyses use different methods and formats. For the assessment of the strength of the overall health system, various potential sources exist. For example, for primary care, the Primary Health Care Performance Initiative (PHCPI) seeks to provide a comprehensive set of similar metrics.¹⁹

We envisage a matrix with the most threatening infectious diseases on one dimension and countries along the other, with a score of intrinsic vulnerability populated in each cell. Of course, there would be challenges in the implementation of such an approach. To create a composite score of intrinsic vulnerability to specific diseases would entail making judgments on the relative importance of different factors. In large countries, substantial variations in vulnerability between different regions could occur. To make the score similar across different diseases would entail making judgments on the relative probabilities and severity of different types of outbreak. Even definition of which infectious diseases to include on the matrix would involve some debate (and thought would have to be given as to how to accommodate as yet unknown diseases). But wrestling with such

judgments could itself deliver benefits, because it would act as a catalyst to data gathering and analysis to support these judgments.

Such a matrix of intrinsic vulnerability would only be valuable if it was continuously kept up to date, incorporating new information as it emerges. For example, if we had created such a matrix a few years ago, we might not have included Zika virus as a priority disease, given the perception of its limited severity at that point.

Who should build and maintain such a matrix? Public health and academic institutions around the world could take the lead in populating the matrix. But the key is to ensure common definitions and standards. WHO should take the lead in this respect, convening experts from leading public health bodies and academic institutions to develop a common method.

2) A rigorous and objective assessment of each country's public health core capabilities with respect to pandemic preparedness and response

The establishment of regular, external, and published assessments of national core capabilities was one of the Commission's key recommendations.³ Indeed, the Commission recommended that WHO develop "precise definition and benchmarks for national core capabilities and functioning" (recommendation B.1); that the WHO devise a "regular, independent, transparent and objective assessment mechanism to evaluate country performance against the benchmarks" (recommendation B.2); and that countries should "commit to participate in the external assessment process...including publication of the results" (recommendation B.3).

This assessment would incorporate compliance with the International Health Regulations 2005 (IHR2005) and would include assessment of component capabilities such as disease surveillance, laboratory networks for diagnostics, contact tracing, and emergency planning.

At the moment, countries self-assess compliance with IHR2005 using WHO's IHR Core Capacity Monitoring Framework and accompanying tool. However, even though this approach, introduced in 2011, represents a substantial improvement on past methods, it still lacks granularity, and because it relies on self-assessment, also lacks credibility. Even on this basis, less than 40% of

countries assess themselves to be compliant with IHR2005.²⁰ To build a more rigorous approach is perfectly feasible. Under the Global Health Security Agenda, a peer-based assessment process has been piloted in five countries.²¹ The World Organisation for Animal Health also has a well established system of external assessment of performance against the Terrestrial Animal Health Code. These initiatives provide good starting points to design a more comprehensive system. The conclusions of the Review Committee of the Role of the IHR2005, which will shortly be reported to the World Health Assembly, will be immensely important in shaping the way forward. The Review Committee was tasked to recommend steps to improve the functioning, transparency, effectiveness, and efficiency of the IHR2005.²² We hope that the committee will recommend the establishment of a robust external assessment mechanism along the lines put forward by the Commission.

Regular, rigorous, and transparent assessment of national core capabilities would have several advantages. Such an analysis would make it easier for governments and donor partners to identify priorities. It would also help to track the progress in rectifying deficiencies, and enable civil society to hold governments' accountable. In the context of what we are considering in this Viewpoint, this approach would provide a basis for assessing the degree to which the intrinsic risks a country faces are effectively mitigated by a country's public health capabilities and infrastructure.

Although WHO do not necessarily need to perform such assessments (because they could be done on a peer assessment basis or through hiring appropriate external third parties) we believe that WHO should be the entity that exercises overall stewardship of the assessment mechanism, ensuring the continued relevance and consistency of definitions and benchmarks, consistency of assessment methods, and transparency on outcomes.

3) An analysis of overall economic vulnerability to infectious disease crises based on the sectoral composition of the economy

Countries vary substantially in how important different industrial sectors are to the overall economy. Industrial sectors vary significantly in their vulnerability to infectious disease crises. Economies that are more

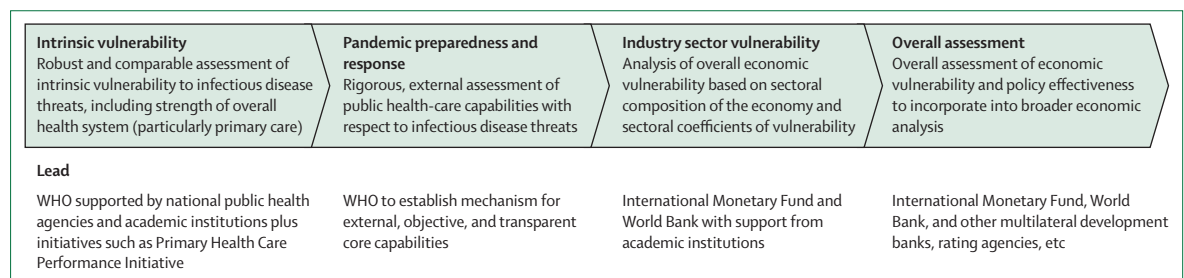


Figure 3: Proposed approach to assessment of economic vulnerability to infectious disease crises

dependent on travel and tourism will be more vulnerable to economic disruption from potential pandemics than those focused on, for example, primary resources such as mining or energy. Working with WHO, and potentially with leaders from the relevant industries, the World Bank and IMF should be in a position to develop industry sector coefficients of vulnerability to infectious diseases (these might be crude at first, but can be refined over time). Together with existing country data on sectoral mix, these coefficients can then be used to develop an overall picture of the degree to which a country's economic activity is susceptible to infectious disease risks. As well as providing crucial input into the assessment of economic vulnerability, such an exercise could be used to engage relevant industry leaders in each sector in thinking through their own vulnerabilities and therefore their own priorities in terms of preparedness and response. Having private sector players understand more fully what is at stake and what part they must play is a vital (and often, undermanaged) part of a country's overall strategy for preparedness and response.

4) An overall assessment of economic vulnerability and policy effectiveness combining components 1, 2, and 3

The results of the assessment of intrinsic vulnerability, state of preparedness, and industry sector vulnerability can be translated into an overall assessment of a country's economic vulnerability and policy effectiveness. This in turn can be incorporated into broader economic analysis of a country's economic prospects, blended with other financial and non-financial risks and analysis of the underlying determinants of economic growth and stability. In other words, given the outputs of the first three components of our proposed approach, macro-economists at the IMF, World Bank, and elsewhere should be able to factor infectious disease risks into their overall economic risk analyses in a systematic and structured manner.

A rigorous approach (figure 3) to assessment of economic vulnerability to infectious disease risks would have important benefits.

First, this approach would address an obvious gap in our analysis of the risks facing specific economies. This analysis should be done prospectively, not just after outbreaks have occurred. If the IMF included such an analysis into Article IV consultations it would send a powerful message to other analysts of economic risk, such as rating agencies, investment banks, buy-side research teams, and economic consultancies. More frequent and structured analysis of such risks would in turn increase their visibility to capital market participants and companies.

Second, inclusion of economic vulnerability to infectious disease risk into Article IV consultations and other economic assessments would ensure that

governments, donors, foreign investors, and bond markets pay greater attention to how these risks should be managed and mitigated. For the poorest countries, inclusion of these assessments would inform discussions on priorities with development partners, given the risks to growth and development posed by infectious disease crises. For middle-income countries and the advanced economies, such assessments would sharpen the economic incentive to devote sufficient resources to pandemic preparedness and response. Finance ministers would view investment in public health capabilities differently if these capabilities featured in the IMF's assessment of their country's policy effectiveness, or in rating agency assessments. Funding for pandemic preparedness and response would go from being a problem for the health minister to being firmly on the agenda of the finance minister as well. In this way, regular assessment of the risks that infectious disease crises pose to economic growth and stability would help reverse the neglect of this dimension of global security.

Conclusion

Infectious disease crises have been the neglected dimension of global security for too long. We have underestimated their threat to human lives and livelihoods, and as a result, have underinvested in preparedness and response to infectious disease outbreaks. Stronger public health capabilities at a national level are the first line of defence against such threats. Systematically including analyses of economic vulnerability to infectious disease crises in overall assessments of economic growth and stability would direct greater attention to these capabilities and reinforce the incentives to strengthen them. Generating such assessments of economic vulnerability is feasible through the structured approach put forward in this Viewpoint.

However, making this happen requires input and leadership from the global health community, led by WHO. Leaving this responsibility to the private sector or even the multilateral financial institutions to do on their own has not worked in the past and is unlikely to work in the future. Although economists now have a greater awareness of the need to think more systematically about the risks to economic growth and stability from infectious disease crises, neither the private sector nor the multilateral financial institutions have ready access to the inputs required to do such an analysis at the level of individual countries in a rigorous manner. The global health community should therefore work with its partners to provide these inputs, focusing in particular on a consistent approach to assessment of individual countries' intrinsic vulnerability to infectious diseases, and objective, external benchmarking of national core capabilities. The goal is straightforward: making the economic threat posed by economic diseases more visible to policy-makers and the private sector will make it easier to mobilise the resources to prevent and mitigate such risks.

Contributors

This Viewpoint was conceived by PS and VJD following the deliberations of the Commission on a Global Health Risk Framework for the Future. PS prepared the first draft and all authors contributed equally to revising the manuscript. AET, PS, and PAS designed the empirical analysis of published reports of macroeconomic risk. AET and PAS retrieved and analysed the reports and prepared supplementary materials.

Declaration of interests

We declare no competing interests.

Acknowledgments

The authors would like to thank all members of the Commission on a Global Health Risk Framework for the Future, as well as Larry Summers, Richard Zeckhauser, and Vladimir Mukharlyamov for their input and counsel.

References

- 1 United Nations Development Group–Western and Central Africa. Socio-economic impact of Ebola virus disease in West African countries. Addis Ababa: UNDG-WCA Ethiopia, 2015.
- 2 World Bank. The economic impact of the 2014 Ebola epidemic: Short and medium term estimates for West Africa. Washington, DC: World Bank, 2014.
- 3 Commission on a Global Health Risk Framework for the Future. The neglected dimension of global security: a framework to counter infectious disease crises. *J Clin Psychol* 2016; **33**: 1125–27.
- 4 Sands P, Mundaca-Shah C, Dzau VJ. The neglected dimension of global security—a framework for countering infectious-disease crises. *N Engl J Med* 2016; **374**: 1281–87.
- 5 Fan V, Summers L, Jamison D. The inclusive cost of pandemic influenza risk. Cambridge, MA: The National Bureau of Economic Research, 2016.
- 6 Jones KE, Patel NG, Levy MA, et al. Global trends in emerging infectious diseases. *Nature* 2008; **451**: 990–93.
- 7 Burns A, van der Mensbrugge D, Timmer H. Evaluating the economic consequences of avian influenza. Washington, DC: World Bank, 2008.
- 8 World Bank. The short-term economic costs of Zika in Latin America and the Caribbean (LCR). Washington, DC: World Bank, 2016.
- 9 Jamison DT, Sachs JD, Wang J. The effects of the AIDS epidemic on economic welfare in sub-Saharan Africa. Geneva: WHO, 2001.
- 10 Jonas O. Pandemic risk. Washington, DC: World Bank, 2014.
- 11 AIR Worldwide. The AIR pandemic model. Boston, MA: AIR Worldwide, 2016.
- 12 Munich Re. Pandemic, risk trading, geographical information systems. Topics 1/2007. München: Münchener Rückversicherungs-Gesellschaft, 2007.
- 13 Woolnough K, Ivanovic B, Kramer S, Busenhardt J. Pandemic influenza: a 21st century model for mortality shocks. In: Dickenson T, ed. Zurich: Swiss Re, 2007.
- 14 Baumgart C, Lemperteder R, Riswadkar A, Woolnough K, Zweimüller M. Influenza pandemics. CRO briefing Emerging Risks Initiative—Position Paper. Amstelveen: CRO Forum, 2007.
- 15 Risk Management Solutions. RMS pandemic influenza model overview. Silicon Valley, CA: Risk Management Solutions, 2007.
- 16 Kahneman D. Thinking, fast and slow. New York: Farrar, Straus, and Giroux, 2011.
- 17 Taleb NN. The black swan: the impact of highly improbable. New York: Random House, 2007.
- 18 The World Bank. Pandemic emergency facility: frequently asked questions. <http://www.worldbank.org/en/topic/pandemics/brief/pandemic-emergency-facility-frequently-asked-questions> (accessed April 22, 2016).
- 19 Primary Health Care Performance Initiative. About PHCPI. <http://phcperformanceinitiative.org/about-us/about-phcpi> (accessed April 22, 2016).
- 20 WHO. Implementation of the international health regulations (2005), report of the Review Committee on second extensions for establishing national public health capacities and on IHR implementation. Geneva: WHO, 2015.
- 21 Global Health Security Agenda. Assessments. <https://ghsagenda.org/assessments.html> (accessed April 22, 2016).
- 22 WHO. The Review Committee on the role of the international health regulations (2005) in the Ebola outbreak and response. <http://www.who.int/ihr/review-committee-2016/en/> (accessed April 26, 2016).