An Economic and Policy Framework for Pandemic Control and Prevention

Peter Daszak
Executive Vice President of EcoHealth Alliance

November 2016
A Significant Address Presented at the Scowcroft Institute’s Global Pandemic Policy Program Texas A&M University, College Station, Texas on Sept. 15-17, 2015

For more information: bush.tamu.edu/scowcroft/
An Economic and Policy Framework for Pandemic Control and Prevention

By Peter Daszak
President of EcoHealth Alliance

Human Activity is at the Root of Pandemic Diseases

Pandemics have a long history in our global population, from the Justinian Plague of AD541-2 through the Black Death of the middle ages to the 1918 flu and a series of recent infections such as HIV/AIDS, SARS, and Ebola. Pandemics are diseases with global spread, meaning they typically affect more than one continent. Historical reviews of the natural history of pandemics suggest some common themes: 1) in the majority of cases, they are caused by diseases that were previously unknown; 2) they often exploit new travel and trade networks; and 3) they frequently originate in wildlife species in remote regions. With the growing interface between human populations and wildlife species, and increases in globalization and air travel, it is likely that pandemic incidences will only become more frequent.

Many pandemics have their roots in emerging infectious disease (EID) events. These pandemic EIDs are essentially diseases on the move, increasing in case numbers, expanding their geographical footprint, changing their nature to become more virulent to people, or making the jump from animal hosts to people for the first time. The different scales of impact can be viewed as representing different stages of emergence, often with different underlying causal drivers (Fig. 1). For example, HIV-1 emerged from Chimpanzees in Central Africa in the early 20th Century when a person was contaminated by chimpanzee retrovirus (SIVCPZ) probably during hunting or butchering of bushmeat. This virus replicated in that person and evolved the capacity for person-to-person spread so that the epidemic smoldered within the human population for decades as the virus evolved into HIV-1. New patterns of human demography and movement in 1950s and 1960s were then exploited by HIV/AIDS as it invaded African cities, then spread globally with the rise of international air travel in the 1970s-80s. Not all EIDs are able to make the transition to pandemic, however. Some infect people, but are unable to spread from one person to another, either never achieving this, or only causing small, localized outbreaks.

Understanding what brings a disease into a population and causes it to evolve the ability for sustained human-to-human transmission can provide a potential policy framework for preventing pandemics because intervention strategies can be tailored to reduce the threat at its origin. However, before we can enact policies, we need to understand when and where to act and how much they will cost.

Most pandemics begin with an initial ‘spillover’ event, when people are infected by a disease typically exclusive to an animal reservoir (Stage 1). Some spillover events die out rapidly when pathogens can’t be transmitted among people, but, in other cases, pathogens do evolve the capacity for human-to-human transmission. These emerging pathogens often undergo repeated cycles of spillover (Stage 2) followed by small-scale spread (green in Fig. 1) and in some cases larger outbreaks (orange in Fig. 1).
Occasionally, pathogens that are transmissible between people enter globalized travel and trade networks to become pandemic (Stage 3). True pandemics are rare events, but extremely damaging when measured in morbidity, mortality, or economic damages.

**The Increasing Frequency and Cost of Pandemics**

Analysis of global databases of EID events provides important insights into recent and future trends in disease emergence, the underlying drivers of emergence, and potential strategies for control and prevention. Firstly, EIDs are increasing in frequency, even after correcting for increasing surveillance over time. The cause of this trend is likely attributed to decreasing boundaries between wildlife and human populations. Additional and related factors include, increasing human population density, land use change, wildlife trade, and agricultural intensification. Secondly, the proportion of EID events that become pandemic is likely to increase because the number of people traveling by air, road and sea is exponentially rising. Thirdly, the economic impact of emerging diseases is likely to increase in the future because trade and travel patterns are often disrupted by pandemics, causing significant financial losses. Finally, statistical analysis of correlates of EID origins show that there are distinct geographic regions from which future EIDs and pandemics will most likely originate. These emerging disease hotspots tend to be tropical regions rich in wildlife biodiversity with large and growing human populations (Fig. 2). As human populations increase and the human footprint expands, bringing us into closer contact with wildlife, livestock and each other, the incidence of EIDs has also begun to increase.
These analyses provide us with a strategic framework to develop policies to better control pandemics, and to prevent them from emerging in the first place. They also provide a way to allocate our global resources efficiently by targeting regions where pandemics are most likely to emerge, the people most likely to be the patient zero of the next pandemic, and the human-wildlife interface from which it is most likely to emerge.

The cost of pandemics is often out of proportion to the morbidity and mortality rates. In 2002-3, the first pandemic of the 21st Century began in a small group of people trading wildlife in Guangdong province, China. SARS eventually spread to 37 countries within a few months and led to a large impact on international travel and trade (between $10 and 50 Billion) despite the relatively small number infected (8,096 infections and 774 fatalities). In West Africa during 2013-15, Ebola virus spread from an initial focus in Guinea to cause the largest known outbreak of this virus, infecting over 28,000 people and causing mortality in more than 11,000. It spread to seven other countries, leading to disruption of air travel, controversial quarantine measures, and social unrest. The estimated cost of the outbreak is between $10 and $30 billion. Policies to prevent or control pandemics earlier in the chain of emergence are likely to be substantially cheaper and more cost-effective than the, often long term, societal changes needed to reduce their impact once they have spread globally.

**How rapidly should we enact a Global Strategy to thwart Pandemics?**

Given the global nature of pandemics, could there be a global, coordinated strategy to thwart them, and is this feasible, possible, or necessary? The geographical hotspots of pandemic emergence are critical to this challenge. Our analysis shows that diseases emerge predominantly in tropical, developing countries that have significant challenges with healthcare and prevention of existing diseases. Economic development often drives pandemic origins, with pressure to alter land use, expand cities, and build road networks. These economic actions put human populations into closer contact with wildlife that harbor novel, potentially zoonotic, pathogens. Once an emerging disease is able to spread person-to-person, it will naturally gravitate to the countries which have the highest rates of air travel, meaning that EID pandemics will likely have a large human and financial impact on developed countries as well as developing countries. Pandemics should thus be viewed as global commons problem that intrinsically requires international cooperation to solve.

The rising frequency of emerging diseases is critical to considerations of the necessity, feasibility and cost of a global pandemic strategy. The relative frequency of EID events (Stage 1 of pandemic emergence) has been measured for the past five decades and corrected for underlying reporting biases. Based on this data, we can predict that around five new EID events will occur each year, and about three of these will originate in animals. Additionally, the rise in EID frequency is exponential. This creates an interesting economic policy conundrum: As the frequency and economic impact of EIDs rise, our ability to prevent their initial spillover is reduced as it becomes too difficult or too costly.

The dynamics of pandemics can be modeled in economic terms to deduce how rapidly an
effective global strategy will need to be enacted for it to be cost-effective (Fig. 3).

Our real options model considers the increasing economic cost of pandemics as they increase in frequency. Given that current policies to control pandemic emergence are expensive, it considers a policy cost \( (k) \) that we will incur as soon as a global program is executed. The policies reduce damages straight away, but because they are costly, it pays to wait until the global damages from disease emergence exceed this cost before enacting them. This value of waiting can be deduced if we parameterize the model with data on EID event frequency, the cost of pandemics, and the cost of global programs to control and prevent them. Using this approach, we find that there is a relatively short window of 27 years within which it is optimal to execute a global program. However, given that national capacity building for the International Health Regulations (IHR) – which are the closest we have to a global policy to reduce pandemic risk - have significantly lagged behind national commitments, it seems that this waiting time window needs to be reduced even further. That is, a global policy enacted now would likely take a few years to adopt and roll out, so that the waiting time is effectively zero. Given this urgency, we now examine different strategies to thwart pandemics at each of the three stages of emergence in Figure 1.

The y-axis represents the net present value of the expected damages of an EID outbreak plus the cost, \( k \), of a policy if implemented. The x-axis represents expected damages over time. The blue line represents expected damages following business as usual, and the value of waiting is not considered. The green line represents the evolution of EID damages if a policy with cost, \( k \), is implemented. If the value of waiting is ignored, \( D_{\text{w}} \) is the threshold at which a policy should be implemented. The red line, known as the ‘continuation value’, illustrates the expected damages under business as usual including the value of waiting. The decision model simply takes the currently experienced damage, a point on the x-axis, and determines which of the three lines is lowest (has lowest expected present damages and costs). For damages less than \( D^* \) it is optimal to “continue” to wait. For all damages above \( D^* \) it is optimal to implement the policy. \( D^* \) is the optimal threshold.

**Preventing the Spillover of Novel Pathogens at Ground Zero (Stage 1 of Emergence)**

In order to develop effective pandemic prevention policies, the underlying drivers of pandemics must be targeted. However, reducing the drivers of EIDs and pandemics almost invariably means altering industrial, trade, agricultural or primary industry
activities, or human behavior over a large geographic scale. These drivers are often at the core of economic development for EID hotspot countries. For example, land use change is a significant driver of emerging disease and pandemic risk, but is central to the economic development of some well-forested tropical countries where EIDs tend to emerge. Thus, policies targeted at underlying drivers may be costly, politically unpopular, or unlikely to be realized. Despite these challenges, it may be possible to enact policies that reduce pandemic risk significantly if they are targeted to very specific activities or to very specific segments of the population. These may be more successful if there is strong political will to accomplish the prevention policies, if there are alternative profitable activities, or if there are clear health benefits to the industry or local community.

There is growing interest in designing new approaches to the underlying causes of pandemics. Firstly, the One Health movement focuses on the interaction between human health, livestock health, wildlife and environmental health. This approach has been used in a series of emerging disease and pandemic control programs because so many emerging diseases have animal origins and/or can be linked to environmental change. Three UN organizations directly involved in global efforts to counter emerging diseases and pandemics have formed a specific One Health collaboration. The Office International des Epizooties (OIE) or World Organization for Animal Health, the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) have signed a One Health tripartite agreement that builds capacity globally to reduce disease emergence among livestock, its spread through trade, and its pandemic potential in people.

Secondly, there is growing involvement of international development agencies and departments of defense in capacity building to prevent pandemics. In particular, USAID launched the Emerging Pandemic Threats (EPT) program to prevent the origin of new, potentially pandemic, agents. Additionally, if they do emerge, EPT can detect them at the earliest opportunity and build capacity for their control in developing countries within EID hotspot regions. This program includes predictive modeling to target hazardous activities and reduce costs; surveillance of wildlife, livestock and people for new pathogens of pandemic potential; human behavioral risk assessment to identify and target mitigation strategies; programs to increase inter-agency One Health collaboration in developing countries; and significant in-country training and capacity building (laboratory, diagnostics, research, and surveillance). Total investment so far in this program is over $500 million. The geographic targeting of this initiative means that these investments have led to significant returns and proof-of-concept in pandemic prevention. This includes the discovery of hundreds of novel viral agents in hotspot countries. Some of these have been identified as causing human infections and outbreaks, while others found in wildlife have been shown to have the potential to infect and cause illness in people.

Thirdly, some programs are beginning to tackle the links between certain industries and disease emergence directly. The IDRAM initiative from Chatham House
works with extractive industries to reduce risk of known and new pathogen emergence to their staff and local communities as a result of extractive operations. The USAID IDEEAL program measures the economic damages associated with diseases emerging during tropical forest land use change, then works with the land planners, ecotourism and the intensive agricultural industries to simultaneously reduce their footprint and the risk of new emerging diseases. It is often necessary to develop approaches that can be seen as a benefit to the industry making the change. This may include creating a competitive edge with a ‘greener’ image for a company, identifying alternative worksites that reduce the risk of disease emergence, demonstrating improved health for a company’s employees, or designing strategies that reduce risk to avoid potential legislation or liability. The latter may become particularly important to drive investment in these programs.

**Containing Epidemics at the Site of Emergence (Stage 2)**

Emerging diseases that have spilled over from wildlife to people often die out after small, localized outbreaks. Sometimes these diseases can even be disruptive, causing localized outbreaks with significant mortality. If infected individuals travel to dense urban centers or across borders, these diseases can become far more significant. Ebola is a prime example of this. Of around 30 previously known outbreaks of Ebola virus, almost all have been localized to a single country, and only seven caused more than 100 cases. In December 2013, an outbreak of Ebola virus began in Guinea, and spread to Liberia and Sierra Leone through their porous borders. By May 2014 Ebola had begun to infect people in the urban center of Conakry, leading to the most significant outbreak so far known. Thus, rapid detection and control of small localized outbreaks is critical to preventing a widespread epidemic with the potential to evolve into a pandemic.

The policy measures to prevent epidemics from making the jump to pandemics, must involve enhancing local in-country capacity to detect, diagnose, and control outbreaks. There are many ways to do this, from academic exchange among countries to non-governmental organization (NGO) activities. However, the success of these efforts depends on the vagaries of governance structures and capacity at the sites where the EID first emerges. The recently launched Global Health Security Agenda aims to counter this problem by specifically identifying and assisting countries most in need of capacity building to combat the threat of pandemics.

**Controlling Pandemics across Multinational Boundaries (Stage 3)**

In the final stage of the spillover- epidemic-pandemic continuum (Fig. 1), novel pathogens have acquired the ability to spread across international boundaries and achieve true pandemic status. Once pathogens are in the network of air travel and global trade, spread can be extremely rapid. The 2009 H1N1 pandemic, which originated in Mexico, had spread as far as New Zealand within 8 weeks of the presumed origin and the virus had infected between 43 and 89 million people within 12 months. Some diseases are capable of global spread even without the capacity for human-to-human transmission, such as West Nile virus, which is carried by mosquitoes and could be easily
transported within passenger and cargo flights.

Is there a global policy framework once diseases have reached a pandemic level of spread? At this point, containment is often the top priority during a disease outbreak. Policies to achieve this include quarantine, flight restrictions, and the rapid deployment of drugs and vaccines. Each of these policies is costly. The price tag of the West African Ebola outbreak control has not been accurately calculated yet, but is likely to be between $10 and 30 billion. Similarly, the global outbreak of SARS in 2003 caused only 8,096 cases and 774 deaths – orders of magnitude lower than the West African Ebola outbreak or typical seasonal flu outbreaks. Yet the cost of SARS is staggering – between $10 and 50 billion.

**How much will Pandemic Prevention and Control Cost?**

Policies for dealing with problems of the global commons are expensive and difficult to enact. For pandemics, our real options model (Fig. 3) provides a framework to estimate cost and assess which strategies are most cost effective. To do this, we set a goal of reducing the continued rise in the frequency of pandemics by 50%. We considered two approaches based on climate change scenario modeling: 1) Adaptation to the annual rise in pandemic frequency, with the model parameterized with data from programs that control pandemics (phase 3 in Fig. 1), e.g. vaccination strategies, outbreak control; and 2) Mitigation of the underlying causes of pandemics (Phase 1 in Fig. 1), parameterized with data from programs that address EID drivers (e.g. the FAO/OIE/WHO One Health framework). In this approach, the rise in pandemics mirrors the rise in CO2, such that we have a choice of continuing business-as-usual and adapting to growing pandemic emergence by relying solely on vaccines and outbreak control; or mitigating the underlying drivers to reduce the number of novel pathogens emerging at ground zero. Our model demonstrates that, in the long term, mitigation programs are more cost-effective than business-as-usual, saving between $344.0.7 billion and $360.3 billion over the next 100 years if implemented today.12

Secondly, we can use our optimal cost-benefit analysis to estimate the global cost of reducing the number of new pandemics emerging each year by 50%. This is an expensive policy involving a one-time cost of approximately $343.7 billion. This hypothetical approach can then be measured against current efforts to reduce pandemic threats and against the economic damages from pandemics. The U.S. government response to the 2013-15 West African Ebola outbreak included an appropriation of $5.4 billion for agencies to control the outbreak, treat patients and reduce the threat of future emergence of Ebola. While this was a large scale outbreak, it is only one pathogen emerging once. With over 350 EID events since 1960, and estimates of continued exponential growth in the annual number of EID events, the likelihood of sustaining significant costs under business-as-usual is high. Considering the high costs of recent pandemics (H1N1, SARS, Ebola and projections of H5N1 costs), a significant investment in pandemic prevention could become politically palatable as well as demonstrably cost-effective if we wait for the next few large scale EID events.

Finally, in light of the growing threat of pandemics, the growing capacity of emerging diseases to spread with increasing population density, and the increasing economic impact of pandemics, the need to
act is urgent. Pandemics should be considered objectively as a cost of doing globalized business on the planet—travel, trade, economic development. We need to insure against them. We need to treat them as a development and security issue, not just a health issue, and we need to work seamlessly across disciplines to prevent, control and combat them. If we are currently living in the age of pandemics, the next few decades give us a stark economic and policy choice—act now, or pay a significantly higher price later.

The views expressed in this report are those of the author, and do not necessarily reflect the positions of any of the institutions to which he is affiliated, the Scowcroft Institute of International Affairs, the Bush School of Government and Public Service, or Texas A&M University.
References:


2 Image courtesy of EcoHealth Alliance (www.ecohealthalliance.org).

3 Pike, J et al. (2014). Economic optimization of a global strategy to reduce the pandemic threat. PNAS111:18519-18523

4 Pike, J et al. (2014) op. cit. lays out full details of this economic model including parameterization, simulations and sensitivity analyses.


10 http://www.flu.gov/pandemic/history/

11 In 2014, at the peak of the outbreak, World Bank estimated Ebola would cost $32 billion by 2015 if the rate of new cases did not decrease. The outbreak was contained significantly by 2015, but with $5.4 billion committed by the U.S. Gov’t, and significant expenditures by China, UK, other European countries, and NGOs.

Peter Daszak

Dr. Peter Daszak, president of EcoHealth Alliance, is a leader in the field of conservation medicine and a respected disease ecologist. EcoHealth Alliance is a global organization dedicated to innovative conservation science that links the ecology and health of humans and wildlife. EcoHealth Alliance's mission is to provide scientists and educators with support for grassroots conservation efforts in 20 high-biodiversity countries in North America, Asia, Africa, and Latin America. Nine years ago Dr. Daszak became the Executive Director of EcoHealth Alliance's Consortium for Conservation Medicine (CCM) - a collaborative think-tank of institutions including Johns Hopkins Bloomberg School of Public Health, The University of Pittsburgh Graduate School of Public Health, The University of Wisconsin-Madison Nelson Institute for Environmental Studies, Tufts Cummings School of Veterinary Medicine Center for Conservation Medicine, and the USGS National Wildlife Health Center. The CCM is the first formal inter-institutional partnership to link conservation and disease ecology. Dr. Daszak's research has been instrumental in revealing and predicting the impacts of emerging diseases on wildlife, livestock, and human populations.

As Executive Vice President of Health at EcoHealth Alliance, Dr. Daszak directed a program of collaborative research, education, and conservation policy. The program examined the role of wildlife trade in disease introduction, the emergence of novel zoonotic viruses lethal to humans (such as Nipah, Hendra, SARS, and Avian Influenza), the role of diseases in the global decline of amphibian populations, and the ecology and impact of West Nile virus in the U.S. Dr. Daszak holds adjunct positions at five universities in the U.S. and U.K., and serves on the National Research Council's committee on the future of veterinary research in the U.S.

With an impressive track record of more than 100 peer-reviewed published papers, Dr. Daszak has also authored book chapters, and his research has been featured in such publications as Nature, Science, The Lancet, Proceedings of the National Academy of Sciences, and Trends in Ecology and Evolution. He is a member of the editorial board of Conservation Biology and is co-editor of the Springer journal EcoHealth, as well as a founding director and treasurer of the International Association for Ecology and Health. He is a recipient of the 2000 CSIRO medal for collaborative research, and his work has been the focus of extensive media coverage, including articles in The New York Times, The Wall Street Journal, The Economist, The Washington Post, US News & World Report and broadcast appearances on 60 Minutes II, CNN, ABC, NPR’s Talk of the Nation, Morning Edition, and Fresh Air with Terry Gross.
The Bush School of Government and Public Service

Mark Welsh, Dean and Holder of the Edward & Howard Kruse Endowed Chair

Founded in 1997, the Bush School of Government and Public Service has become one of the leading public and international affairs graduate schools in the nation. One of ten schools and colleges at Texas A&M University, a tier-one research university, the School offers master’s level education for students aspiring to careers in public service.

The School is ranked in the top 12 percent of graduate public affairs schools in the nation, according to rankings published in U.S. News & World Report. The School now ranks thirty-third among both public and private public affairs graduate programs and twenty-first among public universities.

The School’s philosophy is based on the belief of its founder, George H.W. Bush, that public service is a noble calling—a belief that continues to shape all aspects of the curriculum, research, and student experience. In addition to the Master of Public Service and Administration degree and the Master of International Affairs degree, the School has an expanding online and extended education program that includes Certificates in Advanced International Affairs, Homeland Security, and Nonprofit Management.

Located in College Station, Texas, the School’s programs are housed in the Robert H. and Judy Ley Allen Building, which is part of the George Bush Presidential Library Center on the West Campus of Texas A&M. This location affords students access to the archival holdings of the George Bush Presidential Library and Museum, invitation to numerous events hosted by the George Bush Foundation at the Annenberg Presidential Conference Center, and inclusion in the many activities of the Texas A&M community.

The Scowcroft Institute of International Affairs

Andrew S. Natsios, Director and E. Richard Schendel Distinguished Professor of the Practice

The Scowcroft Institute of International Affairs (SIIA) is a research institute housed in the Bush School of Government and Public Service at Texas A&M University. The Institute is named in honor of Lt. Gen. Brent Scowcroft, USAF (Ret.), whose long and distinguished career in public service included serving as National Security Advisor for Presidents Gerald Ford and George H.W. Bush. The Institute's core mission is to foster and disseminate policy-oriented research on international affairs by supporting faculty and student research, hosting international speakers and major scholarly conferences, and providing grants to outside researchers to use the holdings of the Bush Library.

"We live in an era of tremendous global change. Policy makers will confront unfamiliar challenges, new opportunities, and difficult choices in the years ahead. I look forward to the Scowcroft Institute supporting policy-relevant research that will contribute to our understanding of these changes, illuminating their implications for our national interest, and fostering lively exchanges about how the United States can help shape a world that best serves our interests and reflects our values."

— Lt. Gen. Brent Scowcroft, USAF (Ret.)