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Emergence of infectious diseases

Risks and issues for societies

Serge Morand, Muriel Figuié, eds

éditions Quæ

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Foreword by Frédéric Keck, Anthropologist, CNRS

Emerging infectious diseases. For the past two decades, this term has been used to designate a new stage in the history of public health, and more generally in the government of living beings. The first alert regarding emerging infectious diseases (EIDs) is generally said to be the appearance of the Ebola virus in Zaire in 1976, but this event is significant because it came after the announcement by the World Health Organization of the end of the global smallpox vaccination campaign. The emergence of new infectious diseases only comes as a surprise if one takes the viewpoint of an international organization which was expected to be devoting its time henceforth to chronic diseases. The explosion of the AIDS pandemic at the end of the twentieth century sadly proved this assessment to be wrong.

In this respect, the notion of EIDs signals the end of a certain modernity. The belief that infectious diseases could be eradicated by vaccination was linked to a method of hierarchical organization based on Pasteur's idea of the war on germs. If infectious diseases continue to emerge, it is because nature manages to deflect the means that humanity uses to control them. "Nature strikes back" is one of the tenets of this new world vision, as heralded by biologist and environmentalist René Dubos in the 1950s. This idea is also expressed in the post-Cold War period as "Nature is the greatest bioterrorist threat". Those involved in the fight against EIDs now have to follow the ways in which the germs mutate, anticipate their propagation and send early warning signals. Networks – more flexible and mobile – are replacing hierarchical organization.

This switch is neither simple nor evident, and the contributions in this book explore how EID have led to reorganize the world, changing our conceptions of agency and nature.

To further complicate this switch, take the relationship between the notions of emergence and mutation, considered to be two methods of describing what appears to be new, as a measuring stick. Ever since Darwin, we have known that living organisms come about by means of discrete mutations selected by environments. The mutation/selection pairing is based on a reversible notion of what is living: one particular mutation will be selected in a certain environment, but not in another. On the contrary, the notion of emergence introduces an element of irreversibility. In physics and biology, it designates the appearance of properties through the composition of elements which did not possess these properties. When a new pathogen emerges, it provokes reactions of fear, mobilization and organization to such an extent that it has a profound effect on the environment in which it appears. Even if it were then to disappear, "nothing would be the same again".

Influenza has thus become an EID model since it combines the potential of mutation (as revealed by the sequencing of its RNA segmented into a single strand) with the catastrophic character of emergence (ceasing of economic activity being considered to

be a more serious event than the outbreak itself). A broad reflection needs to encompass this accumulation of properties on physical, biological and sociological levels.

From this perspective, it is essential to focus on one of the central notions used to describe this emergence: the animal reservoir. A pathogen acquires new properties when it passes from one species to another, via a mechanism described as a spillover. Discrete mutations become catastrophic when they find an evolutionary bottleneck in a change in population. The notion of animal reservoir is a means of mapping the discontinuities of transformation within the human population. Zoonoses are diseases which pass from animals to humans and vice versa, demonstrating a vital solidarity in exposure to environmental changes. One of the lessons of the ecology of EIDs is that the reduction in the number of species actually promotes rather than reduces the appearance of new pathogens, since it brings with it a greater proximity of humans to certain species.

Once the emergence has been mapped among living beings, the social worlds which it mobilizes then need to be described. Various stakeholders with often conflicting interests are concerned by any new pathogen, including ecologists, veterinarians, doctors, public health authorities and even the military. Sociologists and anthropologists are mobilized to describe the behaviour of the populations driving the emergence, and to draw up a list of the collectives involved, who are both creating and involved in this new image of the world. The need for surveillance becomes a new watchword in terms of reorganizing global vision, based on the "One World, One Health" principle, although consideration must be given to the plurality of this expression.

That an event as minor as the mutation of a pathogen jumping the species barrier should become the motor of such a reorganization of the social world, that a phenomenon as continuous and reversible should bring about irreversible discontinuities – this is real food for thought for those who seek to describe the contemporary. By going back and analysing each of the thresholds that the emergence has gone through, the descriptive approach is also a critical one, as it uncovers the contingences of what has become evident, but also the potentials inherent in the emergence. This work, by multiplying the perspectives on emerging infectious diseases, provides indispensable material for what is a necessary collaboration between biological, social and environmental sciences.

Introduction

The aim of this book is to demonstrate the mechanisms by which the concept of emerging diseases is establishing itself as a new means of treating infectious diseases as well as the new configurations which this re-framing is bringing about, both in the world of research and in terms of public decision-making. To do this, it will take a multidisciplinary look at emerging infectious diseases (EIDs), taking in biological, political, sociological and historical approaches across five chapters.

More than simply providing multidisciplinary insight into the subject, the authors also illustrate the way in which the concepts, scientific results and plans of action by international and governmental agencies interact and contribute to the co-construction of the EIDs. Furthermore, the book demonstrates that re-framing infectious diseases as emerging infectious diseases poses new challenges, such as collective mobilization around a good whose status as a 'common good' is up for debate. It will provide the lay person, the researcher, the practitioner, the expert and the decision-maker with some key elements for understanding this make-up of the problem and some responses to it.

The first two chapters take complementary views of the mechanisms and the factors behind the emergence – biological for Serge Morand and socio-political for Nathalie Brender and Claude Gilbert.

In the first chapter, Morand explains to us the characteristics of emerging diseases, and the factors which encourage their appearance, born out of epidemiology, ecology and biogeography. This enables him to answer numerous questions: What are the emerging pathogenic organisms? What are the ecological and biological mechanisms which create their emerging characteristic? Are they new or different from historic emergences (the plague, typhus, etc.)? Can one say that there is a biogeography of emergence?

These questions help to give distanced and critical insight into the production of knowledge of the biological mechanisms of emergence. What is truly new in emerging diseases as defined by Stephen Morse in 1995? "The trends in all global infectious disease outbreaks are similar to those that are limited to EIDs alone. Global disease outbreak trends are also increasing exponentially. There is to a certain extent an epidemic of epidemics," says Morand. By which process of spatialization of emergence does the knowledge produced enable countries and regions to be designated as sources or targets of new epidemic threats? And why is so much attention being focused on bats while parasitic diseases within emerging diseases are being "neglected"?

It is the emergence of a new representation of the world which is accompanying the work of researchers, where the human and the non-human, the domesticated and the wild, share a greater epidemiological community. It is also an opportunity to update the old geography of threat and security, with very clear dividing lines between the intertropical zones in developed countries that are the epicentres of the emergence (since they are at

the centre of the current ecological changes), zones of vulnerability which could amplify them due to the human population density and the weakness of the health systems, and those areas able to increase visibility by means of biotechnologies.

In the second chapter, Nathalie Brender and Claude Gilbert provide a different perspective on the mechanisms of emergence, namely that of social sciences. From this point of view, emergence is not only a rupture, a disorder which arises in nature, but also results from the convergence of interests of those who contribute to the emergence of emergence. For the social sciences, it is as much viruses, sufferers and scientific challenges which are being created by the emergence of new pathogens as it is a new type of public problem, of which the recognition as such "seems to depend on their nature, but also possibly even more so on their mode(s) of appropriation".

While the first chapter deals with the question of the 'competencies' of the viruses, vectors and hosts etc., the second chapter, following the emergence and re-emergence of influenza on a national (France) and international scale, reveals in parallel other necessary competencies for 'candidates for emergence', notably their capacity to become part of the strategic priorities of leading stakeholders. This also tends to reframe the problem itself: "Not only was the emergence of the pandemic influenza issue largely determined by the WHO's interest in promoting it, but its classification shifted according to the organization's successively changing positions". If the stakeholders who tackle the problem transform it, they themselves are transformed by the problem since they owe it to themselves to make the necessary adjustments to be both more effective and more widely accepted. The next question is the capacity of those involved to ensure that 'their' problem becomes part of the long-term agenda, and to update the interest it can create so that it can ward off competition from new emergences. This process is similar to that described in the first chapter regarding the co-evolution of pathogens with their hosts, their vectors and their environment.

In the third chapter, Patrick Zylberman tackles the question of emerging risks and in this case infectious emerging risks by means of the history of the international and political relations of the American 'superpower'. A paradigm shift in governmental policies was effected, with the focus shifting from prevention of risks to security. In this new context, preparing for worst-case scenarios takes centre stage.

Zylberman retraces the evolution of the role of health-related security within US national security, from a marginal one at the end of the Cold War to a central one with the emergence of new global threats including pandemics and bioterrorism. The first conference on emerging viruses, held in Washington in 1989, was one of those key moments, both in terms of the multidisciplinary dimension of the participants (virologists, ecologists, agronomists, veterinary scientists, anthropologists, etc.) and by putting the focus of causality back onto humans. "Humans are engineers of microbial circulation," said conference organizer Stephen Morse.

The second event, as Zylberman explains, came during the presidency of Bill Clinton, who implemented the National Domestic Preparedness Program just before the end of

his term in 2001. This turning point from health-related prevention to preparedness was strengthened by Clinton's successor, with George W. Bush opting for continuity via this new governance organization for germ-related threats, while the origins and content of this preparedness can be found in the early 1990s.

The most important aspect, according to Zylberman, resides in the construction of worst-case scenarios. With the implementation of the Homeland Security Council, such scenarios prompt those involved in governance to play their roles in crisis situations, and to invent stories to be able to overcome the situations. Fiction and the imaginary become the new tools for managing threats which are completely out of the realm of usual risk analysis.

In the following chapter, Muriel Figuié questions the collective response capacity to these risks, whose potential scope, complexity and uncertainty call for the mobilization of a growing number and a wider variety of stakeholders than traditional risk management. The chapter runs through the difficulties of implementing a coordinated action among these stakeholders, be they individuals, collectives that are formalized to a varying degree, states or international organizations. In the health sector, whenever it is a question of mobilizing the public, individualist and culturalist approaches tend to dominate. This chapter invites us to go beyond these approaches by highlighting the delicate balance between individual and collective rationales, and also between institutional, local, national and international rationales.

This chapter also demonstrates that while emerging diseases 'invite' ever larger and more disparate collectives to be mobilized, it is also the collectives themselves which define and delineate their points of focus. This construction is not without consequences. At the moment, international organizations intend to promote surveillance of emerging diseases to the status of global public good. By doing this, they are establishing the defence of an interest that is theoretically supposed to be shared (where everyone would benefit from working together) as a principle of coordinated collective action. However, the chapter demonstrates the diversity of interests, and the necessary debate of compromises and arbitration.

In the final chapter, François Roger justifies the essential yet ambiguous role of health surveillance at the heart of global governance concerns. It should make it possible to detect what seems to be becoming more and more unpredictable as early as possible. This surveillance is not without contradictions, and analysis of the epidemiological transitions which have accompanied the socioeconomic development of societies shows this. Health surveillance must address the challenges that reveal the complexity of the problem at hand. It is also crucial to know what should be monitored. Anticipation requires keeping an eye on the signals which herald the possible emergence of a disease and not the emergence of the diseases themselves. These signals are mixed, as are the mechanisms of emergence. What are they? The evolution of biological diversity, agricultural practices, antibiotic use? On what level do they need to be observed? Moreover, how can we prevent these signals, which are weak and uncertain, from replacing the dangers themselves in collective fears?

Health surveillance, as Roger reminds us, appeals first and foremost to empirical sciences. It is necessary to research and appreciate microbial diversity to develop prevention tools and medical responses. Health surveillance next appeals to mathematical forecasting sciences along with risk analysis. Moreover, surveillance implies organizing a permanently increasing network of ever more diverse people, due to the complexity of the systems being monitored. Surveillance also requires new organizational, legal, economic and governance tools, since it is necessary to manage the sharing of costs and benefits between the various social groups, sectors (health, agriculture, environment etc.), and countries. It raises questions of ethics, since "you cannot keep everything under surveillance". This implies economic arbitration in terms of efficiency, but also societal and moral choices. Emerging diseases are more than a health issue. With the aim of anticipating them comes a whole network of surveillance which re-organizes itself, leaving the sphere of specialized organizations and breaking into all sectors at every level of human life.

By treating emerging diseases like hybrid objects, by constantly going back and forth between the biological and social dimensions, this book seeks to develop a pluralist approach to health (Dozon and Fassin, 2001). Its ambition is first and foremost to avoid too positivist an interpretation, which would reduce emerging diseases to merely a piece of data from our natural environment and uncovered by biological sciences. Equally, it wishes to avoid too relativist an interpretation, which would turn it into a simple social construct, and only ever the provisional result of a power struggle between those who have an interest, and different rationales and cultures, all of whom are competing. This delicate balance, between the two extremes that are the authoritarianism of what is 'real' and socio-centrism (Larrère, 1997), is necessary to fully understand what is at stake in this epidemic of epidemics.

1. Biogeography and the ecology of emerging infectious diseases

Serge Morand

A major epidemic of Ebola occurred in West Africa in 2014, causing more than 11,000 deaths by the time the outbreak ended in mid-2016. This extremely deadly haemorrhagic fever of viral origin created a serious regional health crisis and led to fears that it would spread across the globe. In its early days, and for many months, the epidemic received little attention from international institutions, particularly the World Health Organization (WHO). The turning point came when a few cases appeared in Western countries, most of which were health workers who had been repatriated after being infected when treating patients. The risks of introducing and spreading the virus in Western countries became very significant when secondary infections, once again affecting health workers, occurred in Spain and the United States. The health crisis suddenly shifted from a regional concern to a global one.

Ebola is an illustrative example that can be used to examine fundamental questions about the ecology and epidemiology of emergence. This disease is caused by infection from a virus carried by bats. Human contamination occurs not only by handling infected bats, which is assumed to be the cause of the first case of the West African epidemic, but also through contact with wild animals, primates or antelopes infected with the virus that are hunted or sold as bushmeat. But large epidemics like the one observed in West Africa or previous epidemics in Central Africa are the result of contact transmission between sick people and healthy individuals (more specifically, when caring for the sick or when coming in contact someone who has died of the disease). The disease is then transmitted directly between people, with no need for transmission from the animal reservoir until transmission is under control and the virus persists only in bats.

This epidemic raises a number of questions about the ecology and geography of emergence. What are these emerging pathogens? What are their origins? Why are bats so frequently mentioned? What is the link with humans: who infects whom and how? Are there any geographic 'hotspots' of emergence? Is Africa unique, or the tropics in general? Is this Ebola health crisis in West Africa a bat problem, or is this health crisis more indicative of an environmental crisis coupled with a social crisis?

An emerging infectious disease is defined by Steven Morse (1995) as an infection that has recently appeared in a population or that has existed before, but whose incidence or geographic range is increasing rapidly. We should note that this definition also relates to the rise of bacterial resistance to antibiotics. But how is this concept of emergence, derived from the work of scientists such as Steven Morse, supported by comparative studies in global epidemiology?

Human history has been profoundly marked by emerging infectious diseases such as the Black Death in the Middle Ages or the Spanish flu at the end of the First World War. Infections also contributed to the decimation of Native American and Pacific Islander populations following European colonization (McNeill, 1976). These emerging diseases are ever present in our collective experiences. The emergence of the AIDS, SARS, avian influenza (H5N7), swine flu (H1N1), West Nile virus and the recent Ebola virus in West Africa remind us that infectious diseases, still a global risk for world health, maintain a hold on our imaginations. Are these recent emerging pathogens new or different from the emergence and epidemics such as bubonic plague, smallpox or typhus that have occurred throughout human history?

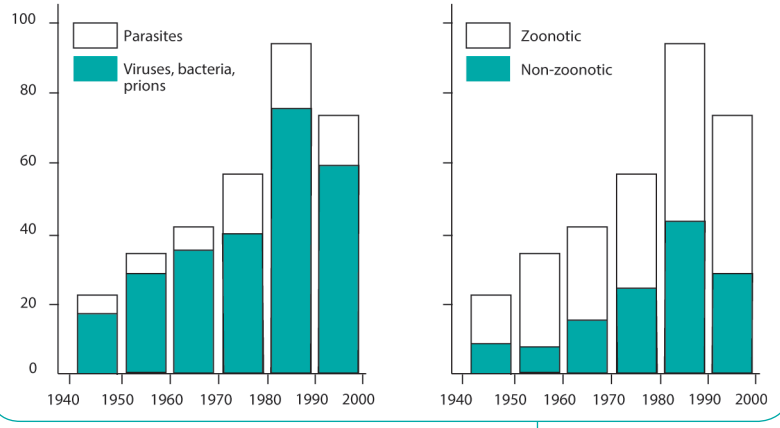
Characteristics of emerging infectious diseases

The human species is infected with a large number of pathogens, undoubtedly making us the most parasitized species on Earth. More than 1,400 species of parasites and microbes have been listed as pathogenic in humans (Cleaveland *et al.*, 2001) and, of these, more than 60 percent are of zoonotic (i.e., animal) origin. The percentage of zoonotic pathogens observed in all infectious diseases affecting humans is the same as the percentage observed for the newly emerging infectious diseases. Thus, emergence does not present an original character within the total diversity of infectious diseases that have and still continue to affect humanity.

The study by Jones *et al.* published in *Nature* in 2008 will serve as a guide for the ecological and epidemiological analysis of emergence and improve understanding of the dynamics. Since its publication, this study has been cited more than 2,000 times in scientific literature, demonstrating both the interest of the subject for the scientific community and how original it is. This study contributed to the effective implementation of several programmes by the United States Agency for International Development (USAID). These programmes aimed to detect and prevent emerging diseases in their likely places of emergence. However, we will come back to this point when discussing the geography of emergence. This study also provided the scientific basis for the One Health initiative led by the United Nations Organization for Food and Agriculture (FAO), the World Organisation for Animal Heath (OIE) and the World Health Organization (WHO).

In their study, Jones *et al.* (2008) showed a significant increase in the number of emerging infectious disease (EID) events from 1940 to 2000 (Fig. 1). They then noted that the agents

Figure 1. Evolution of the number of emerging infectious diseases (EIDs) from 1940 to 2000, according to the type of pathogens (parasites or viruses and bacteria) (left) and according to the type of zoonotic transmission (involving wild or domestic animals) or non-zoonotic (environmental, vectors without animal reservoirs, direct human-to-human contact) (right).



Adapted from Jones *et al.*, 2008.

responsible for these EIDs are mostly viruses and bacteria. Parasites, i.e., worms (such as nematodes or tapeworms) and protists (such as malarial agents) account for a minority of these newly emerging agents. Finally, more than 70% of these EIDs originated from animals (mainly wild).

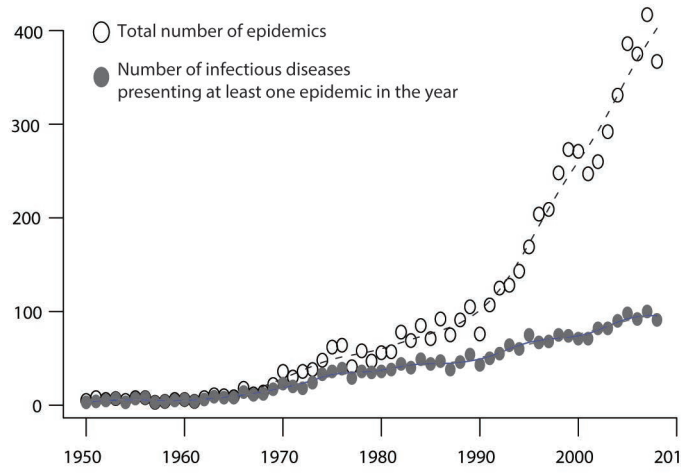
The Jones *et al.* (2008) study focuses on three characteristics of these EIDs: (1) there is an epidemic of EIDs (2) mainly due to microbes (viruses and bacteria), (3) many of which originate in wild animals.

In trying to answer the question as to whether these EIDs are different from the infectious diseases that have and still do affect human populations, we must recognize that the number of infectious diseases that are present in a country or a geographic region and the number of infectious disease outbreaks are two distinct issues.

The number of diseases, or the burden of infectious diseases, is a static measurement that corresponds to the sum of medical knowledge of a given country or region. Although it obviously takes into account past eradications or new emergences, the number of diseases is a measure of how endemic infectious diseases have become in a geographical area where infectious agents may circulate without significant epidemic outbreaks.

The number of epidemics is a dynamic and temporal measurement, which shows the number of remarkable epidemiological events at a given moment or over a given period.

Figure 2. Evolution of the number of epidemics of infectious diseases in the world from 1950 to 2010: total number of epidemics in the year (upper curve in black), number of infectious diseases presenting at least one epidemic in the year (lower curve in grey).



Adapted from Morand, 2015.

Detecting and reporting an epidemic event requires a public health service that is able to monitor, identify and carry out national and international outbreak notifications. The quality of the public health service depends on the financial resources allocated to it and, indeed, there is strong correlation between the number of epidemics affecting a country and its GDP or per capita expenditures for the public health system. The wealthier a country, the more it is able to detect, characterize and report different epidemics internationally, regardless of the number of diseases present in the country. This bias has been taken into account in all published studies (including that of Jones and his colleagues).

Analysing trends in the global epidemiology of infectious diseases has been the subject of several studies, most having used the online database GIDEON (which includes data from the WHO). The trends in all global infectious disease outbreaks are similar to those that are limited to EIDs alone (Smith *et al.*, 2014, Morand *et al.*, 2014c). Global disease outbreak trends are also increasing exponentially (Fig. 2). There is an epidemic of epidemics of all types of infectious and parasitic diseases.

Although less dramatic than the total number of outbreaks, there is also a significant increase in infectious diseases with at least one epidemic in a year. This indicates a rise in different kinds of infectious diseases, including EIDs, presenting an outbreak over the last 60 years. Finally, EID events share two characteristics: more than 60% of these outbreaks are from zoonoses, and the causative agents are mostly viruses and bacteria.

At least two studies have explored these epidemic patterns regionally in Europe and Asia Pacific (Morand and Waret-Szkuta, 2012; Morand *et al.*, 2014a). They also showed the same exponential increase in infectious disease outbreaks. These two regions, which have different socioeconomic and environmental profiles, with high intra- and inter-country variability, showed strikingly similar trends and patterns in the dynamics of their infectious diseases. This raised the question of what common factors might explain such similarity.

What are these emerging pathogens?

The increase in not only emerging but all infectious diseases in recent decades mainly concerns bacteria and viruses. For tropical medicine, this is a major change. Tropical medicine has long focused on parasitic diseases caused by helminth worms (schistosomiasis, tapeworms and intestinal strongyles) or protists such as trypanosomes responsible for sleeping sickness and Chagas disease. Although these diseases are still public health problems, they are not in the scientific mainstream of emerging infectious diseases or even in the global dynamics of epidemics (McIntyre *et al.*, 2011). A new medical field has been created for 'traditional' tropical diseases that are losing the attention of health policies, donors and scientists while new journals are cropping up for these 'neglected tropical diseases'. Some of these neglected infectious diseases are re-emerging (such as leptospirosis), suggesting that the 'emerging' label attached to an infectious disease is first and foremost an indication of emerging scientific, social and political interests.

Going back to the definition of emergence given by Steven Morse, for an infectious disease to become emerging, it must be new and/or expand its geographical range. Starting with the new aspect of an infectious disease, the development of molecular biology must be considered along with its applications in the biomedical and epidemiological field with new rapid and less expensive methods to detect and characterize pathogens (still requiring significant technical advances). While medical or veterinary parasitology still relies on macroscopic characterization of parasites, such as the use of the optical microscope, the development of molecular methods has helped refine the distinction of certain species (within species complexes) or genetic variability between different circulating strains. Microbial infectious diseases, i.e., bacterial and virologic, greatly benefited from the rapid growth of these new molecular techniques. The coronavirus responsible for SARS is the best example of the rapid detection and characterization of a new infectious agent. New species and strains have been and can be characterized by these new tools very quickly. These advances led to virtual real-time sequencing and analysis of the circulating strains of the Ebola virus in West Africa. A new profession appeared: virus or 'bug hunter' as defined by Nathan Wolfe.

Paradoxically, this scientific and technological development is part of the rise in EIDs. Emergences are easier to see and different emergences are better characterized because of the financial, technological and scientific resources available to detect them and identify the causative pathogens. Accordingly, any analysis of temporal epidemiological trends

must take into account the means that a country or the international community could use to monitor epidemics and characterize the pathogens that are circulating and emerging.

The rise of new high-throughput sequencing techniques also makes it possible to carry out an unbiased investigation of the entire community of microbes and parasites that an individual or an animal species harbours. This is what is referred to as the microbiome (all bacteria living on the skin or in the digestive tract), the virome (all viruses including pathogens and retroviruses) and the parasitome (all parasites). Brand new explorations of living beings are now possible, similar to the great expeditions conducted by museums of natural history. However, the consequences for societies are very different. Once again the example of bats and the first studies of their viromes provide a good example.

Based on characterization of part of a bat's virome, a species of flying fox that is a reservoir of many emerging viruses, Anthony *et al.* (2013) statistically extrapolated their results to the potential number of all viruses circulating in mammals. Without going into the many methodological and statistical biases of such work, the authors arrived at a number of more than 320,000 viruses waiting to be discovered in mammals.[1] All of these 'possible' viruses were presented as 'potential' sources of future EIDs. But the authors concluded that the complete characterization of these viruses (it would multiply by a factor of 60 the number of known characterized viruses) would cost $6.3 billion, a "small fraction of the cost of many pandemic zoonoses". This work and these quotations have been widely reported by the international press (the BBC, *Le Monde* and major American networks).

A year later, in 2014, an Ebola outbreak erupted in West Africa. Would the characterization of all mammalian viruses proposed by Anthony and his collaborators have helped prevent and contain this epidemic? Are bats the culprits of this epidemic, and if so, would a wildlife surveillance strategy or even monitoring of bushmeat hunters as promoted by Nathan Wolfe (2011) have prevented and contained the epidemic?

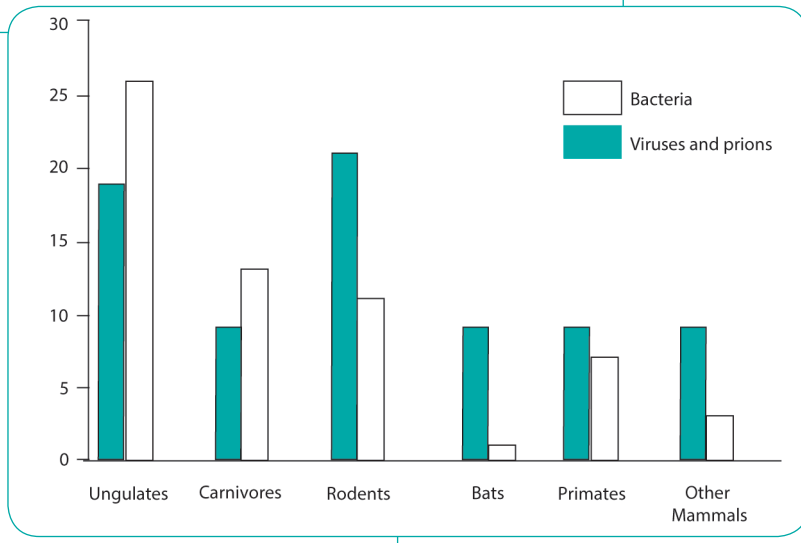
What are the animal reservoirs of these new emerging infectious diseases?

Woolhouse *et al.* (2005, 2008) have characterized the reservoirs of these emerging parasites and microbes. Their articles again show that viruses and bacteria are the main agents at the origin of emerging infectious diseases, and that emergences are overwhelmingly zoonoses. But the main interest of these studies is the characterization of animal reservoirs of zoonoses (Fig. 3).

First of all, ungulates (hooved animals such as cattle, horses, goats and sheep) appeared as major reservoirs of new emergence, but carnivores (dogs, mostly cats) also play an

1. It should be noted that over 5,000 virus species have been fully characterized and that the total estimated number of viruses on Earth is 10^{31} (a one followed by 31 zeros!), with most being bacteriophages, viruses that infect bacteria.

Figure 3. Characterization (number) of emerging zoonotic disease reservoirs.



Adapted from Woolhouse and Gowtage-Sequeria, 2005.

important role in the spread of emerging infectious agents. In the case of wildlife, rodents are the reservoir group that contributed most to new emergence, followed by primates and bats.

It should be noted that certain rodents responsible for disease transmission are long-time human commensals (such as black rats, brown rats or house mice) or newly kept as pets (e.g., prairie dogs or Gambian pouched rats). For example, leptospirosis caused by a bacterium that lives in the environment re-emerged globally from the 1990s with rodents and domesticated animals as reservoirs. Despite the many people at risk and infected – mainly the poor in developing countries – this disease remains under the radar.

While bats are stigmatized when major health crises arise, such as during the last Ebola outbreak, they are only responsible for a relatively small proportion of these emergences. Why do they receive so much attention?

What are the emerging viruses in bats?

Bats receive considerable attention from health services as well as scientists. Understanding disease emergence related to these animals requires studying modes of virus transmission from bats to humans. Transmission is rarely direct and most often involves other wild or domesticated animals.

Although human rabies cases are mostly the result of a bite from a rabid dog, the lyssavirus that causes this frightening and fatal zoonotic disease originates in bats (Johnson *et al.*, 2010). Carnivores are secondary carriers of this virus, which also infects many other animals. In the early 1900s in Brazil, 4,000 cattle and 1,000 horses and mules died of paralytic rabies. Bats, which were actually infected with the rabies virus, had been observed near these animals trying to bite them. This was the first causal link between bats and viral diseases (Halpin *et al.*, 2007). The rabies virus was then isolated from an insectivorous bat in the United States in 1953. A few cases of human rabies have been described following a bite by a bat, but they remain marginal compared to bites by dogs.

With regard to Ebola, there is not just one Ebola virus, but several species that have been responsible for multiple outbreaks in Central Africa and the most recent one in West Africa. The first emergence dates to 1976, with the Zaire Ebola species, followed by the Sudan, Taï Forest and Bundibugyo species. Transmission is often the result of handling bushmeat at the markets, as in the case of primates infected in markets in the Democratic Republic of Congo. High mortality and human-to-human transmissions make Ebola a high-risk zoonosis. Bats are the reservoirs of these Ebola viruses.

Reston virus (RESTV), also in the Ebola group, was discovered in macaques at Hazleton Laboratories in the United States in 1989. This virus is non-pathogenic for humans, but dangerous for monkeys. It has been found in macaques in Southeast Asia.

The first infections from the Marburg virus (named for a city in Germany) involved researchers from a pharmaceutical company who became ill following kidney cell manipulations taken from green monkeys imported from Uganda. Epidemics were then reported in the Republic of Congo in 1998, in East Africa in 2000, in Angola in 2004 and 2005, and in Uganda in 2014. The reservoir is a dogfish.

Some emerging viruses belong to the Paramyxoviridae family (Wang *et al.*, 2008). Viruses in this family are the agents of measles and mumps in humans, and Newcastle disease, distemper and rinderpest in domesticated animals. Three new paramyxoviruses of bat origin have emerged since 1994 in Australia, South and Southeast Asia and the Arabian Peninsula. These are the Hendra virus (HEV) isolated from horses and humans infected in Australia in 1996, the Nipah virus (NiV) in humans and pigs in Malaysia in 1999, and the Menangle virus (MENV) in pigs in Australia in 1997.

The various Hendra virus epidemics in Australia all affected horses and humans who were in direct contact with infected horses. Large frugivorous bats are the reservoirs of this virus.

Nipah virus outbreaks occurred in Malaysia in 1998, where pigs raised as livestock and humans were infected. In Singapore, human infections occurred in slaughterhouse workers where pigs were imported from the contaminated areas of Malaysia. Flying foxes and small insectivorous bats are NiV reservoirs. Other Nipah virus outbreaks occurred in Bangladesh between 2001 and 2005, and in India in 2001. The infections are believed to be directly from bats (flying foxes) with proven human-to-human transmissions.

The Menangle virus emerged in Australia in 1997 at a large intensive pig farm near Sydney, with two human cases associated with swine disease. Bats remain reservoirs for this virus.

Four Coronaviridae viruses cause anodyne human diseases, but two other virus species from this family are responsible for two major health crises: Severe Acute Respiratory Syndrome (SARS), with more than 8,000 people infected in around 30 countries, and the Middle East Respiratory Syndrome (MERS). In 2002, a coronavirus emerged in Guangdong Province, China, which was responsible for the SARS epidemic reported to be related to small carnivores called civets sold in bushmeat markets in southern China. Wild reservoirs of this virus are bats (Moutou 2007). In 2012 in the Arabian Peninsula, the first human case of infection with a new coronavirus causing a respiratory syndrome, MERS-CoV, was identified. Human-to-human transmissions have been identified with imported cases in Europe, Asia and the United States. The reservoirs are small insectivorous bats, but human infection occurs through dromedaries infected with the virus.

There are several key points to take away from this brief summary of emergences. First, bats are the reservoir of highly lethal infectious diseases that have emerged in recent decades, leading to major health crises such as SARS, Nipah, MERS-CoV and the recent Ebola outbreak. However, direct viral contamination between bats and humans is rare, and happens through an intermediate species like primates, carnivores, horses or dromedaries. These animals are close to humans, either phylogenetically, such as primates with whom we share many diseases and parasitic infections, or because they have domesticated for millennia. Finally, two main geographical areas host these emergences: Africa and Asia Pacific. We will return to the geography of emergence, but will first look at the role of domesticated animals.

What roles do domesticated animals and pets play in emergence?

Human interactions with animals appear essential to understanding the human epidemiological environment. Studies have examined the ecological, historical and biogeographical associations of humans with their parasitic and infectious diseases (McNeil, 1976; Diamond, 1997; Wolfe *et al.*, 2007), and some have specifically focused on the importance of animal domestication.

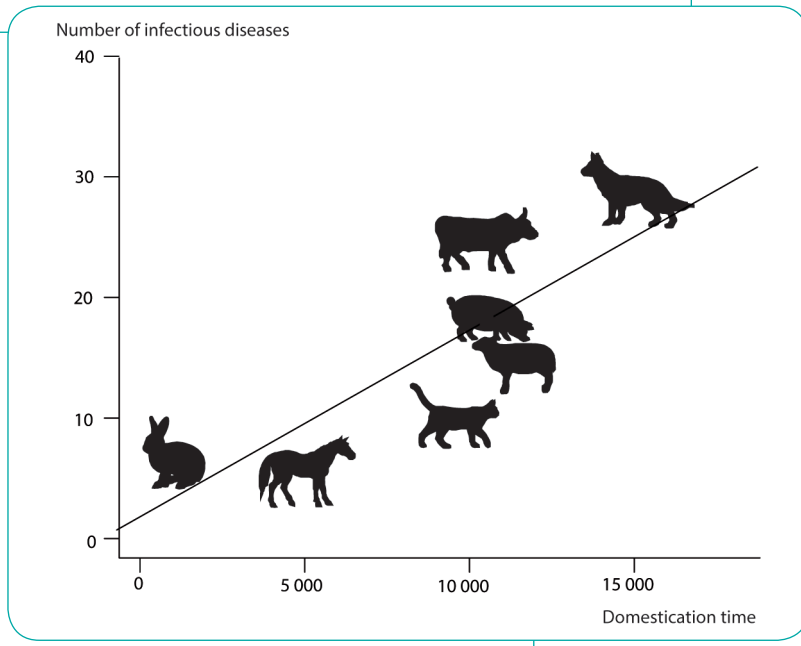
Archaeological studies show a rapid and large-scale domestication of animals starting around 12,000 years ago, during an intense wet climate phase. The main animal domestication centres are located in the Middle East and Central, South-west, South and East Asia. Few mammal species were domesticated in Africa (the donkey in the Horn of Africa), Western Europe (the rabbit in the Iberian Peninsula) and the New World (llamas and the Guinea pig). Animal domestication associated with the Neolithic Revolution significantly altered human nutrition just as the domestication of plants changed land use. The consequences were considerable for human and animal health, leading the Neolithic populations to have a significantly poorer health status compared to the hunter-gatherer populations that preceded them. Similarly, the initial stages of domestication resulted in a deterioration of

the health of these animals. New and lasting interactions between humans and animals, associated with the stresses of domestication, have favoured the emergence of disease.

In his book *Plagues and People* (1976), historian William McNeil was the first to hypothesize that infectious diseases were major, albeit contingent, agents in human history (an assumption picked up and later popularized by Jared Diamond). McNeil suggested a positive relationship between the time of domestication and the number of diseases that humans share with each domestic species. A statistical analysis of this hypothesis using novel sources for domestication or infectious diseases and updated data on the dates and origins of domestication confirms McNeil's idea. The number of pathogens shared between humans and each domestic species is proportional to the time since its domestication (Morand *et al.*, 2014d) (Fig. 4). A long period of interaction is necessary for the number of infectious diseases shared between animals and humans to increase.

To gain a better and more comprehensive view of the interactions amongst pathogenic agents, humans and domestic animals, a network analysis (like those widely used in

Figure 4. Relationship between the domestication time of major domesticated mammals and the number of infectious diseases shared with humans.



Adapted from Morand *et al.*, 2014d.

epidemiology) can help determine the domestic species that share the most pathogens between humans and all domestic animals. These central species in the network are infected with many pathogens that also infect myriad other species in the network. The oldest domesticated species carry the most zoonotic agents that they then share with humans and, more recently, other domesticated species.

These statistical observations underscore that time and close proximity with livestock and other domesticated animals are essential factors in the construction of the epidemiological environment of human societies. However, this type of analysis does not take into account reservoirs and new targets of these agents. Doing so requires phylogenetic studies, which show that cattle and pigs are the source of many infectious or parasitic agents for humans, such as roundworms in wild boars very early in their domestication. However, domesticated animals were in turn affected by pathogens from humans such as *Mycobacterium bovis*, a bacterium from a strain of the human tuberculosis agent *Mycobacterium tuberculosis* (Smith *et al.*, 2009). Finally, different domesticated animals may exchange pathogens amongst themselves, as in the case of influenza viruses.

There are two essential aspects to consider from these phylogenetic studies. First, it takes time and close proximity (or numerous repeated contacts) for an infectious agent to adapt to humans or to a community of humans and domestic animals. This phenomenon concerns mainly the parasites and pathogens of non-human primates which, because of their close evolutionary history, have advantages – particularly physiological and biological – to infect humans (such as AIDS viruses, or Plasmodium in African and Asian primates). Second, it is important to note the importance of certain domesticated animals for the maintenance and transmission of pathogens by operating as epidemiological 'bridges'. Emergent (but also non-emergent) influenza viruses illustrate this with domestic or wild bird reservoirs, and animals such as pigs allowing the rearrangement of viruses, thus promoting their 'humanization' and their potential to infect humans.

These observations also apply to pathogens from wildlife, such as the emergence of viruses from bats. The vast majority of emergences of viruses associated with bats are due to viral amplifications and adaptations in domesticated animals such as horses, pigs, dromedaries, dogs or primates.

What is the geography of emergence?

The recent Ebola outbreak in West Africa appears to be the manifestation of Pulitzer Prize-winning journalist Laurie Garrett's worst prediction from her book *The Coming Plague* in 1994: humans would contract new pathogens in the tropics – environments rich in animal biodiversity – such as Equatorial Africa. The risks of emergence are linked to the increase in local, regional or international human mobility coupled with a change in the natural environment due to increasing demographic pressures.

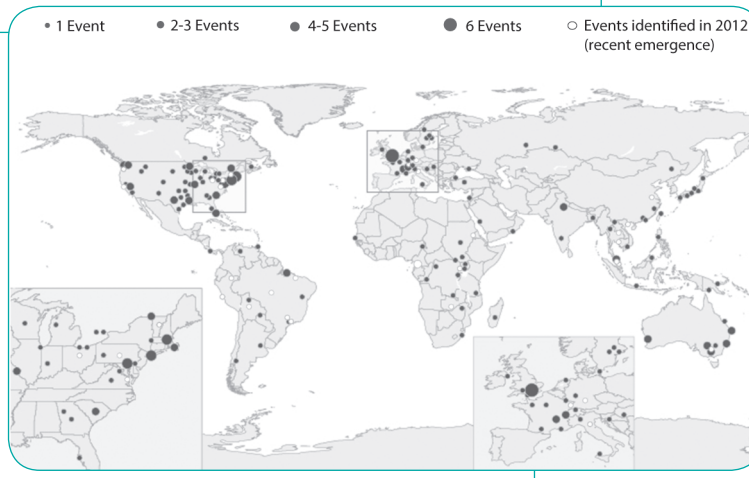
A new infectious disease of local origin would have its chances of emergence – or even possible pandemic success – reinforced by globalization. Examples include SARS, avian and swine

flu, and the human immunodeficiency virus (HIV) that causes acquired immunodeficiency syndrome (AIDS). Our collective memory remembers the epidemics of bubonic plague in the Middle Ages, which spread due to regional and international trade and mobility as well as socioeconomic and climatic conditions that weakened societies of the time.

Is it possible to depict a biogeography of emerging infectious diseases? The article by Jones *et al.* (2008) further illustrates this point. The authors provided two maps, which were also widely repeated and commented on in the scientific literature and international organizations such as the FAO. The first map pinpoints the localities of the emergence of these new infectious diseases while the second map uses statistical models to extrapolate the probable geographical areas where the next infectious diseases might emerge. These maps are interesting for several reasons.

The map of locations of past emerging infectious diseases shows that Europe and the United States are the main regions of the Western World with EIDs over the last 60 years (Fig. 5). Other developed countries such as Japan and Australia are also clearly visible as hotspots of past EIDs. A second observation is that the world's largest cities, including those in emerging economies, were affected by past EIDs. Such a map suggests that Western societies are at risk for emerging diseases as well as all major world cities, including those in the Global South. The entire world dominated by the Western model of economic development seems to a 'target' of EIDs.

Figure 5. Map showing the location of emerging infectious diseases from 1940 to 2000, depicted in Fig. 1.



Adapted from Jones *et al.*, 2008.

A second map, published in Jones *et al.* (2008), provides an interesting perspective. This map presents potential future areas of emergence for infectious diseases of zoonotic origins (wild and domesticated animals). Western developed countries and large cities are hotspots of potential new EIDs of zoonotic origins, but new regions appear, especially South and East Asia. The map points to the newly emerging economies of South Asia, characterized by dense populations, agricultural intensification, rich biodiversity and an increasingly strong integration into the world economy.

The African Great Lakes area around the East African Rift as well as southern Nigeria also appear as hotspots of potential new EIDs. This can be explained by their rich biodiversity and the densely populated areas of these African regions. Note that West African countries affected by the 2014 Ebola outbreak are only slightly highlighted. Finally, South America does not appear as a hotspot for future emerging zoonotic diseases.

From the article by Jones and his colleagues, the conclusion can be drawn that emerging diseases start in the tropical world, and especially Asia and Africa, but that ultimately developed or emerging economies suffer the consequences. This explains the differences between the locations of reported EIDs (in developed and emerging economies) and the locations of wildlife-related infectious disease risks (in developing countries, with both high biodiversity and dense populations). Active policies focusing on researching conditions prone to the emergence of infectious diseases and identifying and detecting emerging pathogens, coupled with prevention strategies in these potential EID hotspots, would avoid having to manage health crises in both developing countries and the developed world. Such approaches have been included in USAID programmes and publications by international UN agencies (such as the FAO).

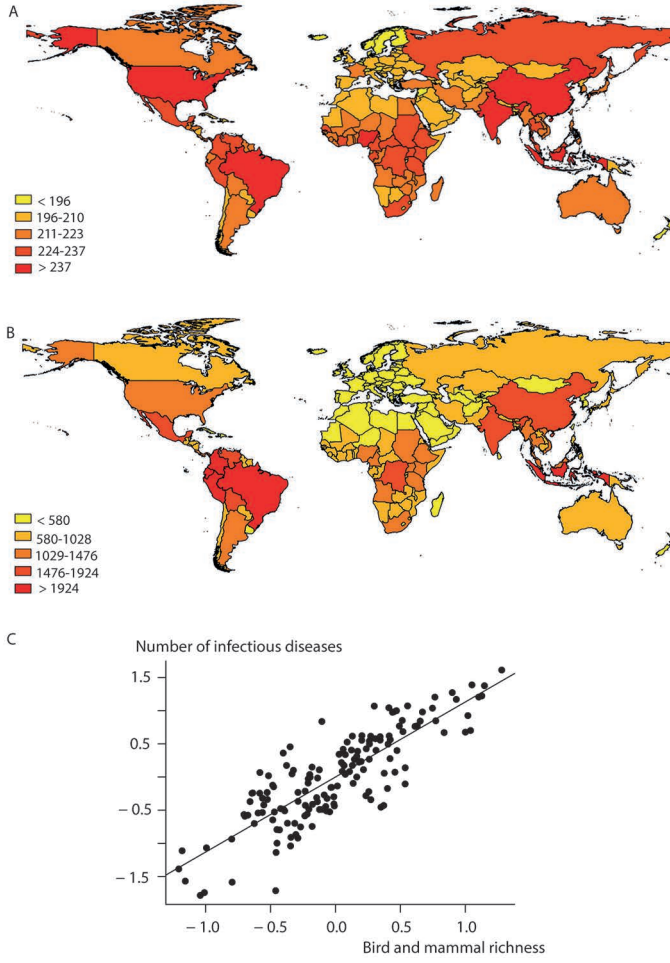
With regard to the global epidemiological data, a number of questions can be raised. For example, what is the geography of infectious diseases and the parasitic burden of the human species? How can it be explained?

What is the geography of infectious diseases and parasitic burden?

Human pathogens are not distributed randomly across the planet. The richness of infectious diseases increases from high latitudes to the tropics (Guernier *et al.*, 2004, Dunn *et al.*, 2010, Morand *et al.*, 2014) (Fig. 6A). Interestingly, this latitudinal gradient follows that of general biodiversity. The richness of bird and mammal species is also higher in the tropics than in the northern latitudes (Fig. 6B). This fact has been known since the inception of biogeography and continues to generate questions about the ecological, climatic or energetic mechanisms responsible for this biodiversity gradient.

Interestingly, a positive correlation is shown between richness in birds and mammals species and richness in human infectious diseases. A country with a high biodiversity of vertebrates (birds and mammals) is also home to a wide diversity of pathogens (Dunn *et al.*, 2010, Morand *et al.*, 2014) (Fig. 6C). This observation on a global scale is found at regional scales:

Figure 6. A. Map of infectious disease richness by country. B. Map of species richness of birds and mammals by country. C. Relationship between infectious disease richness and bird and mammal richness by country (data from the GIDEON database).



Adapted from Morand *et al.*, 2014c.

according to two studies performed at a regional level, the richness of infectious diseases correlates positively with the richness of birds and mammals in Europe and Asia Pacific.

More intriguingly, cultural diversity, known to be correlated with biological diversity, also is positively correlated with diversity in infectious diseases. This means that a country rich in biodiversity is a country rich in cultural diversity (often measured by its linguistic diversity) and with a high diversity of infectious diseases.

Studying the mechanisms that explain the diversity of infectious diseases affecting human populations must therefore take into account not only ecology (animal diversity), but also anthropology (cultural diversity). An approach for such research is what can be called the 'socioecological niche' of health, which might find its supporters in both anthropology and ecology. The existence of varied environmental niches enables adaptation, specialization and local diversification for both biological diversity and cultural diversity. Some researchers even identify mechanisms of co-evolution and local co-adaptation of humans and nature (e.g., for natural biodiversity and cultivated biodiversity) contributing to biogeographic entities defined as 'eco-regions' and hotspots of 'bio-cultural diversity' (see the work of Hamond and Maffi, 2002, Maffi, 2005).

The observed relationships between biological diversity and cultural diversity on the one hand and biological diversity and infectious disease diversity on the other have led some authors to focus on searching for causal links between cultural diversity and infectious disease diversity (Fincher and Thornhill 2008). These authors proposed sociobiological explanations, which are beyond the scope of this chapter. However, as emphasized here, studying infectious diseases needs to confront fundamental questions in biology, ecology and anthropology with potentially important policy and philosophical implications.

What lessons can be drawn from this first chapter? First, the pattern and diversity of emerging infectious diseases are not fundamentally different from those of all infectious diseases that have affected and continue to affect human populations. They are mostly zoonoses caused by viruses and bacteria.

Second, emerging infectious diseases are detected in developed countries of the northern hemisphere (and some southern hemisphere countries such as Australia) because these countries have the biotechnological capabilities to characterize them. However, the risks of new zoonotic diseases are most likely located in the intertropical zones (South and South-east Asia, Central Africa), which are hotspots of animal and plant diversity, cultural diversity and infectious disease diversity.

Factors of emergence: climate change, biodiversity, land use and globalization

Studies on emerging infectious diseases attribute their increase to human activities. The explanatory factors are those of ongoing global changes: climate change and its variability, globalization with economic development and international trade, land use

changes including deforestation and associated biodiversity loss, and biological invasions. The impacts of these changes on arthropod vectors, such as the Asian tiger mosquito, are among the most cited examples. EIDs are a phenomenon related to these global changes that is characteristic of a new geological era: the Anthropocene.

There would appear to be a contradiction at this point. The previous section of this chapter showed that rich biodiversity is associated with many human infectious diseases (the statistical correlation observed between the number of birds and mammals and the number of human pathogens). If this is true, how could a loss of biodiversity be associated with an increase in the number of EIDs? The explanation given is that biodiversity loss is associated with more interactions between humans, their domesticated animals and wildlife. Habitat fragmentation and agricultural and livestock intensification affect local biodiversity in terms of both species richness and the composition of animal and plant communities. These phenomena also lead to new contacts between humans and domesticated and wild animals.

A typical example is the emergence of the Nipah virus in Malaysia, where massive deforestation has caused fruit bats to migrate to new areas and food sources, such as date palm plantations. These plantations, located in areas of intensive pig farms producing for the international market, have created conditions for new infectious contacts between bats and pigs, followed by infectious contacts between pigs and humans, both locally in Malaysia and in Singapore, where the pork ends up.

Several studies have also shown that reduced biodiversity at the local level can lead to an increase in prevalence rates and transmission of certain infectious diseases. These studies focused on Lyme disease, West Nile fever, and hantavirus haemorrhagic fevers (Keesing *et al.*, 2010). Note that these three EIDs have affected the United States and were the subject of intense research efforts. The studies explain the success of transmission of a pathogen by a mechanism called ‘dilution effect’.

Dilution effect occurs when the local biological community is enriched with species that are not pathogen reservoirs. Infections of these species are epidemiological dead ends or ‘lost transmissions’ that negatively affect the persistence of the pathogen despite the presence of highly competent reservoir species. The proposed initial mechanism for dilution effect with lost transmission concerns vector-borne diseases. Arthropod vectors are often not very discriminating (such as ticks in Lyme disease or mosquitoes in West Nile fever). The number of their blood meals on non-competent species (they are the ones that do not allow the development of the pathogen) increase with the richness and abundance of these non-competent species in the overall community. These non-competent hosts are unable to ensure the multiplication or transmission of pathogens. A study showed that the human prevalence of infection for West Nile fever is negatively correlated with the species richness of birds. High local bird biodiversity appears to dilute virus transmission due to the presence of many non-competent bird species for the virus development and transmission. This high biodiversity of wild avian fauna reduces human exposure to this virus (Swaddle and Calos 2008).

Other dilution-effect mechanisms have also been proposed for directly transmitted pathogens, often referred to as 'indirect dilution effects'. In this case, it is no longer a question of transmission losses to non-competent species, but of a decrease in the abundance of reservoir (or competent) species. High biodiversity is characterized by many species with relatively low abundance. A highly diverse animal community is therefore composed of reservoir species and non-competent species living in low-density (population) abundance. The effect is reduced efficiency of transmission to the relatively rare competent hosts, as observed in the case of hantavirus hosted by rodents. Highly diverse communities of rodent species are characterized by a low population density of reservoir or competent rodents. Transmission and prevalence of hantaviruses are low, and so are the risks of transmission of these viruses to humans.

Several other studies have provided strong support for the dilution effect (direct or indirect). This has encouraged certain scientists to conclude that biodiversity loss tends to increase pathogen transmission and the incidence of infectious diseases (Keesing *et al.*, 2010). Local biodiversity conditions, species richness and species composition (including reservoir hosts) are believed to be the determining factors in the transmission of zoonoses from wildlife. The loss of biodiversity would be associated with a loss of ability to control or regulate the spread of pathogens in the ecosystem. Accordingly, biodiversity is assumed to provide an ecosystem service for the regulation of infectious diseases.

However, other studies question any positive role of biodiversity on zoonotic disease transmission. The preservation of biodiversity can even lead to increased health risks. The fight against deforestation would lead to an increase in malaria risk in Brazil as suggested by Valle and Clark (2013). Lafferty and Wood (2013) emphasized that considering biodiversity as a protection against wildlife health risks is a "myth" that can be counterproductive to the intrinsic goals of biological conservation. In support of their demonstration, a meta-analysis[2] of a set of studies tested the effect of dilution and found a lack of statistical support for this effect. Additionally, this meta-analysis was not very optimistic in its conclusion on the theoretical power of scientific ecology. The effect of biodiversity on the local transmission of an infectious disease would not be predictable because it is idiosyncratic, i.e., contingent on local conditions, (Salkeld *et al.*, 2013). However, two more recent meta-analyses conducted on a greater number of studies confirmed the statistical existence of a dilution effect (Civitello *et al.*, 2015; Johnson *et al.*, 2015).

The research appears to be quite contradictory, but many of the studies cited above sometimes confused or maintained confusion between disease diversity, disease transmission and disease epidemics. Disease epidemics are characterized by temporal and geographical aspects from local to global (i.e., pandemics), regardless of whether

2. Meta-analyses are statistical analyses of statistical results from various independent studies. They are quite common in the field of biomedicine to compare epidemiological studies.

they concern an emerging infectious disease or not. We should now look at how infectious disease epidemics are linked to global changes and biodiversity.

What are the effects of biodiversity changes on disease epidemics?

A previously cited study on one of the emerging infectious disease hotspots – Asia Pacific – sought to explain how biodiversity could affect the infectious disease epidemics (Morand *et al.*, 2014b). This macro-epidemiological study took into account socioeconomic aspects (population, GDP per capita, public health expenditure), geographical aspects (latitude and country areas), climate factors (precipitation, temperature) and biodiversity (bird and mammal species richness, forest cover, and the number of species of mammals and birds in danger of extinction). Although the number of infectious diseases correlated well with biodiversity, the total number of zoonotic disease epidemics over the 1950–2010 period was positively correlated with the number of endangered mammal and bird species. The number of vector-borne infectious diseases (whose agents are transmitted by arthropods) was negatively correlated with forest cover. These results suggested that zoonotic and vector-borne disease epidemics were associated with biodiversity loss as measured by endangered wildlife or forest cover. These results support the hypothesis that biodiversity regulates the spread of pathogen transmission. However, these results do not explain the underlying ecological and epidemiological mechanisms that should be analysed at local scales.

A key point that should be highlighted is the role of economic development, estimated by GDP per capita. Biodiversity-rich tropical countries are developing by intensifying agriculture and livestock for the needs of local, regional and global markets. The increase in GDP correlates to the environmental impact on biodiversity linked to economic development and integration in the global economy. But the increase in GDP also improves the public health system, which in turn enhances the ability to detect infectious diseases and their epidemics, and lifts the well-being and health of populations. The downside is that economic development, through its impact on biodiversity (richness and forest habitats), favours zoonotic or vector-borne infectious disease epidemics, including the risks of new emerging diseases. The emergence of the Nipah virus in Malaysia as a result of agricultural intensification is one example of this, as is the emergence of zoonotic malaria due to *Plasmodium knowlesi* following the conversion of Malaysian tropical forests to oil palm plantations.

What are the effects of globalization?

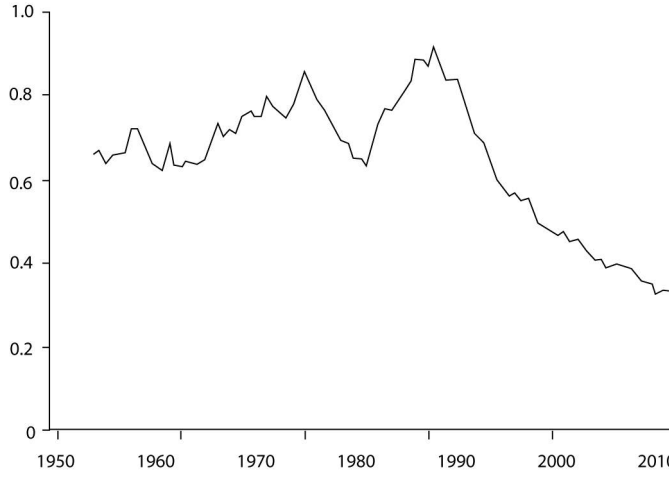
As noted above, the number of emerging and non-emerging infectious diseases has risen over the past century. At the same time, the number of outbreaks has also increased dramatically. The explanatory factors for these trends are associated with the global changes that continue to occur at an unprecedented speed and scale. These global

changes of anthropogenic origin impact biodiversity, which is undergoing a major crisis of extinction.

Biodiversity loss also applies to parasites themselves, which constitute more than half of all biological diversity (Morand *et al.*, 2015). Parasites are affected by the biodiversity crisis, even though their extinction rate is far from being accurately estimated (Dunn *et al.*, 2010). In developed countries, a sharp decline in parasite loads and the extinction of some human infectious diseases have been observed in the last century (Armstrong *et al.*, 1999). Finally, it is not so much the rise in the total number of human pathogens (including emerging pathogens) in the world over the past decades, but the increase in the number of infectious disease epidemics that makes the different (see Fig. 2).

The last decades stand out for the homogenization of parasitic diversity. This phenomenon appears to have started in the 1960s (Smith *et al.*, 2007), and is characterized by a striking homogenization of global epidemiological patterns. Countries are becoming much more similar in terms of their infectious disease epidemics, with these epidemics being increasingly shared in space and time among countries. Nowadays, epidemics link a larger number of countries that are geographically close or economically connected, as depicted by a network analysis (Fig. 7).

Figure 7. Temporal evolution of the global epidemiological pattern of infectious diseases.



A network analysis of epidemics shared by countries and by year showed that the number of clusters of countries sharing epidemics or the same infectious diseases decreased from the 1960s, whereas the total number of epidemics increased (see Fig. 2). More and more countries had similar infectious disease epidemic profiles (data from the GIDEON database, taken from Poisot *et al.*, 2015).

At the same time, there is a loss of the genetic diversity among parasites and pathogens. This loss is likely related to a decrease and homogenization of domesticated animals breeds selected for intensive breeding, resulting in an alarming decline of genetic resources (Rosenthal 2009). Globally distributed livestock parasites, such as *Trichinella* worms, tapeworms or *Toxoplasma* protists, show a growing standardization of their genetic diversity, reflecting both global trade and the global circulation of a few high-performing strains adapted to the homogenous genetic backgrounds of these domesticated animals (Rosenthal 2009).

The main conclusion of the second part of this chapter is that although global changes affect the conditions of emergence or local epidemics, the globalization of the economy and trade makes it possible for new EIDs to reach anywhere in the world (provided that the location is well-connected to the global network). However, this globalization is accompanied by a decrease in the global genetic diversity of pathogens and the homogenization of the epidemiological environments.

Conclusion: Is the next plague certain?

Human pathogen communities have been enriched by wildlife and animal domestication, but globalization affects the tempo and geography of epidemics because of major changes in the interactions amongst humans, animals, biodiversity and the environment. Evolution and human history have repeatedly provided exceptional conditions for pathogens to thrive. Ongoing changes are creating new opportunities for infectious diseases to emerge and take hold.

The spatialization of disease emergence, past or future, if not accompanied by the understanding of the socioecological mechanisms of disease transmission, would only designate countries or regions as sources or targets of new epidemic risks that should be contained. Disease contagion can be prevented if their socioecological causes are treated. The globalization of exchanges and new epidemiological connections should help better guide our surveillance and public health systems, not for the unimaginable, unpredictable new emergence, but rather for the predictable, which is to say the many infectious disease epidemics that are already becoming globalized.

Interestingly, while parasite biodiversity has declined in developed countries as a result of an effective public health policy, new health problems have emerged. Two final examples will illustrate this point.

The eradication of smallpox (obviously a good thing) has led our societies to abandon vaccination against this terrible disease. However, smallpox vaccination provided protection against other related viruses, and stopping smallpox vaccination has had the unexpected consequence of promoting new infections from related viruses such as monkeypox and other viruses harboured in rodents (Vorou *et al.*, 2008).

However, the decline of parasitic biodiversity appears to favour the emergence of autoimmune diseases. Ulcers caused by the bacterium *Helicobacter pylori* seem to be

linked to the disappearance of nematodes and tapeworms in many developed countries. The absence of a parasitic community interacting with the microbial community results in increased antimicrobial inflammatory responses, leading to the emergence of ulcers (Weinstock *et al.*, 2004). Improved hygiene due to modifying the parasitome and the microbiome increases allergies and autoimmune diseases (Parker *et al.*, 2012). Ironically, we face two new pandemic disease threats at the same time: infectious communicable diseases due to new emerging pathogens and noncommunicable diseases due to the disappearance of pathogens!

In exploring the ecological and biological mechanisms possibly associated with emergence potential, this chapter has emphasized the importance of our relationships with wild and domesticated animals. New emerging infectious diseases may be indicative of these ultimate contacts with biodiversity in a period of major crisis. But, in terms of public health, the worst may not be where we are looking. We may be witnessing the final outbreaks of infectious diseases emerging from wildlife, and the new emergence of non-infectious diseases are still to come with the biodiversity crisis.

2. From emergence to emergences – a focus on pandemic influenza

Nathalie Brender, Claude Gilbert

The emergence issue has for several years been the cause of major concern within scientific communities and amongst public and private stakeholders aware of the onset of new types of risk that stand out from those already identified and addressed.[3] This concern is not new since, for instance, many discussions and analyses in the 1980s were focused on 'major technological risks' (Lagadec, 1981). This line of thinking highlighted the shortcomings of domestication efforts since the late nineteenth century to turn threats into risks to make them easier to manage (Ewald, 1986). Debates on the risk society (Beck, 2001) and the precautionary principle (Hermitte and Dormont, 2000), while taking public health into greater account, were clear signs of the disruption prompted by the return of threats that are hard to identify, foresee and manage once substantiated.

The term 'emergence' has, however, primarily been adopted by infectious disease specialists, fully in step with public concerns, especially with regard to the AIDS situation. Emergence is often explained in quite general terms. For example, the Oxford Dictionary defines it as "The process of coming into existence or prominence". This is nevertheless appropriate in referring to changes or disruptions occurring in nature, in the broadest sense of the term, which then trigger reactions from public safety authorities due to the threats they pose. The emergence of a threat seems to be above all determined by the reality of the phenomenon, regardless of the knowledge and tools that highlight its significance. Relevant scientific communities are thus expected to determine the seriousness and scale of emerging issues. Public measures or policies should therefore be defined and initiated on the basis of scientific expertise, which has an essential role. While it is widely acknowledged – including amongst stakeholders involved in producing basic knowledge and consulting – that the processes are far from being linear and that scientists and experts can have an influence on the choice of priorities (because of the interests of the different sciences and disciplines or, more trivially, due to their proximity with regard to the political and especially economic community). These aspects are,

3. This work also benefitted from exchanges in the framework of the *Européanisation des risques sanitaires et environnementaux* programme conducted by the SAGE laboratory (UMR 7363, CNRS, *Université de Strasbourg*, France), funded by the *Maison des sciences de l'homme Alsace* (MISHA). It was carried out in collaboration with Laurence Raphaël, Research Engineer at CNRS (MSH-Alpes, Grenoble, France).

however, at most considered to be artefactual effects of the functioning of the scientific community, ultimately without any real impacts on the reality of an emergence attributed to a particular virus or bacteria.

Humanities and social science specialists have a different approach to this issue. They do not question the fact that scientists study actual situations by focusing on detecting new disorders since that is their function, and they may even sound the alert if the need arises (Chateauraynaud and Torny, 1999). But they incorporate specifically scientific rationales and interests in their analyses without considering that the effects may not be artefact-free. Conversely, they consider that the latter is just one factor to be taken into account alongside the findings of scientific assessments of the actual situation. Scientists, from their standpoint, are social stakeholders like any other category of actors. A brief look at the background of famous scientists like Alexandre Yersin, who discovered the plague bacillus (Deville, 2012), highlights the extent to which social life is crucial in scientific careers and concomitantly in discovery processes.

Humanities and social science specialists also do not question the fact that public authorities, backed by experts, strive to deal with new risks and threats (Godard *et al.*, 2002) via public policy implementation – so it is essential to identify and shield against any potential enemies (Gilbert, 1992). But here again they do not overlook the fact that the political and administrative actors also operate according to their own specific rationales and interests and that putting an issue on the agenda involves various considerations that are not limited to resolving the problem as it has been scientifically defined and isolated. Any emerging issue makes sense against the backdrop of already established situations, relative to what is "already there" (Lascoumes, 1994), along with the corresponding authority, power and legitimacy implications. From this standpoint, the onset of a threat is certainly a constraint for the different stakeholders focused on the issue, especially given the potential of health crises like those that have arisen in recent decades. But it can also provide opportunities for stakeholders who seize this occasion to assert themselves, boost their power, etc.

Emergence mechanisms are therefore quite hard to analyse when, for instance, it is necessary to focus on a burst of growth of mushrooms, how they are sought and found, but also the different uses mushroom pickers have for them once they leave the woods. To understand these mechanisms, it could be useful to consider political science and public sociology studies that have dealt with the emergence issue via analyses on modes of defining and recognizing public issues and placing them on the agenda. The aim is to assess why some issues – significant or made to be significant – acquire a public issue status while others do not, by focusing on the issue building process (Gilbert and Henry, 2012). With the building concept, the focus is less on imperative necessities – accounting for serious and urgent cases often goes hand in hand with the emergence concept – than on how stakeholders appropriate or not debate-provoking issues and on the way they succeed or not to impose them in the public sphere. Public recognition of issues seems to depend on their nature, but also possibly even more so on their mode(s) of appropriation.

Emergence can thus be viewed as a breach of reality due to unexpected phenomena or as an effect of a social mechanism set in motion when there is a sign of a breach. This mechanism unfolds according to its own logic and can lead to many surprises. An emerging issue can successively or simultaneously be defined in different ways, hence complicating its identification. Like the above mushroom example, it would seem better to refer to a plant generated by many crosses, where it is not possible to predict what kind of flowers or fruit it will produce. Pandemic influenza has thus again been the focus of public concern but not only for health reasons. Pandemic influenza is theoretically presented as an issue of a virus that is a serious threat to public health, but has turned out to be an open issue that is becoming increasingly open as its appropriations multiply. To gain insight into the re-emergence of the pandemic influenza issue, in reference to Spanish flu, it is essential to identify the different related interests, implications and definitions that have been put forward on both national and international scales.

WHO re-appropriation of the issue

Current WHO management of the pandemic influenza threat now seems to be taken for granted. This threat – which has long been overlooked in international health risk regulations (Rasmussen, 2015) – has always been on the WHO agenda, although sometimes muted (Vagneron, 2013; 2015). It has also had a key role in the structuring and functioning of this organization. WHO has strengthened a surveillance network that was founded in 1947, set up a network of laboratories and encouraged countries create referral centres following the 1957 pandemic, with the H2N2 virus outbreak. Similarly, the development of a network-based system including WHO collaborating centres that centralize information on a global scale has largely been determined by the Hong Kong flu of 1968 outbreak. Expertise in this area has further increased since WHO has been getting support from technical laboratories to validate tests and develop vaccine strains. This system – although not essential to the activities of this organization – is the most long-standing and successful of the organization's control systems. Its alert function was first implemented during the emergence of SARS, which was initially identified as a potential new flu strain (Heymann, 2005).

WHO's recent interest in pandemic threats appears to be in line with its ongoing activities. It is essential to consider the criticism focused on WHO in the 1990s to be able to understand this situation. WHO re-appropriation of the pandemic influenza issue – which is crucial with regard to its re-emergence – was one solution to the difficulties faced by this international organization.

Pandemic influenza – a remedy for an organization in crisis

The legitimacy of WHO, like all organizations, depends on its ability to identify and deal with issues that in principle fall within its remit. This is the case regarding the eradication

of diseases such as smallpox. Through top-down initiatives focused on specific agents, WHO has long been considered one of the best UN organizations, if not the best (Peabody, 1995, p. 732). It has also experienced failures, such as in its management of the AIDS crisis, of which it lost control in the 1990s to the Joint United Nations Programme on HIV/AIDS (UNAIDS) (Peabody, 1995; Beigbeder, 1999). It has also been challenged for its clientelism during the 1993–1995 period and for the corruption prevailing in its regional offices (Beigbeder, 1999). Moreover, during the 1990s, WHO seemed to be a fragile structure burdened by serious financial problems, as well as being an inward-looking bureaucratic organization with many internal conflicts. It has also been criticized for being less operationally efficient than other agencies (e.g., UNICEF) and stakeholders such as nongovernmental organizations (NGOs). This situation prompted WHO to reform in the late 1990s by defining its remit and adjusting its strategic position in relation to other actors.

The resulting discussions indicated that WHO should remain within its area of excellence by asserting itself as a reference centre for biomedical expertise; by pooling, assessing and disseminating knowledge in scientific, medical and public health fields (especially by collecting and publishing epidemiological and statistical data); by establishing itself as a supervisory body to monitor the application of international health regulations; and finally by drawing up international recommendations (Beigbeder, 1999). WHO's key role was thus to provide advice on, formulate and support more suitable health policies, while promoting better research. This placed a very high value on intellectual functions, with the idea being that WHO should be both a moral and technical authority. WHO thus expanded its role beyond that of an information provider for international organizations, especially via the Global Public Health Intelligence Network (GPHIN), a warning and notification system launched in 1999, and the Global Outbreak Alert and Response Network (GOARN), which was founded in 2000 and brings together over 150 partners while providing outbreak response experts. WHO has been developing this system since 1996 to enhance detection and management of infectious disease outbreaks and was first implemented in response to the emergence of SARS (Brender, 2010).

Moreover, WHO was called upon to position itself as an overriding body whose remit was to frame international health policies, with two associated consequences: reaffirmation of non-intervention against actors implementing health policies in the field (governments or regional authorities) and – to enhance its influence – strengthening relationships and its coordination role with different categories of actors (scientific community, manufacturers, particularly in the pharmaceutical sector, and NGOs). Since 1998, WHO has been striving to establish itself as a reference body and go-between to bring together multiple stakeholders. Various contradictions have, however, complicated the task: between the management of health issues amongst countries (with the preservation of economic interests as imperative) and management within countries (with public health and individual rights as imperatives, especially in developed countries) (Fidler, 2004; Guilbaud, 2007); and between top-down programmes that have ensured its success (eradication of smallpox, poliomyelitis and guinea worm disease) and horizontal 'health for all by the year 2000' based programmes aimed at strengthening local healthcare systems (Beigbeder, 1999).

Furthermore, as already mentioned, WHO found itself facing powerful and sometimes new actors reluctant to acknowledge the organization's attributed role, including Gavi, the Vaccine Alliance, the Global Fund to Fight AIDS, Tuberculosis and Malaria, and the Bill & Melinda Gates Foundation. The proliferation of these actors has also led to what is often referred to as the institutional labyrinth of international health.

WHO's repositioning has been further complicated by the fact that the actors are coping with so-called public health issues with other concerns. This is not a new situation as health threats have long been handled on the basis of the dangers they pose with regard to country safety and sustainability (Guilbaud, 2007). However, the connection between human health and (bio)terrorism (Scoones and Forster, 2008; Zylberman, 2013), particularly due to the new status of smallpox as a biological weapon, the ever-closer link between human and animal health (with increased involvement of the World Organisation for Animal Health [OIE]) and, more broadly, the fact that health risks are being dealt with in terms of economic trade disruptions they could incur (with increased involvement of the World Trade Organization [WTO]), have undermined the definition of issues on which WHO focuses.

In the late twentieth century, WHO – despite its international legitimacy and repositioning in 1998 – did not have a strong stance in an immense and hazy system of actors. The agency was also unable to clearly distinguish the topics that in principle came within its scope. Given this situation, there were many good reasons for WHO to re-appropriate the pandemic influenza issue. It was an available and almost 'orphan' public health issue that no major stakeholder had actually taken on (the influenza issue was largely confined to seasonal flu cases). Although fresh in the minds of all public health stakeholders since the Spanish flu epidemic, the pandemic influenza threat was partly overshadowed by other public health problems in both developed and developing countries, as reflected in the WHO Influenza Pandemic Plan report which focused on other diseases such as malaria (WHO, 1999). WHO was already partially prepared for this health issue and thus able to come up with solutions. This situation could almost be explained by the 'garbage can theory' (Cohen *et al.*, 1972) whereby solutions that have already been formulated and are available sometimes determine the nature of the topics to be managed. Moreover, this public health issue was the focus of national and international lobbying by influenza specialist scientists and experts. For instance, an Organisation for Economic Co-operation and Development (OECD) working group placed infectious diseases – particularly pandemic influenza – back on the list of systemic risks, on the same level as terrorism and chemical and nuclear accidents (OECD, 2003, p. 102). Through its widespread global presence, pandemic influenza has emerged as a disease that could only be effectively managed on an international scale by an organization capable of implementing policies globally, handling coordination activities, etc. Finally, in addition to being a major health risk, pandemic influenza turned out to be linked to other issues (due to the many possible global impacts of pandemics), or even as a means to simulate other serious issues. It has thus been claimed that preparedness for an influenza pandemic could serve as 'the basis of planning for a possible bioterrorist attack' (OECD, 2003, p. 149), an argument that was subsequently put forward by WHO and its Member States to justify investments

earmarked for pandemic influenza preparedness. Some scientists even believed that the influenza virus could serve as a terrorism bioweapon and demanded that protection measures be implemented at national and international levels, while also asking WHO to take up this issue (Madjid *et al.*, 2003). These reconciliations sometimes complicated the definition of pandemics and helped open the issue to many other stakeholders, while they still highlighted that the issue was critical.

The many 'qualities' of the pandemic influenza issue, its consistency with WHO objectives and resources were largely conducive to its re-appropriation in the crisis context impacting the organization at the time. So it was a real opportunity for WHO which, by participating in managing the re-emergence of pandemic influenza, found a way to bounce back and reposition itself in the circle of major globally involved public and private stakeholders. This re-appropriation – prompted by strategic considerations – was promoted by different alerts, particularly by the SARS outbreak in 2003 (Brender, 2010), and by the almost simultaneous resurgence of the H5N1 avian flu virus. During these events WHO positioned itself as 'owner' of this issue, with the capacity to define, provide solutions and assign responsibilities regarding its management (Gusfield, 1984).

SARS, H5N1 and H1N1 – emergence catalysts

WHO TOOK ON THE RESPONSIBILITY FOR RISK ANALYSIS in emergency and uncertain situations at the onset of the SARS outbreak. The agency relied on innovative expertise mobilization systems and it set up, for the first time, virtual networks connecting virologists, clinicians and epidemiologists. Moreover, and also for the first time, it issued a global alert and coordinated the international response especially by activating the Global Outbreak Alert and Response Network (GOARN) to send 300 experts into the field. Via this action, it gained legitimacy that was widely recognized by many countries, despite objections from Canada and Thailand, for instance, that the International Health Regulations (IHR) – the only international instrument for infectious disease management – did not apply to SARS. WHO had no coercive capacity to deal with countries but still managed to take advantage of an incentive system to bring countries together in a global effort, particularly with regard to China, even though its support was late in coming. WHO established itself as a pivotal actor in health risk governance at the end of this epidemic and despite some criticism about the cost of the measures taken, rivalry between researchers, and the information overload relative to the processing capacity (Brender, 2014). SARS has symbolic significance for WHO because it represents the first test of its new experimental international risk governance processes and tools, even as the corresponding legal framework had yet to be stabilized. The agency explained its action by the multiple benefits of the SARS management systems set up (an argument that was subsequently put forward with regard to the H5N1 avian influenza and H1N1 situation) with regard to managing future influenza pandemics, new infectious diseases or bioterrorist attacks (WHO-GAR, 2003). This argument was meant to justify the use of resources earmarked for SARS measures and to convince donors to

invest in preparedness activities for the management of a future influenza pandemic. It was subsequently put forward in different WHO publications, especially in the World Health Report 2007 (WHO, 2007a, p. 35). WHO took full advantage of its experience by collecting feedback regarding SARS management, establishing good practices and improving its processes, procedures and tools to eventually be implemented in the management of H5N1 avian influenza and H1N1 pandemic influenza outbreaks. In short, WHO was back on the international stage in quite a bold manner and based on its expertise.

WHO strengthened its stance with the emergence of H5N1 avian influenza, alongside the emergence of SARS and the onset of the H1N1 influenza pandemic in 2009. The organization benefitted from the positive momentum created by the control of SARS to accelerate the IHR revision started in 1996. The revised IHR were approved in 2005 (coming into effect in 2007) in a version that broadened WHO's scope of action concerning infectious disease management, while being less constraining for countries than the project that served as a basis for the SARS response (Brender, 2014). In Appendix 2, this instrument provides for a risk analysis mechanism for countries to issue alerts on public health emergencies of international concern (PHEIC), which was applied by Mexico during an emergency influenza pandemic (H1N1) in 2009. Meanwhile WHO analysed the situation and its Director General mobilized an emergency committee to decide whether this situation warranted a PHEIC and to put forward recommendations for controlling the outbreak.[4] The strong involvement of WHO in SARS management and different pandemic influenza threats enabled the agency to clearly entrench its role in international arrangements, which was a primary benefit of this emergency.

WHO was mobilized by the highly lethal H5N1 avian influenza virus upsurge in February 2003, right at the time of the SARS crisis. The agency readily established itself as the key actor in the preparedness for future pandemics threatening to become a human health issue. The organization's rhetoric was based on the certainty of an imminent pandemic, and hence on the need and usefulness to prepare for it by improving monitoring systems and hospital infrastructure, while anticipating the vaccine and antiviral needs (Check, 2005). Based on its SARS experience and the adoption of the revised IHR, WHO intended to coordinate the preparedness activities and the international response in case of pandemics. This, however, overlooked the competition with other international organizations such as the Food and Agriculture Organization of the United Nations (FAO) and especially the World Organisation for Animal Health (OIE), which ultimately received more funds than WHO for their interventions (Figuié, 2014). WHO then adopted a more cooperative strategy and positioned itself as a federating and coordinating agency. This, for instance, involved organizing an international conference in November 2005 to draw up a global H5N1 control strategy and determine the financial needs. A funding plan of about $2 billion was then formulated (World Bank, 2006) to deal with future pandemics, but finally $4.3 billion was

4. This was also the case for the poliomyelitis and Ebola outbreaks in 2014. However, in the same year, neither MERS-CoV nor the H7N9 avian influenza outbreaks led to a PHEIC declaration.

pledged for this purpose according to a World Bank estimate (Kamradt-Scott, 2012). WHO then worked on a containment protocol generated by a multi-stakeholder working group including recognized experts from various institutions and geographical regions, WHO experts, representatives from other governmental and nongovernmental organizations, and even a representative of the Roche pharmaceutical group (Brender, 2010). This protocol and the WHO Global Influenza Preparedness Plan (and national plans) were the key response elements, complemented by the flagship revised IHR after they came into force in 2007.

The overall outcome of WHO's action in dealing with the H5N1 avian influenza outbreak nevertheless seemed mixed. The position of this organization was certainly consolidated following the implementation of the revised IHR, the strengthening of its coordination activities and the publication of its Global Influenza Preparedness Plan in 2005. However, it came under fire because of controversy among experts on the impact of future pandemics on human lives and the reliability of reporting from countries affected by avian influenza. The agency also had to deal with the refusal of Indonesia to supply virus strains for the purpose of developing a vaccine that would not benefit developing countries. Furthermore, it had to address major actors that were striving to position themselves on the international stage. As the influenza pandemic had yet to occur, concern about it also began to wane, resulting in stakeholder demobilization in the preparedness for this risk. All of this highlights that the H1N1 influenza pandemic in 2009 could thus be considered as an emergence in crisis.

In April 2009, concomitantly with the publication of its new Pandemic Influenza Preparedness and Response Plan, WHO acted on behalf of Mexico and the United States and placed the H1N1 pandemic influenza issue on the international stage. The organization applied the IHR for the first time – the Director General formed an Emergency Committee and declared H1N1 influenza to be a PHEIC, and then a pandemic on 11 June 2009 (although emergency committees also likely previously operated unofficially for SARS and H5N1 avian influenza). WHO took a leading position in managing the pandemic based on risk analysis mechanisms, mobilization of expertise, its pandemic preparedness plan and the procedures in place for managing SARS and H5N1 avian influenza outbreaks. The organization mobilized virtual networks including epidemiology modelling experts, epidemiologists, clinicians and virologists, while promoting vaccination and antiviral administration because the containment measures were no longer practicable. WHO was, however, strongly criticized, especially concerning the inefficacy of its governance, the quality of its risk communications and the unsuitability of its recommended measures, especially the mass vaccination programme, relative to the mild disease severity. It was also accused of collusion with the private sector (Cohen and Carter, 2010), particularly regarding members of the Emergency Committee, and squandering of resources (Council of Europe, 2010). This led to a loss of confidence and undermining of WHO's legitimacy, especially in Europe, whereas Asia and the United States were relatively satisfied with the management of the pandemic, and Africa had been spared.

The benefits that WHO reaped from its management of the SARS outbreak, and to a lesser extent the H5N1 outbreak, were partly undermined by its management of the

H1N1 pandemic, despite the fact that it was the first global public health emergency that occurred after the revised IHR entered into force in 2007. Moreover, the IHR, which aim to protect global public health from diseases while minimizing interference with international transport and trade, actually played a key role in the global response to the pandemic, with the result that the assessments of the IHR and of the measures taken to manage the pandemic influenza situation were closely linked (WHO, 2010). WHO, in response to the criticism and to not lose the benefits gained from its previous initiatives, and with the assistance of experts of various origins, decided to justify itself by reviewing the actions taken to deal with the pandemic influenza threat. This gave rise to a report that was published in 2011 (WHO, 2011).

Although this report partially cleared WHO, it highlighted the need for greater transparency with regard to the expertise (especially in the nomination of experts and the management of potential conflicts of interest) and for designing an organizational structure that would integrate any WHO criticism. Recommendations were also put forward concerning IHR implementation and cooperation intensification, which resulted in the signing of an agreement on the sharing of virus strains and facilitated access to vaccines in 2011 (PIP Framework[5]). Meanwhile, WHO shifted towards a new strategic framework, i.e., the Emergency Response Framework (EFR), which was more generic than just being focused on health. It was considered more effective for the coordination of activities during emergency situations while providing a way for WHO to promote its action on a larger scale. WHO was thus seeking to reassert its role while more clearly defining its scope, thereby striving to limit its exposure to criticism and questioning of the legitimacy of its action.

Pandemic influenza – a scalable emergence

Despite some difficulty, and while coping with a long-standing internal crisis, WHO took advantage of the opportunity that arose when the pandemic influenza issue and various other health alerts were back on the agenda to return to the circle of major international organizations. However, the way WHO managed this return had an impact on the definition of this pandemic as an emerging issue, i.e., not only was the emergence of the pandemic influenza issue largely determined by WHO's interest in promoting it, but its classification shifted according to the organization's successively changing positions. These variations and shifts are reflected in a number of WHO guidelines, syntheses and recommendations.

A first major WHO Influenza Pandemic Plan was drawn up in 1999 (WHO, 1999). This pandemic was described as an event whose occurrence should be taken seriously, especially because of the increase in global trade and the fact that it is impossible to predict despite scientific progress, that it cannot be halted after onset, and that it could seriously strain economic systems and cause social unrest, in addition to saturating

5. Pandemic Influenza Preparedness Framework for the sharing of influenza viruses and access to vaccines and other benefits.

healthcare systems. Despite this pessimistic and even alarmist outlook, it was felt that pandemic impacts could be mitigated via effective preparedness and strategic effort, especially by setting up National Pandemic Planning Committees (NPPC) coordinated by national authorities, and mass vaccination programmes (despite delays in implementation and potential impacts, as in the United States in 1976). WHO was acting as a sentinel by announcing a pending hard-to-control health catastrophe, while nevertheless positioning itself as a manager with political authority by setting the degree of threat, thus "deciding on the exceptional situation" and posing as a "sovereign" agent (Schmitt, 1988, p. 15).

A first change in this initial framework occurred in 2005 following the SARS crisis and the H5N1 avian influenza outbreak with the development of the WHO Global Influenza Preparedness Plan (WHO, 2005). The threatening pandemic looked like it could take place at any time due to the widespread presence of a pre-pandemic virus (H5N1) at that time. The goal was no longer just to deal with the threat, but more specifically to respond to occurrences of pandemic influenza (WHO, 2005, p. 1). While keeping in mind that, "the responsibility for management of the national risk of pandemic influenza rests primarily with the relevant national authorities," WHO was taking a much more active role, with a firm intention, to "link phase changes [of increasing public health risks associated with the emergence of a new influenza virus subtype] more directly with changes in public health response, and focus on early events during a 'pandemic alert' period when rapid, coordinated global and national actions might help to possibly contain or delay the spread of a new human influenza strain" (WHO, 2005, p. 1). The containment concept gave rise to a specific protocol (WHO, 2007b) to contain the emergence of a disease or at least delay its spread. Even if the approach recommended by WHO were "not successful in containing spread [of a pandemic virus, it] should gain time to develop vaccines against the new strain, and to implement other pandemic preparedness measures that had been planned in advance" (WHO, 2005, p. 1). Finally, while focusing on public health aspects, WHO now stresses the need for "intersectoral planning involving partners outside the health sector" (WHO, 2005, p. 2). This is an acknowledgement of the multidimensional nature of pandemic influenza, although public health stakeholders are responsible for its management.

The Preparedness Plan became WHO's mainstay with the aim, in 2007, of developing and implementing tested plans in every country to ensure that the international response would be fully operational. Developing these plans was the recommendation most widely followed by countries, even the most reluctant, including the United States and some Asian countries. In August 2006, about 176 countries had drawn up a pandemic preparedness plan, but the quality varied in terms of content and especially with regard to plan effectiveness tests. In 2009, on the eve of the H1N1 pandemic, WHO estimated that 68% of the 119 revised national plans were based on the WHO plan, but only 8% had been tested (WHO, 2011, p. 66). During the process of drawing up these plans, WHO also had its say on the implementation of additional capacities for patient quarantine, timely treatment and laboratories.

The WHO guidance document published in 2009 (WHO, 2009) represented a new pandemic preparedness plan resulting from the 2007–2009 revision process. It was published almost

simultaneously with the emergence of the H1N1 influenza virus and confirmed the direction taken in 2005, considering that since that time progress had been achieved in many preparedness and response planning areas, with regard to antiviral drug stockpiling, a containment protocol to stop or delay the spread of pandemic influenza upon its emergence and, more generally, a better understanding of the pandemic phenomenon. "There is increased understanding of past pandemics, strengthened outbreak communications, greater insight into disease spread and approaches to control, and development of increasingly sophisticated statistical modelling techniques" (WHO, 2009, p. 8). So WHO had further distanced itself from the 1999 guidelines by tending to present public health actors – primarily itself – as being capable of responding despite the magnitude of the situation and uncertainties. However, it did this quite cautiously, while pointing out that, "pandemic preparedness requires the involvement of not only the health sector, but also the whole of society" (WHO, 2009, p. 12), given the potential impact of a pandemic crisis. Moreover, the link between animal and human health was stressed, with the H5N1 virus being the most likely candidate for an influenza pandemic. The 2009 pandemic plan took the IHR into account and, although still consisting of six phases, they were grouped and mainly concerned virus propagation for determining the phases and ultimately the declaration of pandemics. Phases 1 to 4 focused on the virus transmission capacity and its containment, while phases 5 and 6 concerned sustained human-to-human transmission with grading of the geographical spread of the virus.

WHO's action was hinged on this instrument, but it was still criticized. The pandemic criteria had already been fulfilled for several weeks when Margaret Chan, Director General of WHO, finally declared the pandemic on 11 June 2009. This announcement triggered pandemic plans in most countries, but some had been set in motion earlier. The rapid spread of the virus and the uncertainty regarding its severity, as well as the time squeeze also, depending on the plan arrangements, led to the issuing of vaccine and antiviral requests to deal with the pandemic threat. It was found that a response mechanism based on automatic implementation of the WHO plan and national plans was not always adapted to the situation. This resulted in strong criticism given the fact that the pandemic turned out to be mild.

WHO again acknowledged these difficulties. In 1999, 2005 and 2009, the agency published a plan each time, but it had still not revised and drawn up a new plan following the H1N1 influenza pandemic. Only an interim document was disseminated to guide countries in risk assessment (WHO, 2013), especially in determining the threat severity. Some countries published new plans following the 2009 H1N1 influenza pandemic, including Switzerland in 2013. This development clearly reflected the intention of some countries, particularly in Europe, to distance themselves from WHO, while continuing to recognize its pandemic response expertise and coordination role. Most countries seemed to want to re-appropriate the responsibility for risk assessments (including national pandemic declarations) and for decision making on the implementation of measures. WHO was then asked to position itself in a federalist-inspired international model, with its assessment serving as a guide for countries retaining national flexibility. This was likely an implicit trade-off between the different stakeholders.

Beyond the difficulties it faced, WHO managed to establish itself as 'owner' of an exceptional issue which – by being associated with the common seasonal influenza issue – took the form of a recurrent threat (with concomitant possibilities of routinization and regular funding). WHO also designated a specific area of expertise: uncertainty management on behalf of countries (regarding the nature of the threat, expected mortality rate, etc.). Because of its pivotal role in information collection and dissemination and its close connections with the scientific community, WHO had a greater capacity than other agencies to deal with uncertainties or even, via different categories of experts, to trigger a scientific controversy (Gilbert, 2009). It had the role of shifting the cursor between certainties and uncertainties. WHO was thus again able to become one of the main actors in charge of dealing with global issues, while promoting a new type of global governance of these issues (particularly in the framework of the One World, One Health programme).

WHO acquired this status by positioning itself as a key actor in managing infectious disease emergence and governance thanks to its involvement in controlling SARS outbreaks, the development of a pandemic preparedness plan during the H5N1 avian influenza outbreak, and its management of the H1N1 influenza pandemic, along with all of the above-mentioned criticism which that entailed. WHO – as a learning organization, strengthened by its SARS experience and in competition with other organizations for handling H1N1 outbreaks – developed more efficient strategies, procedures and tools, which it tested in MERS-CoV and H7N9 avian influenza outbreak situations.

Following the H1N1 pandemic, WHO reaffirmed its leadership in managing infectious disease emergence, while stressing the role of countries and their responsibilities, especially strengthening of national public health capacities. Through this balancing act, it was able to sustain its status as a key actor despite the new positioning of countries and the economic crisis, which sharply reduced financial and human resources previously earmarked for the pandemic issue (thus delaying the development of a new pandemic plan to replace the temporary guidelines issued in 2013). The fact remains that WHO's capacity for action was markedly affected and the agency was once again forced to question its strategic positioning.

An issue seeking owners – the French case

At first glance, the fresh interest in pandemic influenza in France, as in other countries, seems to have primarily and almost mechanically resulted from the global emergence of influenza episodes that could develop into crises equivalent to or even greater than that resulting from the Spanish flu epidemic. The SARS, H5N1 and H1N1 outbreaks seemed to embody such threats, forcing authorities to reconsider situations that seemed to match past trends. So the potentially high impact of the event seems to have been enough to place this public health issue back on the agenda, but the conditions of its re-emergence actually seemed a bit more complex.

Pandemic influenza was seriously taken into account in France in the early 2000s with the development of a plan devoted specifically to this issue. France appeared to be amongst the countries at the forefront (Mounier-Jack and Coker, 2006), yet it had in fact lagged in placing the issue on its agenda because in the 1990s stakeholders from the scientific community were already highly mobilized to boost awareness on the extent of the pandemic influenza risk and the need and even urgency to deal with it. Some French researchers were actually the most fervent advocates of this cause on the national, European and international scene. Moreover, although the pandemic influenza issue was initially dealt with by health specialists, it was quickly linked with other issues that partially masked its initial features. The emergence of pandemic influenza in France is an issue that metamorphosed over its appropriation history, thus explaining its current hybrid nature.

Multiple appropriation

The pandemic influenza issue re-emerged in France prior to the health alerts in this century, while very few countries had shown an interest in this issue (only the United States and Canada had a rough draft plan on the issue). The attention that was refocused on the pandemic influenza threat was actually the result of a very deliberate action by stakeholders concerned about seasonal flu in the early 1990s. This involved scientists specialized in the issue, particularly those involved in a surveillance network (*Groupes régionaux d'observation de la grippe*, GROG), along with major scientific laboratories with which these scientists directly collaborated in a specialized group, i.e., the *Groupe d'étude et d'information sur la grippe* (GEIG). The aim of this group (founded in 1979) was to streamline the activities of flu vaccine producers in France (few at the time). It was also – with the assistance of researchers participating in its scientific council – to educate the media and therefore the public on the importance of vaccination. The different stakeholders, closely interacting with each other and forming an 'influenza sphere' (Becker, 1988), thus aimed to increase immunization coverage. The public health arguments were fruitful as they led to a partnership between private industries and the French national health insurance fund to launch national immunization campaigns.

In the 1990s, stakeholders of the influenza sphere felt it necessary to go beyond seasonal flu issue, increasingly implement routine treatment, and take into account more exceptional risks associated with influenza, such as pandemic influenza (that had actually been somewhat forgotten). The virologist Claude Hannoun of the Pasteur Institute (Hannoun, 2009) stood out amongst these stakeholders as he seemed to be the main 'policy entrepreneur'. The pandemic influenza issue was promoted through a lobbying campaign to convince the national and international scientific community and health authorities. This strategy first involved the organization, by GEIG in 1992, of an international closed-session conference on Options for the Control of Influenza, which brought together the main researchers and other stakeholders concerned about the global influenza issue. This subsequently led to organizational expansion, the creation of a similar European-scale

structure at GEIG by Claude Hannoun (European Scientific Working Group on Influenza, ESWI), and direct interventions with stakeholders who could have a decisive role in the recognition of this re-emerging issue. Following meetings in Berlin in 1993, senior public health officials from various Western countries and international organizations were invited to make a statement to this effect. The statement was followed by an appeal by renowned scientists stressing the need to rapidly prepare for an influenza pandemic (Aymard *et al.*, 1994). Efforts to place this issue on multiple agendas were successful for reasons as much to do with the forcefulness in issuing the alert (by stakeholders with substantial resources and arguments) as with the interest that institutions and organizations could have in taking it into account.

This process was unique in that it was triggered and completed in the absence of a proven pandemic influenza threat. The re-emergence of this issue was therefore the result of the influenza sphere dynamics as it was reasonable to expect that this disease would inevitably resurface. However, despite successes on the European and international scene, French health authorities did not immediately listen to the call of the influenza sphere stakeholders and thus failed to place pandemic influenza on their agenda. It was only a few months after the Berlin meetings that a group of experts was formed with representatives from different French ministries (Health, Defence, National Education and Agriculture) by the Ministry of Health to sketch out a plan to deal with this potential threat. Although initially viewed from an interministerial standpoint, the pandemic influenza issue was essentially dealt with from a health and medical angle. Upon its emergence, seasonal flu specialists were thus able to assert their approach on the basis of a preliminary outline plan that had been developed in 1995 (RNSP, 1995). Different stakeholders nevertheless felt it was a plan by scientific and medical experts without much operational applicability and which – due to the lack of suitable procedures – did not really come within the scope of risk management policies. Pandemic influenza had not solely been defined in terms of public health, nor did it only concern actors in this domain.

As of 2001, pandemic influenza became increasingly associated with terrorism because of fears of malicious use of pathogens, as in the case of anthrax, smallpox, haemorrhagic fever agents, etc., which had already given rise to specific arrangements within the government. With the smallpox plan, health professionals, especially those in the hospital sector (emergency, ambulance and infectious disease services, etc.) had already adopted a rationale of a plan related to terrorist threats. This approach was reinforced with the bioterrorism thinking that developed in the early 2000s (e.g. with the Dark Winter exercise in the United States in 2001 where the spread of smallpox by terrorists was simulated) (Zylberman, 2013), along with various exercises in France and Europe in the framework of the PIRATOM (nuclear risk), PIRATOX (chemical risk) and BIOTOX (biological risk) plans. The 2003 SARS outbreak, particularly in Hong Kong and Canada, markedly heightened the concern. Hence, the rationale and operational strategies regarding bioterrorism also tended to be applied to pandemics. Moreover, as in the case of a potential bioterrorism attack involving the spread of smallpox, the emergence of pandemic influenza led to

the development of a programme for large-scale immunization of the population over a very short period (even though the latter case concerned the second or third wave of pandemics). The linkage with bioterrorism had varied and sometimes contradictory impacts. This confirmed the relevance of health sector stakeholders in their role as experts since the targeted enemy was clearly the pandemic virus, but once this role was acknowledged, influenza specialists from all disciplines were then asked to leave the way open to stakeholders competent in dealing with a range of new threats facing society. So it was not entirely a coincidence that the French General Secretariat for National Defence (SGDN[6]) – an interdepartmental structure that reported to the Prime Minister – was highly involved in the reflection on these issues and in preparing a plan as of 2002–2003.

Actors from the civil security and the defence sector in general were backed by a group of specific actors organized around the French interministerial delegate for avian influenza control (DILGA) appointed in August 2005. This entity consisted of a small number of senior officials from various ministries who were at the delegate's disposal. The group operated in an interministerial setting, despite the fact that it had initially been decided to assign this function to the Director General of Health. So public health was just one dimension amongst others covered during the many meetings DILGA organized, with pandemic influenza being approached in a much more global manner and as a potentially long-term issue. Representatives from many ministries and public organizations were consulted, as well as those from large local authorities and companies having a key economic role, while the focus was increasingly on the issue of the continuity of activities. DILGA's assessment of this especially dynamic aspect also helped change the approach to pandemic influenza.

An issue with a range of definitions

Pandemic influenza has been defined in several ways because of the many appropriations to which it has been subject. We assess this through the successive tones of the different versions of the plans developed to effectively manage this threat.

The first French governmental pandemic influenza plan in 2003–2004 (SGDN, 2004) was developed from a scientific and medical perspective, but it should be noted that the initial version was classified as a confidential defence document. The existence of this version, which was soon replaced by a public version, nevertheless clearly highlights the links with national security issues at the time. Links between the medical and military sectors were facilitated by the fact that 'pre-pandemic' viruses were equated with potential enemies. Given the nature of the threat, the approach was very warlike as human and animal health specialists had a confirmed role as experts and, in a related way, the health system seemed to be primarily concerned. The aim was to cope with the threat with active vigilance so as to be able to promptly identify the 'enemy', with preparedness for mobilization of

6. Now the Secrétariat général de la Défense et de la Sécurité nationale (SGDSN).

different medical, material and human resources to 'combat' the pandemic threat (with 'vaccination' as the ultimate weapon) (Gilbert, 2007). The confrontation with pandemics was here approached mainly from a civil security crisis angle, thus with a shift towards administrations with governmental obligations in the conventional state of emergency framework. The approach to the pandemic influenza issue – although always marked by public health concerns – was thus ambiguous and paved the way to various appropriations.

The second version of the plan (2006), drawn up under the auspices of SGDN, did not markedly change the previous framework. A new direction was, however, taken with the third version (2007) influenced by DILGA, which in turn was increasingly involved in designing the plan. By focusing on the issue of the continuity of activities, the small group of senior officials involved in this structure, as well as in SGDN, was no longer solely committed to mobilizing state actors in emergency situations. They were at once led to consider a broader interministerial collaboration (thus not limited to the health, security and civil defence sectors), an association with actors other than those from the central government (local authorities, especially the largest ones) and much more active involvement of civil society stakeholders, including businesses. This changed the essence of the pandemic influenza dimension, with society overall now being concerned by this threat. The focus shifted, with less concern about determining how to handle the pandemic crisis issue, which was delegated to the central government, and more interest in checking the resistance or resilience capacities of the different constituents of society. Note that resilience was a term that was 'emerging' in the collective risk and crisis domain, and more broadly in public policy, especially following the publication of the French white paper on national security and defence (*Défense et sécurité nationale*) in 2008, which stressed this dimension (Mallet *et al.*, 2008).

Subsequent versions of the plan (2009, 2011), especially that of 2011, confirmed this change of perspective since, based on feedback, they highlighted the government response strategy, emphasizing flexibility and adaptation to the characteristics of the pandemic. This was a real strategy shift away from foreseeing and planning everything via a set of highly precise specifications, which was the approach adopted in the first versions, to preparing authorities for highly uncertain situations. It seemed that the authors of the previous version had taken into account some criticism of the prior approaches, which were considered to have been too planning oriented, to the detriment of the analysis of situations in all of their complexity (Gilbert, 2007), or they had focused on theoretical studies challenging strategies based solely on proactive initiatives (Jullien, 2002). Moreover, it had become clear that, beyond the governments, the pandemic influenza plan concerned, "all public authorities, health professionals and socioeconomic stakeholders participating in the response to the pandemic situation" (SGDSN, 2011).

In very broad terms, the pandemic influenza issue could be considered to have re-emerged via three overall stances. The first, i.e., the most obvious and spontaneous, was the adopted public health approach, whereby pandemics simply represented an extension of influenza control, with specific features due to the change of scale. The second, which was less obvious but also very relevant, was the consideration of pandemic influenza as

a collective security issue. From this standpoint, pandemic influenza had a public health dimension, along with a civil security (public order and national defence) dimension. Confirmed links with terrorist threats reinforced this approach. The third and last stance involved viewing pandemic influenza as a global issue burdening contemporary societies, especially the most modern ones. The idea was no longer to deal with temporary threats under a state of emergency, but instead to ensure the continuity of activities in uncertain and degraded situations while relying on commonplace social resources and forces.

These three general definitions of pandemic influenza steered this issue in quite different directions. They swayed the issue towards various potential types of 'owners', but were not mutually exclusive and links existed between each definition. The public health oriented definition accommodated the collective security oriented definition, even in its most extreme aspects (social unrest, terrorism). Similarly, the collective security oriented definition, with specific reference to government interventions, accommodated a much broader definition via the introduction of the resilience concept and overtures to civil society stakeholders. Although the issue was transformed in a very precise way, with vulnerabilities and structural resistance capacities being taken well into account, the different definitions were overlapped and intertwined. This is a fairly common situation regarding public issues where various definitions coexist, with some often taking precedence over others, some pertaining to public areas and others restricted to 'discrete areas' where there may be trade-offs between concerned stakeholders (Gilbert and Henry, 2012). Concerning pandemic influenza, however, this coexistence seems to mainly correspond to a certain degree of indecisiveness regarding the attribution of the 'ownership' of the issue. Clearly, the health sector stakeholders did not have the capacity to retain this issue within their field of expertise even though they were the main promotors of pandemic influenza as a public issue to be placed on the agenda. It eluded their grasp when security stakeholders took up the cause and implemented their own instruments. But these latter stakeholders in turn lost their grip on the issue when other stakeholders (some from the security domain) presented pandemics as a perfect example of new global issues. So no stakeholder category really emerged as the 'owner' and even today any aspect of the pandemic influenza issue can be placed under the spotlight depending on the circumstances and setting.

This situation obviously had direct impacts on the re-emergence of pandemic influenza, which may occur in different ways depending on the extent of investment in it, which in turn depends on quite different factors. The obligation of any category of stakeholders to manage a given issue given the formal powers or missions they have been assigned is certainly one key factor. Regarding pandemic influenza, it goes without saying that stakeholders of different domains (public health, civil security and defence, global security) are all focused on this issue because of these different possible definitions. However, the interest in the issue cannot be dismissed as being simply linked with institutional obligations. It is also related to the way the stakeholders seize opportunities that arise, which was likely the main factor in the re-emergence of pandemic influenza as a public issue in France.

Drivers of an emergence

One of the drivers of this emergence was the possibility for different actors involved in seasonal flu management to expand and promote their action. This was the case with regard to political/administrative actors who felt this warranted the adoption of a health policy based on vaccination, to economic actors who could see an opportunity for market expansion in the drug sector, but perhaps even more to scientists specialized in flu issues. Despite ongoing costs for society (concerning both mortality and economic impacts), influenza did not (or no longer did) call for special scientific attention. It had gradually acquired the status of an ordinary issue to be managed in an ordinary way via proven methods. By promoting the re-emergence of the pandemic influenza issue, seasonal flu specialists managed to bring this issue back under the scientific spotlight. While these specialists had adopted a relatively marginal position, they managed to obtain research funds and jobs as well as gain access to leading scientific journals, which until then had been difficult. So finally it became possible to have a career working on influenza. These specialists were able to demonstrate the expertise acquired with regard to influenza monitoring and alerts, which in the influenza sphere was the subject of heated debate between virologists (who considered themselves natural owners of this issue) and epidemiologists (in an outsider position). The issues especially concerned the way these two disciplines approached the influenza phenomenon and the impacts this had on their respective capacities to organize surveillance and conduct foresight studies (e.g., characterizing new threatening viruses or developing epidemic dynamics models). Influenza specialists therefore jointly promoted the re-emergence of the pandemic influenza issue, but the dispute over its ownership was an additional driver (despite the subdued aspect of this dispute). Disciplinary tensions thus increased with the growing demand for surveillance and the expansion of the disease intervention field (e.g., potential modes of virus spreading, estimates of attack and fatality rates, individual and collective benefits that could be expected from different control strategies, etc.). As the pandemic threat was being taken into account, influenza became a real challenge for the scientific community well beyond the scope of virology and epidemiology (i.e. with specialists in infectious diseases, immunology and public hygiene also being concerned). The re-emergence process was thus triggered by the many incentives, including institutional ones, as in the case of the French Institute for Public Health Surveillance, which was determined to play a key role in monitoring and forecasting health threats (Buton, 2006).

This situation closely mirrored that in the animal health field since actors in this sector – in scientific research, consulting and public administration – continued to stress that most human infectious diseases stemmed from animal diseases. This claim, which was driven by the avian influenza (H5N1) threat, was underpinned by the powerful administration in place with experience on health crises (especially since the mad cow crisis), by the strong support available (from veterinarians; Alam, 2009), and the almost immediate backing from an international organization (OIE) with a strong French presence.

Another driver of this emergence concerned the way a group of actors incorporated (in its field) a theme that normally was beyond its realm of expertise. Collective security actors (to simplify) actually managed to take over the pandemic influenza issue by assimilating it to threats attributable to real enemies and turning it into an issue that could be managed as part of a plan focused on security objectives and which, like all public policy instruments, had its own programme (Lascoumes and Le Galès, 2005; Buton and Pierru, 2012). Various explanations for this takeover could be put forward. It could have been the result of the prevailing circumstances, such as the fact that a tool was available to address an issue requiring a solution (again in reference to the garbage can theory; Cohen *et al.*, 1972). The fact is that actors in the health domain claimed that *a priori* pandemic influenza did not have an instrument to incorporate this issue in a specific public policy, and moreover that they were already prepared for the security aspect of public health issues. But collective security actors were also provided an opportunity to expand and reconfigure their area of intervention by grasping an easily incorporated public health issue. This standpoint is in line with recommendations put forward in French national defence white papers that placed the pandemic threat at the same level as other global threats (without any clear distinction between risks with or without human enemies). Irrespective of the hypothesis, however, the possibility of including the pandemic influenza issue in a non-public health domain was a challenge for different actors and thus a driver of emergence (but not focused on a public health issue).

A third type of emergence factor revealed by the pandemic influenza situation was the possibility of attaching a general rationale onto a given issue. The approach taken by DILGA markedly exceeded the objective it had been assigned. The setup of this structure provided an opportunity for a small group of officials to very deliberately get involved in a major work programme combining a large number of stakeholders and geared towards determining – in terms of a global threat – the strengths and weaknesses of the French state and French society overall. From this viewpoint, pandemic influenza proved especially suitable for such an exercise and, in the name of public health, a broad review of the capacities of government bodies, local authorities, businesses, associations, etc., was conducted (especially in the framework of weekly meetings, or so-called 'influenza Tuesdays'). The review was backed by very broad discussions on the government role, which was beginning to shift more from that of a leader to a facilitator, thus to accept a new form of modesty in a complex society confronted with globalization, while not abandoning any prerogatives (Bourcart, 2015). So pandemic influenza provided an opportunity for stakeholders to take on a reformer role in an interministerial structure that actually had very little power but did have a sufficiently large audience to interest various categories of actors. This, for instance, was the case for very large companies which – driven by risk and crisis managers – formed a club to deal with the pandemic influenza issue and consider new forms of cooperation with governments, while considering how the responsibilities could be allocated (Steyer and Gilbert, 2013).

There had thus been many different emergence drivers which, once triggered, fuelled other events. Various sectors of the scientific community (research in basic and more

applied areas) took advantage of pandemic influenza programmes to develop studies corresponding to their own research programmes. Governments and local authorities also used pandemic influenza as a vector boost the awareness of their services and communities on public health issues. Moreover, via the pandemic influenza issue, some French government-run services (e.g., the *Institut national des hautes études de la sécurité intérieure*) or closely linked agencies (e.g., the *Haut comité français pour la défense civile*) positioned themselves to rethink collective risks and crises and incorporate the resilience aspect. Some structures, like the Ethics Research Department at the *Université Paris-Sud 11*, focused on pandemics with regard to ethical issues, etc. Pandemic influenza was hence used in many different ways. Although some of the uses were relatively opportunistic and some projects could not be carried out (such as the journal *Pandémiques : Pandémies, éthique et société*, which halted after three issues, i.e., nos. 2 and 3, November 2007), they helped maintain the pandemic influenza re-emergence phenomenon by confirming its status as an issue to be taken into account alongside other issues seeking recognition as a public concern.

Assessment of the appropriation of the pandemic influenza issue in France and the effects on its re-emergence raises many questions. It is hard to identify a category of actors that has taken on a real leading role to become owner of the issue. Different actors have shared this role but not always in a complementary way despite reconciliations between health, security and civil defence stakeholders via the pandemic influenza plan. Moreover, the definition of this issue has fluctuated from public health, public security (public order, terrorism) and activity continuity (resilience) orientations. The hybrid or even baroque sense given to pandemic influenza thus varies according to the appropriations, and even more to the intensity of the appropriations of this issue. Finally, the aspects that make pandemic influenza an interesting issue differ markedly, which means that the existence of this issue from a social standpoint, thus beyond its natural dimension, is based on mixed and relatively unrelated dynamics. The re-emergence of the pandemic influenza issue has also been the result of lobbying by scientists, of its inclusion in a security rationale, and of its qualities as a subject of debate on general or fundamental issues.

The approach to the pandemic influenza issue is thus the result of a relatively complex process that nevertheless has not prevented this disease from getting a foothold due to a series of explicit and implicit trade-offs between stakeholders (or at least interested parties). It is recognized that a pandemic is primarily an issue of a virus whose spread and development must be monitored – a point upon which both virologists and epidemiologists agree. The disease can mainly be overcome via vaccination – an option promoted by virologists and not challenged by other disciplines, despite some reserves (mainly because of the time required for mass vaccine production once the pandemic virus strain has been identified). This framing has been toughened by the use of increasingly sophisticated instruments in the areas of surveillance and proactive response (proactive epidemiology), and by the enhanced capacity to produce vaccines, which in turn could substantially progress (via increased use of molecular biology techniques), but it tends to limit the scope of health expertise regarding pandemic influenza. It is further acknowledged

that pandemic influenza is also a security (especially public order) issue warranting the intervention of sovereign bodies (especially since terrorism is associated with the pandemic threat). Moreover, pandemics are considered to be a societal problem via the activity continuity concern. This raises the question as to how to bring together governments and civil society to cope with new threats, develop intervention plans and adopt tailored ethical principles. These three general aspects are in some ways the package through which pandemic influenza is approached in France.

There is broad consensus on this framing of the pandemic influenza issue, with benefits for all stakeholders but, like any framing, it works by both inclusion and exclusion. Hence, influenza is not as much the issue as the agent that could induce it, so the focus is mainly on monitoring this agent and on implementing a vaccination programme to sidestep a potential attack. Accordingly, the disease always tends to emerge by default (failure to implement suitable surveillance, failure to quickly set up and apply a mass vaccination programme). Moreover, upon onset, the disease can only be treated by means that are often ineffective (e.g., public hygiene), questionable (e.g., use of controversial antiviral agents) or considered as a last resort (e.g., massive use of antibiotics in the treatment of pulmonary complications, which may also be controversial). Some disciplines (e.g., infectious diseases, immunology, public hygiene) may thus be marginalized in the pandemic management process, while warranting the intervention of sovereign bodies in the pandemic control process (as attempted during the H1N1 avian influenza outbreak with the implementation of a mass vaccination programme). In short, various types of investment tend to distance pandemic influenza from its primary definition regarding public health, but it is clear that the conventional approach is ultimately needed. Although new stakeholders have tried to appropriate the pandemic influenza issue via competing definitions, it has seemingly had no impact on the approach to this issue in the public health sector. This is especially true since the relative loss of interest in this issue in the public arena has given rights back to the 'natural' owners, i.e., core actors in the influenza sphere.[7]

Emergences at issue

Whether on the international level through the WHO case or on the national level, it is quite clear how the emergence of a public health issue is specifically associated with disorder in the natural environment, as reported by scientific experts, but even more so with the various interests that different categories of actors may have to take on the issue and even give it different definitions. Therefore a naturally occurring issue will have no social existence unless the actors present and making use of this issue can appropriate

7. A study carried out with Christophe Milazzo (*Université Pierre Mendès-France*) in the framework of the ANR Index project showed that within this 'little world' stakeholders multiply their allegiances to structures and engagements in networks, and that the most enduring challenges persist when the pandemic is taken off the agendas of other categories of actors interested in this issue.

it. The emergence phenomenon may then be highly complex, depending on many factors, particularly the nature of the relationships, adjustments and trade-offs between actors who have stated they are interested in any specific issue. The question of sharing the potential benefits of an emerging issue impacts both the force acquired by this emergence and its form. From this standpoint, situations that may be observed on international and national levels are unalike.

WHO, by contributing to the re-emergence of the pandemic influenza issue, promoted its own emergence as an international organization able to manage policies and emergency actions tailored to global issues such as pandemic influenza under the new One World, One Health concept adopted by a group of organizations in 2004. The emergence of a renewed WHO did not take place without some difficulty. The agency had to carve out its niche amongst the plethora of other actors (by making necessary trade-offs), strengthen its institutional foundations (especially via IHR) and make some changes to ensure that it would be both more efficient and better accepted. However, from an organizational perspective, this emergence process – with all of the associated constraints – had an impact on WHO's definition of the pandemic influenza issue. Its approach changed concomitantly with the adjustments and trade-offs that the organization was obliged to make when taking into account the international pandemic issue definition fights that were developing. This was especially the case with the avian influenza threat which was at the crossroads of three major types of definition or narrative: "it's a bird disease that affects people's livelihoods"; "human-human spread is the real risk, and could be catastrophic"; and "a major economic and humanitarian disaster is around the corner and we must be prepared" (Scoones and Forster, 2008, p. 12). WHO, by favouring the second narrative while still keeping other options open, neutralized the action of potential competitors (knowing that its main role could always be questioned depending on whether the emerging pandemic was of animal or human origin). Pandemics are still mainly a health risk, but they now have other dimensions that WHO cannot overlook and which it has thus partially integrated.

The situation differs with regard to the French case because, contrary to the international trend, there is no clearly identifiable group of stakeholders with both the willingness and capacity to take over and manage the pandemic influenza issue as leader and owner. Although interest in this issue by various categories of actors has actually led to its re-emergence, in parallel with the current international dynamics, the potential benefits of this re-emergence have been shared in a dispersed or even disordered manner, with each major category of actors pulling the issue in its direction without really appropriating it. Therefore, in the French setting, the question that arises concerns the actual purpose of the pandemic influenza issue considering how it has been used so far, but also how it could be further used. In other words, would a new alert be sufficient to trigger renewed interest in the pandemic threat or, considering current concerns in France about public health, collective security and the respective roles of the government and civil society, should it be considered that investment and profit making that have taken place via the pandemic issue is generally finished and that other emerging issues are likely to be a new

focus? This questioning rationale has led to a major change in perspective because the analysis no longer begins with the issues (emerging or not) but rather with configurations of pre-existing interests in the society that could host and manage them (Gilbert and Henry, 2012). Thinking from this angle might help gain insight into why – now that pandemic influenza is established as a multidimensional composite hybrid issue – it has partially lost its interest in the eyes of some stakeholders who had previously invested in it, except of course in the eyes of those who, as already mentioned, seem to be its natural owners. Contrary to the international trends, it is not certain that stakeholders in the influenza sphere would be powerful enough to boost the pandemic influenza issue to the height that they would like it to be positioned. This very clearly means that the emergence of an issue and its maintenance on the government's agenda are generally dependent on how they could become part of present interests. In other words, that which is 'emerging', regardless of its nature, must still contend with that which is already 'installed', even if this means upsetting its scheduling.

3. Future as a moving target United States, CBRN risk and the scenario planning method: 1995–2008

Patrick Zylberman

Fear, fiction, risk, threat, scenarios and civic activism – all of these factors underline the growing importance of emerging infectious diseases in epidemiology, virology, the ecology of infectious agents, and the history and sociology of epidemics in the present clearly defined global setting. The twenty-year period between the unchallenged global supremacy of the United States and the crisis currently wreaking havoc on the global power hierarchy has also been the backdrop for a 'political awakening of populations', or a kind of 1848 'spring of nations' on a global scale (Brzezinski, 2012). The intrigue is forcing governments on both sides of the Atlantic to deal with technological, biological, climatic and environmental risks. But what are the focuses of the policies: risk prevention or security? Historically, two distinct cultures have prevailed in this regard (Packard *et al.*, 2004). Prevention is now clearly not just a marginal sector in risk policy, but it is no longer its centre of gravity – security has filled that position.

Global setting

The stage seemed set for the supremacy of the transatlantic world right after the fall of the USSR. America became the only global superpower, or hyperpower, in the words of Hubert Védrine, French Minister of Foreign Affairs in the government of Lionel Jospin at that time. This chapter reviews this brief unipolar post-Cold War time during which a 'globally dominant West' was backed by international organizations – World Bank, International Monetary Fund and World Health Organization – which still had a fully recognized legitimacy in their respective fields. This period was split in two phases. Immediately after the USSR collapsed, the transatlantic relationship was based on shared faith in the broad deep-rooted ties existing within the transatlantic community. This spirit ebbed, however, during the years under George W. Bush's presidency (Hassner, 2003).

At the close of the period in question, the financial crisis of 2008 put an end to an almost perfect balance, while triggering a double shakeup. The first was in the global hierarchy, with India and China becoming members of the exclusive club of leading countries (G20)

– replicating Japan's rise to power in 1905 following its victory over Russia – and then, concomitant to this first change, in the European Union's irreversible decline in global governance, and the subsequent geopolitical dispersal of power and influence. Although the United States remained *primus inter pares*, the legitimacy, effectiveness and continuity of its leadership were beginning to be challenged. The days when an Atlantic club headed by the UK, France and the United States was at the world's helm were thus numbered. As a logical result, consensus was increasingly hard to achieve with regard to making decisions on global issues. The broadening of the global power base (US, EU, Japan, India and China) came at the price of less cohesion.

This diminished power cohesion was compounded by the worldwide political awakening of populations that were previously passive or repressed into docility – a novel phenomenon. Humankind (mainly rural) had always lived with a certain degree of geographical isolation and political unconsciousness. All of that changed with the mass communications revolution and the gradual overall increase in literacy worldwide. The world is now, "shaped to an unprecedented degree by the interaction of popular emotions, collective perceptions, and conflicting narratives of a humanity no longer subjectively submissive to the objective power of one politically and culturally specific region. As a result, the West as such is not finished, but its global supremacy is over" (Brzezinski, 2012, p. 35). Freed from the shackles of colonialism, peoples have the same historical representation in which their relative poverty, the domination they have suffered and the lack of recognition of their dignity are a legacy from the West.

International cooperation got trickier upon the decline of the global leader. The world's 'common parties' with similar strategic (sea, sky, space and cyberspace) and environmental (water, Arctic, climate, public health) features became exposed to overexploitation and indifference of governments and major countries. The water issue was twofold: water resource scarcity (especially in developing countries) and access conflicts (for transnational catchment basins). The combination of political uncertainty and resource scarcity represented a real threat in geopolitical terms. Although the United States considered that environmental issues were important, it lacked a long-term strategy and above all political commitment, a situation that was clearly not conducive to encouraging other countries to seek a global arrangement for dealing with these issues.

Hence, the dominant power became a stumbling block in the way of developing an effective global policy to safeguard humankind's common heritage, while its geopolitical decline exposed it to terrorist attacks even on its homeland and to heightened border insecurity, while ultimately reducing its capacity to prevent and resolve regional conflicts.

Immediate setting

In the aftermath of the Cold War – which was regarded as the setting for the end of history – a heady fragrance of apocalypse was in the air (Gray, 2009, p. 6–7). We will get

back to this later. Paradoxically, it was also the time when Western politics, although once perceived as a derivative or competing version of religion (regeneration ideology; Burleigh, 2007), was finally seen for what it really was: "the art of devising temporary remedies for recurring evils – a series of expedients, not a project of salvation" (Gray, 2009, p. 3). Health security is one of these expedients.

Health security, although a marginal issue until recently, is now associated with national security. Health risks and threats are currently crucial health policy components in developed countries. The latter have drawn up a range of plans and procedures against chemical attacks and pandemic threats of natural (e.g., influenza), accidental (e.g., Chernobyl) or criminal (e.g., the letters containing anthrax spores in the fall of 2001) origin. Meanwhile, in May 2002, WHO developed a series of standards to help countries defend themselves against serious infectious disease threats (WHO, 2002). A few months earlier, the European Union adhered to the Global Health Security Initiative, an informal partnership launched in November 2001 by Canada, France, Germany, Italy, Japan, Mexico, the United Kingdom and the United States, bringing together countries wishing to strengthen their preparedness and response to biological, chemical, radiological and pandemic threats. WHO served as an expert on the group's board. Scenario planning was a key feature amongst other tools, including standards, procedures and plans.

The United States led the way but its approach, contrary to that of Europe, was more offensive than defensive (Flynn, 2004). Preventive or preemptive action is called for when there is an issue of "not if, but when".[8] Colin Powell proclaimed "America is at war" against terrorism, in the sense that it was at war against crime and drug trafficking. War here takes on a very specific meaning. It involves marshalling the resources required to reduce, not eliminate, fundamentally antisocial activities to ensure system stability. George Orwell noted shortly after the end of the Second World War that our neglected expression led us to brood over senseless thoughts (Orwell, 1968, p. 157). It was a time of totalitarianism, but the situation was not left to worsen. In the aftermath of 9/11, the US administration – which has now become a master of rigmarole – exemplified furious confusion. 'Declaring war' on terrorists was a double-sided mistake. First it gave terrorists legitimacy, turning them from criminals into combatants. But even worse it created a kind of psychosis within the American people, with an expectancy, a demand for prompt spectacular action against a readily identifiable enemy. The use of force was no longer considered a last resort, but rather as the first one – hence the idea of preemptive action, i.e., preventive war, was back on the table (Howard, 2007).

The use of force as a first or last and always available resort was nevertheless not a universally popular option, especially in Europe. In 1928, Charles Nicolle was already discussing the risk of bioterrorism in his book on 'new' diseases (Nicolle, 1930). However,

8. Haass R., former Policy Planning Director at the State Department, in *The New Yorker* (2002), quoted by Ikenberry (2002, p. 52).

since the 1990s, Europe – intent on implementing the 'peace dividend' – was wagering on the emergence of a post-tragic world free from the use of force (Clarke, 2005; de Villepin, 2005). Europeans, virtually 'history's retirees', just wanted a rest (Delpech, 2005; Védrine, 2005; 2008; Gray, 2007, p. 195).

So had the transatlantic differences faded? Nothing could be less certain. Health security policies still differed markedly on both sides of the ocean. The trend has, however, been towards reconciliation in the wake of the Madrid terrorist attacks, with the increased chemical, biological, radiological and nuclear (CRBN) risk, and the rise in the need for substantial research and development efforts on combating terrorism and enhancing public health preparedness for biological threats. But this reconciliation process is difficult, turbulent and by no means certain to succeed.

At the turn of the century – in a setting of preemption, media coverage and the culture of immediacy – the health security concept developed via the spontaneous meshing of national security and health security terms. We will now discuss a few of the main steps in this process.

Fortunes and misfortunes of triumphalism

When, on 4 December 1967,[9] William Stewart, Surgeon General of the United States, declared before a learned assembly of US public health service doctors, "It is time to close the book on infectious diseases, and declare the war against pestilence won".[10] It was hard to foresee that his words would plunge US public health into deep disarray (Institute of Medicine, 1988). A series of hitherto unknown diseases burst onto the scene some ten years later:

– Legionnaires' disease, which is caused by a bacteria and named after an outbreak that occurred amongst attendees of an American Legion convention held in Philadelphia in 1976;
– an Ebola virus outbreak the same year in northern Congo-Zaire;
– a human immunodeficiency virus (HIV) outbreak in 1981, which subsequently spread at an alarming rate worldwide;
– an aggressive return of tuberculosis (TB), a disease whose incidence had been steadily declining over the previous century in the United States; in 1985 there was a very serious

9. Here we give a summary of chapters 1–5 of our book *Tempêtes microbiennes. Essai sur la politique de sécurité sanitaire dans le monde transatlantique*, published (in French only) by Gallimard in April 2013. We have included only a minimum number of notes and references. Interested readers will find all of the bibliographical and documentary information in the book.

10. W.T. Stewart, In: "A Mandate for State Action", a speech given on 4 December 1967 before the Association of State and Territorial Health Officers. The attribution of this quote was recently challenged (Spellberg and Taylor-Blake, 2013). When questioned by Brad Spellberg, Stewart replied that he could not, "recall whether or not he made this statement" (Spellberg B., Stewart W.H., 2008).

outbreak that began in New York (with alarming newspaper titles such as, "Killer TB on Subway"), and then spread to other states, sometimes in antibiotic-resistant forms (in 1991, a third of TB cases in New York involved multidrug resistant forms, with a 40–60% mortality rate, which was identical to that of untreated TB);
– finally, as of 1993, myriad other viruses emerged, including hantavirus, Escherichia coli O157:H7 and cryptosporidiosis (Table 1).

Because infectious diseases were regarded as relics of a bygone era, research teams were dispersed, laboratories dismantled, and funds transferred to other diseases (cardiovascular disease, cancer, etc.). Stakeholders became complacent, lulled by blind faith in preventive (vaccines, DDT) or therapeutic (penicillin, antibiotics) technologies. WHO in Geneva complied with this trend, with the closing of its TB office in 1989 (an Emerging Infectious Diseases department was founded six years later). These were lean years for virology and the arsenal to protect against infectious disease threats had been depleted. The cost of this complacency proved exorbitant.

The organizers of the first conference entitled "Emerging Viruses: The Evolution of Viruses and Viral Diseases" that was held in Washington in May 1989 were geared towards overcoming this complacency. What is an emerging virus? It is a new or previously unknown virus that is able to spread rapidly in naive populations (i.e., without immunity) and is thus responsible for a sudden increase in morbidity in these populations. Three mechanisms could explain this novelty: the emergence of a new variant (a familiar influenza virus mechanism), the invasion of new hosts (naive human populations) and finally the spread of the agent from a small isolated population (islands) to larger and denser populations. The invasion of new hosts seems to have been the main mechanism involved over the historical period since the Neolithic Age.

This Washington conference was not just one of the many scientific meetings that take place and are quickly forgotten. In addition to virologists and epidemiologists, it was of interest to palaeontologists, anthropologists, economists and historians because it stressed the responsibility of humans – a novel feature. Indeed, humans – through

Table 1. A few emerging microbial diseases (1970–2014).

1970s	1980s	1990s	2000–2014
Rotavirus enteritis	HIV/AIDS	Multiple drug-resistant tuberculosis	Severe acute respiratory syndrome (SARS)
Legionellosis	Hepatitis C	Cryptosporidiosis	Middle-East respiratory syndrome (MERS)
Campylobacter enteritis	*E. coli* O157:H7 (diarrhoea)	Variant Creutzfeld-Jakob disease	H9N7
Lassa haemorrhagic fever	Toxic shock syndrome	H5N1	Ebola (West Africa)
Ebola haemorrhagic fever	Lyme borreliosis		
	Methicillin-resistant *Staphylococcus aureus*		

agricultural practices, migration, travel, war, public health budget cuts, etc. – are partially responsible for causing microbial emergences. The situation in Malaysia is a typical example. From the late 1990s, the intensification of pig rearing led to the expansion of farms. With deforestation, the livestock animals were getting ever closer to the edge of the forests where they came into contact with faeces containing a reservoir of the previously unknown Nipah virus (NiV), which is normally hosted by the Malaysian flying fox (*Pteropus vampyrus*). NiV then crossed the species barrier by spreading from the pigs to the farmers, thus triggering an emergence.

Even the infection process rationale was changing with the emergence concept, thus generating a new image of the microbial world. Pasteur's germ theory, which was the basis of the tremendous progress achieved in public health, had been superseded by a dynamic relationship in which humans, including their practices and behaviours, were depicted as one of the causes of the circulation of infectious agents. This is called anthropogenic causality. Steve Morse, one of the organizers of the Washington conference, claims that humans are engineers of microbial circulation (Morse, 1993). Humans – like Molière's character Mr Jourdain who learnt that he had been speaking prose all his life without knowing it – unknowingly trigger microbial circulation.

This crucial role of humans in emergences has long been a focus of concern to historians. The black plague of the fourteenth century was a blueprint case. In 1331, China experienced a serious plague outbreak. The disease raged in a setting of civil disorder, leading to the overthrow of the Mongol emperors and the rise of the new Ming dynasty. The bacillus then reached the gates of Europe in the baggage of the Mongolian army (the Golden Horde that controlled most of the area of present-day Russia) which besieged the Crimean city of Caffa in 1346. The Mongols eventually withdrew as the plague got a foothold. This disease was subsequently disseminated via shipping throughout the Mediterranean and northern Europe. The germ was hosted and disseminated by merchants, soldiers, wanderers and anything that moved, rolled or navigated. Much later, in the seventeenth century, there was talk of the Black Death but there were no clear links between this descriptive adjective (i.e. Black) and the disease symptoms.

Microbial disease emergences are of course not confined to major pandemics. Global movements have accelerated since the Second World War, with a concomitant marked increase in the number of emerging diseases over the years. Moreover, most of these diseases (53.4%) are bacterial, not viral, and many involve antimicrobial drug resistance. The emerging infectious disease incidence has peaked since the 1980s, particularly due to the HIV/AIDS pandemic. Ultimately three main factors are responsible for this accelerating emergence rate:
– wildlife, the main origin of these emergences, which are a major health threat worldwide;
– climate change (and thus indirectly humans), which is responsible for the increase in vector-borne diseases in developing countries (28.8% of emerging diseases in the 1990s);
– finally, the increase in antibiotic resistance, which is a major health risk in developed countries (Jones *et al.*, 2008).

Bill Clinton and the CRBN risk

In the mid-1990s, two sensational events suddenly raised fears that rogue states or isolated terrorists could use emerging viruses for obviously criminal purposes. On both sides of the Atlantic, budding yet decisive new measures laid the foundations for legislation aimed at protecting the public and state against a new threat – bioterrorism.

The first of these events was the Tokyo subway sarin attack on 20 March 1995. That day, members of the cult movement Aum Shinrikyo ('Supreme Truth') placed plastic bags containing neurotoxic sarin in five Tokyo subway trains heading towards the city centre. The bags were punctured with sharpened tips of umbrellas and the sarin leaked onto the floors, generating a toxic vapour. The attack caused 12 deaths, with 17 severely injured, 37 seriously injured (muscle spasms and gastrointestinal problems) and 984 minor injuries, involving 5,510 hospitalizations in 278 hospitals or clinics and 4,000 psychosomatic disorders. The cult movement and its guru Shoko Asahara aimed to spread panic in order to bring down the government and take over the country. This was a chemical, not biological, attack but it represented the first terrorist operation conducted with a weapon of mass destruction. The attack was less intended to capture media attention than to achieve a high casualty rate. Its impact was also likely due to its temporal proximity with the Oklahoma City bombing (19 April 1995), which was a conventional but much deadlier bomb attack (168 killed and 500 injured).

The second event was the testimony before the US Congress of Ken Alibek, former Deputy Director of the Biopreparat programme on the militarization of certain viruses secretly implemented by the Soviets in 1974 (Zylberman, 2013, p. 93–96, 230–233). What Alibek told the Congressmen – he confirmed and further fuelled the revelations of British and American researchers who were rushed to Biopreparat sites just after the fall of the Soviet Union – was scary enough to leave the President greatly concerned.

In June 1995, the White House published Presidential Decision Directive 39 regarding US policy on counter-terrorism, which laid the foundations for the federal government response to threats involving weapons of mass destruction. One feature of this Directive was that it differentiated crisis management (police work and intelligence, assigned to the FBI and CIA) and consequence management (disaster management, assigned to the Federal Emergency Management Agency [FEMA]).[11] The Directive also set the conceptual framework for biodefence. In the wake of discussions amongst the Interdepartmental Working Group (Defense-Health) (April 1995) which was formed to propose research projects on protecting populations in case of the criminal reintroduction of smallpox (dreaded on the basis of the severe tension between Saddam Hussein and UNSCOM[12]

11. Note that six years later in France the *Plan Biotox* distinguished between crisis warnings and management.

12. United Nations Special Commission (regarding Iraq).

inspectors), the microbial crisis arising after a bioterrorist attack was defined both as a national security crisis and a public health crisis.

Meanwhile, although Bill Clinton was previously promoting the destruction of smallpox virus samples stored in Atlanta and Novosibirsk, he had a spectacular change of heart. WHO discussions on this issue began in the aftermath of the global eradication of smallpox, but out of the blue Clinton decided to stand up for countries in favour of preserving samples of this virus, including Russia, Britain and Australia, to be used (they claimed) for the purpose of antidote research and development. There is good reason to assume that Ken Alibek's revelations and Saddam's quirky behaviour played a role here, in addition to the conclusions of the President's roundtable meeting convened in the White House Cabinet Council Room on 10 April 1998, with a handful of scientists in attendance, including Joshua Lederberg, Nobel Laureate in Medicine, and in the presence of part of the Cabinet and military chiefs of staff. Indeed, the conclusions of this studious afternoon meeting gave little cause for optimism: first, virology had been abandoned (as a result of triumphalism with regard to the disease risk, as discussed earlier); secondly, biotechnology was considered as a seedbed for bioterrorism; and finally, the United States would be unable to cope with a potential biological attack.

The President kept a close eye on this issue. A few weeks after the 10 April meeting, in quick succession he signed two directives, one nominating a National Coordinator for Security, Infrastructure Protection and Counter-terrorism (including bioterrorism), who in turn was the chief counter-terrorism advisor on the National Security Council, while the other paved the way for establishing the Strategic National Stockpile of vaccines and antibiotics – the authorities tapped this stockpile during the autumn 2001 anthrax attacks involving letters sent containing anthrax spores. Finally in October, the White House set up the National Domestic Preparedness Program, which designated the US Public Health Service (i.e. an unarmed military commissioned corps) as responsible for the response against bioterrorist attacks.

For its part, Congress did not remain idle. In 1996, the Defense Against Weapons of Mass Destruction Act (Nunn-Lugar-Domenici Act) ordered the Centers for Disease Control and Prevention (CDC) to draw up a list of the most dangerous substances that could potentially be used by terrorists (24 infectious agents and 12 toxins). It also created specialized medical teams in major metropolitan areas of the country. At the end of Bill Clinton's mandate, the (Bill) Frist – (Edward) Kennedy Public Health Threats and Emergencies Act passed in November 2000 established a hierarchy of civil and military authorities assigned to take over the management of microbial threats – this was a major shift towards viewing health protection from a national perspective. At the risk of pre-empting George W. Bush's subsequent presidential tenure, we should here mention the Public Health Security and Bioterrorism Preparedness and Response Act of June 2002, which modified the bioterrorism legislation (prohibiting over-the-counter sale of dangerous biological substances), strengthened CDC powers (recall that this is a federal agency), broadened the authority of the Department of Health and Human Services at the interdepartmental

level, authorized the allocation of US$1 billion to states and counties for 2002 (earmarked for upgrading state capabilities and preparedness against bioterrorism and other health disasters – this was the most substantial funding in the fifty-year history of US health services). One idea that was catching on in Washington was deterrence by denial, or the assurance that a nation that is well prepared to withstand and respond to a (bio) terrorist attack (especially via a strong public health system) is the best deterrent against terrorists, thus from the outset thwarting their hopes of inflicting a real blow to their victims. "Preparing is deterring," exclaimed Senator Sam Nunn during a Senate hearing of the authors of the Dark Winter project, which was a table-top exercise designed by the Johns Hopkins Center for Civilian Biodefense Studies in 2001 simulating the response to a widespread criminal smallpox attack on the United States.[13]

The preparedness juncture was actually being negotiated in Washington. From the National Security Council (1998) to the Office of Homeland Security (founded in 2001) – both White House agencies – the antiterrorism doctrine was shifting from 'risks' (natural or technological) to focus on 'threats' (natural, accidental or intentional). The orientation was moving away from the natural/technological disaster model – the intellectual framework encompassing the precautionary principle and the 'risk society' – in favour of the emerging infectious disease model discussed earlier. The threat had become transcendent (first emerging seemingly without cause or reason). Although a rare event may be rational (possibly explained *ex post facto*), it could be the result of a rare but impossible to control event (impossible to determine 'where' and 'when' the threat will actually materialize). Clinton's strategy regarding the health security issue was subsequently more or less upheld by George W. Bush.

George W. Bush – from prevention to preparedness

The focus shifted, however, as echoed by a George W. Bush Directive of April 2004, which was followed up by the founding of the Department of Homeland Security. The text indicates that the prevention strategy is replaced by preparedness. Prevention – a twentieth century public health philosophy – was not entirely excluded from the new twenty-first century public health strategy, but it was no longer a pivotal aspect. This new preparedness concept took centre stage.[14]

What is preparedness? Originally, in the late 1990s, preparedness involved exercises and simulations imposed on administrations at various levels in response to all kinds of crises.

13. "Preparing is deterring (the enemy)": Strategies for Homeland Defense, Hearing on the Threat of Bioterrorism and the Natural Spread of Infectious Diseases, US Senate Committee on Foreign Relations, 5 September 2001.

14. Bush G.W., Biodefense for the 21st Century, The White House, 28 April 2004, http://fas.org/irp/offdocs/nspd/hspd-10.html.

In 1998, Congress thus obliged federal administrations and large municipalities in the country to conduct at least one exercise a year. Shortly after 9/11, preparedness became even more important as a result of the strengthening of epidemiological surveillance and the responsiveness of warning systems. The concept was considerably enhanced and differentiated within a few years and ultimately referred to five areas of action: threat detection (surveillance and warning), threat identification (laboratory tests, epidemiology), threat interception (non-pharmaceutical measures such as quarantine), threat neutralization (vaccines, antibiotics, antivirals), and post-crisis reconstruction. In 2006, 80% of the 5,000 health centres in the United States received funding to organize around 9,500 exercises. Preparedness clearly spans a much broader semantic range than prevention.

The type of simulation upon which preparedness is based is also unique. Mathematical models are not excluded of course, but strategic choices are currently modelled using the scenario planning method. Later we will discuss this method in greater detail. But let us first point out that its main feature is the absence of probability measures. As an extreme but telling example, let us consider for a moment Dick Cheney's famous '1% doctrine'. According to the Vice President, the worst-case scenario should be regarded as a certainty, even though a specific probability cannot be assigned to it. In fact, there would only be a 1% probability that a disaster would certainly happen. Ironically, this sort of super precautionary principle was put forward by an American – albeit unlikely to occur, everything should nevertheless be done to prevent any terrorist attack (Sunstein, 2007).

Obviously preparedness primarily affects different aspects of microbial threat governance. George W. Bush policies in this area were mainly focused on biodefense centralization and kicked off with the creation of the Department of Homeland Security (following the 2002 Homeland Security Act). This bureaucratic behemoth pooled 22 previously autonomous government agencies, including 180,000 civil servants, and was strongly criticized for its huge cost and low efficiency. The second project involved the publication (in January 2005) of a National Response Plan that merged the different response plans for all sorts of emergencies and disasters in a single document. There is little doubt about its ideological bent, as we will see later. Finally, the third project, which was far-reaching although greeted with some scepticism, was Project BioShield, which involved the creation of a US$5.6 billion reserve fund (a US$890 million credit provided in 2004, plus US$4.7 billion provided in instalments over the 2005–2013 period), aimed at facilitating the creation of procurement contracts for the treatment and prevention of smallpox, pulmonary anthrax, tularaemia and botulism.

Overall, was there a change or continuity regarding preparedness between the second mandate of Bill Clinton (1995–2000) and the first mandate of George W. Bush (2001-2004)? We would tend to favour continuity, in line with Jeanne Guillemin's reasoning (Guillemin, 2005). Clinton seems to have been the real architect of this new vision. Biodefence reused the 'materials' of the 1950s (Epidemic Intelligence Service), while wavering between public health and national security, typical of George W. Bush's presidency. As we have seen,

this strategy emerged in 1998 and became the official thrust of the White House in 1999 on the occasion of a vote at WHO on the conservation of smallpox virus samples, and at the UN Security Council session on HIV/AIDS in January 2000. Health security sought to achieve a balance between the three 'Ps': prevention, precaution and preparation. These were the three key strategies and layers in the timeline of the recent history of public health and their dovetailing highlights the significance of public health policies throughout the transatlantic community.

Scenario planning and worst-case scenarios

The scenario planning approach – an alternative to strategic planning – emerged at the end of the Second World War, in the wake of US Air Force bombing operations and operational research initiatives. The latter were taken over and systematized in 1948 by the RAND Corporation, a Californian non-profit strategic research institute.

The American defeat in Vietnam and the failure of mathematical models in strategy planning, along with the first oil crisis in 1973, heralded the second coming of the scenario planning method. The Frenchman Pierre Wack – one of the scenario planning designers – was head of the planning department at the London headquarters of the Royal Dutch Shell Group from 1971 to 1981. In September 1972, Wack presented Shell's governing board a set of scenarios concerning the sudden increase in per-barrel crude oil prices. This idea seemed preposterous at the time, but exactly a year later the Organization of the Petroleum Exporting Countries (OPEC) imposed an embargo on crude oil shipments after the Yom Kippur War. Only Shell was prepared for this turn of events and the scenario planning method thus subsequently spread like wildfire throughout the corporate world. In 1976, 41% of the top thousand companies in Europe were using it. However, predicting the future was not what interested Wack. His aim instead was to open the minds of leaders to a range of different possibilities in order to help them foresee, prepare for and respond quickly to sudden changes in the environment.

Without going any further into the history of scenario planning (which is outlined in Zylberman, 2013, p. 153–159), let us just take a quick glance at the many contributions of the method.

Using simple theatre and role playing techniques, officials are invited to design stories and play them out. The game (role playing) and stories break down the crisis process (sudden change in the environment) into a small number of stereotyped components similar to those proposed to soldiers during a war game or drill. These components, as they are stereotyped, are easy to understand and memorize. Each group of scenarios can be open to free interpretation or presented as a kind of storyboard upon which players can then improvise, with the latter being increasingly common. The scenarios are necessarily presented in packages where players may consider a best-case scenario, a worst-case scenario and one or several mixed scenarios. Just focusing on the worst-case scenario

– like Dick Cheney's famous '1% doctrine' – will obviously generate considerable bias in the reasoning at the end of the method.

Scenario planning – which is much better than using mathematical models – enables stakeholders to grasp an immediate understanding of the crisis. Scenarios also provide insight that diagrams and equations cannot do, i.e., highlighting human behaviours and rational or emotional variables that determine individual and collective behaviour. Overall, according to the players' choices and reactions, scenarios help determine the psychological impact of the spread of a threat on individuals and the social relationship dynamics.

The scenario planning method has impacts that go way beyond the scope of forecasting methodology. These impacts actually concern the ontology of risk and the very idea of future. This scenario-based approach gets away from the risk society concept whereby accidents occur at the edges of the technological system while remaining within the world of technology and science. Is not the conceptual basis of the risk society underpinned by an insurance-oriented rationale? The realm of threat – contrary to that of risk – is an environment in which danger is transcendent and unpredictable. The threat is not a potential accident within the technological system but rather an act of God that does not comply with any human laws. To use the words of Raymond Aron, scenarios represent the victory of subjective probability over the 'casuistic technique' of mathematical probability. With this partial withdrawal from objective probability, the focus shifted completely onto the impacts of the materialization of risks. 'Low probability, high consequences' is the current formula – which is also derived from the insurance-oriented rationale – regarding risks under the scenario planning approach. This formula thus readily encompassed bioterrorism, severe acute respiratory syndrome (SRAS) and avian influenza, which in turn triggered rapid development of the health security concept that took shape in the 1990s with the increased awareness of technological risk (i.e., therapeutic risk).

The future concept was therefore also completely transformed. As we know, forecasting and prospective analysis have a short-term future (1-3 years). The future is simply a projection of current trends, or a series of variations of a present theme. Conversely, the long-term future (5-25 years), i.e., the future of scenarios, has nothing to do with these accidental and occasional deviations – its fundamental structure is based on uncertainty, i.e., like Pascal's notion of uncertainty. In the words of Pierre Wack (1985, p. 76), the future has become "a moving target". Uncertainty is no longer a deviation in a trend, it is now the actual structure of the future.

Each of the 15 Homeland Security Council planning scenarios (Box 1) concerns a CRBN threat category. In addition to covering threats and responses, the scenarios stage a red team consisting of "terrorists, domestic radical groups, state-sponsored adversaries or in some cases disgruntled employees," pitted against the services responsible for managing the response. Typically, this red team is referred to as the 'Universal Adversary' (Howe, 2004; NPS Attack Timelines, 2006). Satan prevails in the epidemic scenarios! Generated through a neoconservative/Christian right alliance, national security at that time (i.e., over the 2002–2008 period) was viewed in purely demonological terms (Gray, 2007, p. 117).

Box 1. National Planning Scenarios, Homeland Security Council (2005-2006).

Nuclear detonation
Biological attack – aerosol anthrax
Biological disease outbreak – pandemic influenza
Chemical attack – blister agent
Chemical attack – toxic industrial chemicals
Chemical attack – nerve agent
Chemical attack – chlorine tank explosion
Cyber attack
Natural disaster – major earthquake
Natural disaster – major hurricane
Radiological attack – radiological dispersal devices
Explosives attack – bombing using improvised explosive device
Biological attack – plague
Biological attack – food contamination
Biological attack – foreign animal disease (foot and mouth disease)

This was yet another way to jump head first into the ideological trap criticized by Milton Leitenberg (2009, p. 101–102), expert and critic of the bioterrorism concept, whereby it is assumed that all terrorists – being monsters of intelligence and expertise – are technically at the same level as the perpetrator of the 2001 anthrax letters. This presumption was proven ill-founded by the documents and evidence gathered by the US Army in Taliban camps in 2003–2004.

The apocalypse has also been a focus of strategic thinking in the United States since the Reagan era. Extreme climate events and biological threats combine environmental disorder and human perversity. Wars, disasters and epidemics are signs of 'Messianic sufferings' heralding the Last Days. All large-scale historical crises are *ipso facto* taken as telling proof of a cosmic disaster. A crisis is not something that is or will be, it is coming, e.g., "the next pandemic," in the words of Michael Osterholm (2005) with regard to avian influenza pandemics. This marked an astounding return of a very old conception of fear (and fault), as echoed by Cicero, for whom the future was a current threat. By this logic the future is an approaching evil which gives way to the imminent.

A similar worst-case scenario rationale has long been rooted in a certain line of thought hinged on technology and its ill effects. Since the 1950s, a mood of combative pessimism has been rising concerning triumphant technology (Hans Jonas), the bomb (Günther Anders) and damage to the natural environment (Arne Næss, Rachel Carson). In the United States, since the oil spills that occurred over the 1970–1980 period, laws have been passed forcing the government to take worst-case scenarios into account. Moreover, alarmism

clearly often pays off in Congress. Let us not get back to the forecasting crisis, the worst case occupies centre stage in scenario planning. Prospective analysis eccentrics – Herman Kahn and Pierre Wack – have never held themselves back from exploiting all available possibilities to "think the unthinkable" (Kahn, 1962). In its three forms, i.e., epidemics (virus-host-ecology), accidents (system-operator-external environment) and criminal intent (project-biography-opportunity), rare events combine three unpredictable components: chance events (rational event, but the when and where are unpredictable), denaturation (sudden virus mutation, sudden unveiling of an intention to kill in a seemingly harmless person) and nonexistence (preparing to combat a not yet existent disease). The design and perception of disasters has clearly changed the paradigm.

Risk was a rational category in this cautious world. No risk without a specific etiology. Precaution was a superior rationale encompassing both the risk and its etiology. Nothing like in a world of threat that transcends all systems and leaves little room for prevention. This shift from a technical rationale to geopolitical transcendence stifles all forms of threat etiology. We now live in a world that can only be considered as having no cause or justification. There has obviously been a breakdown in the thinking.

Stranglehold of fiction

These framework scenarios offer managers of large-scale crises a fictional environment to help them prepare for a range of different situations, with each type of situation being the subject of a specific scenario. Fiction here means more than just a story and should be considered as a learning method. Players improvising a scenario immerse themselves in a fantasy world and through this mimed immersion become familiar with the attitudes, knowledge and benchmarks that absolutely have to be managed to be able to control a situation as tense and complicated as an epidemic crisis, for instance.

This presence of fiction is of paramount importance in the history of epidemic crisis scenarios. George Annas, the philosopher and legal scholar, wrote "Before September 11, most procedures for dealing with a bioterrorist attack against the United States were based on fiction. Former President Bill Clinton became engaged in the bioterrorism issue in 1997, after reading Richard Preston's novel *The Cobra Event*" (Annas, 2002, p. 1337). Another source of inspiration which heightened Clinton's concern after the Tokyo attacks is the article of Martin Meltzer *et al.*, 'The Economic Impact of a Bioterrorist Attack', published in Emerging Infectious Diseases, a CDC journal, which analysed the cost of unpreparedness (delays in diagnosis and slow antibiotic distribution) in the event of an anthrax attack (Kaufmann *et al.*, 1997). There is thus constant wavering between fiction and scenarios, or in other words, between openly Romanesque fiction (Preston) and supposedly real fiction (Meltzer).

Could the bioterrorism risk really be a literary passion? Yes, indeed, fiction abounds in globalized societies and is a steady trend. In the second century AD at the height of the

Roman Empire, fiction proliferated at an unprecedented rate. A common market of fantasy and the supernatural prevailed over local myths, old stories and dated provincial legends (Bowersock, 1997, p. 2). *Mutatis mutandis*, we are currently experiencing an analogous trend with the onslaught of all forms of fiction. Always local and specific, the common view of risks and threats was swept away by a kind of second-hand reality where uncertainty overwhelmed probability, with the future being a 'moving target' at the expense of the plausible, whose 'tyranny' was rejected (Conetta and Knight, 1998, p. 35). Moreover, this second-hand reality, i.e., that of scenarios, appears to be the only relevant reality, but from which no clear-cut rules emerge to pinpoint the exact minute when the event could occur – everything is deferred to its spatiotemporal coordinates (where and when). The scenarios are thus more focused on the epigenesis of the threat than on the science of the motives and intentions of the (terrorist) groups. However, without knowing the inspirational spirit, the veritable etiological legacy, time and location undoubtedly provide essential but limited information. The epigenesis of the threat is actually just another form of this widespread fictional empire, a symptom of the modelling crisis and forecasting failures that the scenario planning method seeks to overcome.

States of emergency once gave rise to emergency measures, with security barriers and cordons being quickly dismantled as soon as the danger had passed. In the age of terrorism, emergencies can no longer be seen as temporary – not that 9/11 precipitated the United States (and the rest of the Western world) into war – it is peace and the nature of peace that has been fundamentally altered (Zakaria, 2006). Altered, but not in a post-tragic sense and (with all due respect to David Fidler) more in a pre-Westphalian sense through a return to a sort of Hobbesian setting – peace "is not the fortunate absence of war, but rather its latent threat".[15] Moreover, security as a whole (national, civil, health, environmental) currently tends to override emergency measures with a permanent state of mobilization being fuelled, nurtured and augmented by the unrelenting proliferation of all forms of fiction.

15. In 1648, following the Thirty Years' War, the Peace of Westphalia laid the foundations of European international law (Senellart, 1989, p. 42).

4. Collective action in response to emerging zoonotic diseases

Muriel Figuié

In recent decades infectious diseases have been the focus of increased attention from medical and veterinary services and many institutions (public and private; governmental and nongovernmental; national, international and transnational, etc.). The main aim is to boost stakeholder involvement in the surveillance and control of these diseases (doctors, veterinarians, patients, livestock farmers, wildlife managers, legislators, researchers, etc.).

Many stumbling blocks are nevertheless in the way that hamper coordinated mobilization of all of these stakeholders, as recently shown following outbreaks of new infectious diseases (e.g., SARS, influenza associated with H5N1 and H1N1 virus strains, Ebola, etc.).

These difficulties are generally explained from two viewpoints – individualist and culturalist – that prevail in medical and veterinary sciences. The individualist viewpoint is based on key elements associated with cognitive and psychological factors or with an individual economic rationale, whereas the culturalist viewpoint stresses the more or less conscious attachment of societies to a legacy of beliefs and know-how that restrain their potential to adapt and respond to new challenges. These viewpoints attribute the failure of infectious disease control systems to differences between actual and expected individual behaviours. They are in favour of the implementation of communication, awareness and educational initiatives as a way to change the knowledge, attitudes and beliefs underlying these behavioural biases.

These viewpoints have been liable to substantial criticism in the human health field (Dozon and Fassin, 2001; Farmer, 2006): they tend to deem that the victims, i.e., patients, are responsible for the spread of these diseases and for the failure of disease control; they show little regard for the rationales of concerned stakeholders, their heterogeneous interests or the collective determinants of individual behaviours. These determinants are broad ranging. Some concern the structural organization of society, which generates inequality with regard to exposure and access to healthcare, thus limiting the ability of some individuals to apply recommendations.[16] Others are linked to the fact that individual

16. Farmer (2006) explains why the poorest women in Haiti sometimes abandon their AIDS treatment. Their reasons are often associated with logistical and economic difficulties regarding access to healthcare and discouragement due to the sluggishness or incompetence of institutions responsible for the poorest people.

behaviours are also the result of their interactions with others, i.e., individuals are influenced by their respective behaviours.

This last point raises the question of the coordination conditions between individuals that enable them to act collectively. The functioning of organizations (e.g., health agencies) and networks (e.g., epidemiological surveillance) relies on this coordination. How can individual behaviours be tailored to build efficient collective action? This issue goes beyond individuals to include coordination between collectives, such as health, governmental and international organization agencies.

This chapter assesses available answers to these questions based on a non-exhaustive review of sociological and economic investigations and empirical studies. The examples given are from infectious disease control initiatives, especially emerging infectious animal and zoonotic diseases.[17] Many are focused on avian flu caused by the H5N1 virus and were identified in research conducted by the author in the framework of multidisciplinary collaborations (social science and epidemiology), in various institutional (academic research and expertise) and geographical settings.

Surveillance and vaccination (when a vaccine is available) are major infectious disease control tools. The examples presented here hinge on these two types of collective action – livestock farmer participation in disease surveillance (with reporting of notifiable diseases to the competent authorities) and involvement in a vaccination programme.

In this chapter, emerging diseases are considered as modern collective risks that are dealt with via collective action. Factors that hamper this action at different individual, collective, governmental and international organization scales are reviewed.[18] The chapter concludes with a discussion on proposals by various international organizations to consider emerging infectious disease (EID) management as a global public good.

Emerging zoonotic diseases – modern collective risks and collective action

EIDs are in many ways new diseases. The underlying biological mechanisms may be new, such as their rate of spread and geographical range (due to globalization and the speed of trade). The processes involved – biological, sociological, political and economic – are increasingly complex. Urgency and uncertainty characterize their management to an increasing extent, given the anticipation imperatives especially of international organizations (e.g., WHO and OIE).

17. Note that 60% of EIDs are zoonotic, i.e., they infect both humans and animals, and that 70% of them are of wildlife origin (Jones *et al.*, 2008).

18. But without any claim to exhaustive coverage of this issue, which would require focusing on many other stakeholders, especially from public and private sectors.

Emerging diseases could hence be analysed based on the 'modern collective risk' concept, with the challenges they pose assessed according to the 'collective action' concept.

Emerging zoonotic diseases – modern collective risks

Infectious human and animal diseases are communicable and may, especially via animals, potentially affect large communities. They are called pandemic diseases in cases of worldwide infection. Communities located in infected regions are involuntarily exposed (environmental contamination, animal or food trade, etc.) thus necessitating collective organization to control the spread of the disease, (i.e., through epidemiological surveillance, vector control, quarantine, sanitary slaughter, etc.).

Infectious diseases can thus be addressed on the basis of the collective risk concept, as defined by Gilbert (1998) and Borraz *et al.* (2007). Godard *et al.* (2002) specified that collective risks are dangers (for confirmed risks) or threats (for potential risks). They directly or indirectly affect individuals as well as communities. They are partially the result of collective behaviours or decisions, while exposure to these risks is beyond individual control. Individual protection initiatives are possible but their efficiency depends mainly on initiatives of other individuals. Management of these risks is in the general or collective interest and thus requires coordinated action, sometimes under the responsibility of the state, and may therefore be analysed through the collective action concept (Borraz *et al.*, 2007).

Collective actions are organized to coordinate the individual actions of members of a collective. The terms of this organization, the intentionality of the action and the formalism of the collective may vary according to the definitions and schools of thought that underpin them.[19] The collective at issue in the collective action concept pools individuals who are more or less deliberately brought together by the same motives. The collective may also include political/administrative authorities, as was our choice here.

Mobilization of large collectives to cope with uncertain issues

Infectious diseases are collective risks that constitute specific challenges. By definition, EID management requires the mobilization of a large heterogeneous collective, especially because of their frequently zoonotic nature. Advanced scientific research has highlighted the complexity of these so-called systemic risks (Mayer, 2000; OECD, 2003), indicating that their emergence is less the result of random events than of complex interactions between humans, animals and their environment [according to

19. This concept is sometimes used in a restricted sense in sociology in reference to a group's political mobilization, with the aim of advancing its interests or voicing its opinions in the public arena. Some see it as being the result of spontaneous dynamics, the logical consequence of the objective structure of problems to solve or the result of an ongoing process, while others consider that it can only be obtained under pressure.

the One Health concept[20]; Jerolmack (2013)]. Their impacts are magnified or revealed by acute social vulnerability (poor health and veterinary services, social inequality) (Farmer, 2006). They are thus able to mobilize large collectives with diverse knowledge and demands (economic, environmental, social, etc.), and whose profile may change, especially with the advancement of knowledge.[21]

Collectives mobilized by EID management have a broad geographical scope. EIDs emerge in a globalized setting where interactions between stakeholders are frequent, rapid and span vast areas, sometimes even worldwide. Accordingly, they represent large-scale health risks that spread quickly and require rapid transdisciplinary, trans-sectoral and even transnational coordination (Gilbert, 2007; Beck, 2006). This geographical setting may also be constantly shifting (Hinchliffe *et al.*, 2013; Enticott, 2008). The advent of EIDs has renewed collective action issues because of the variety of members involved and the size of the collective potentially mobilized.

EIDs also pose new challenges to collective action because of the highly uncertain setting in which this action takes place. Emerging (or re-emerging) diseases are new or arise in a new or changed setting. Typically there is a high degree of uncertainty surrounding these diseases and limited knowledge on them.

The uncertainty that characterizes many emerging diseases cannot be used to justify inaction in the contemporary socio-political context. Sound scientific knowledge is generally required to clearly guide individual, collective and public decision making. However, while considering the current rise of the precautionary principle and the critical need for anticipation, the management of these diseases calls for early action despite the lack of reliable data or even in the controversial scientific setting that may prevail (Godard *et al.*, 2002).[22]

This action takes place in settings where the 'visibility' of the issue is variable. The challenge is sometimes to be able to act in response to weak signals that may herald a potential disaster [e.g., in the case of H5N1; Chateauraynaud (2011)], whereas a response to massive infections may sometimes be required (e.g., in the case of Ebola outbreaks). Collective mobilization is thus sometimes complex and must take denial and even panic

20. The One Health concept is an attempt to broaden the horizons of sectoral approaches to health issues. During a symposium organized by the NGO Wildlife Conservation Society in September 2004 on 'current and potential movements of diseases among human, domestic animal and wildlife populations', the participants, including many international organizations (WHO, FAO, OIE, IUCN, etc.), drew up the '12 Manhattan Principles', which underpin the One World, One Health concept, which in turn is the basis of the One Health concept. They underline that human, animal and ecosystem health are one and the same, thus warranting an intersectoral approach and multidisciplinary research.

21. In the UK, for instance, badgers were blamed for spreading bovine tuberculosis. Health authorities decided to slaughter these animals in 2013 in order to reduce contamination of cattle herds. Environmental conservationists, who previously had nothing to do with the tuberculosis issue, became mobilized and thus enhanced the collective formed to manage this disease.

22. Here we refer to the precautionary principle as defined by (Godard *et al.*, 2002). Precaution differs from prevention, i.e., prevention applies to confirmed risks, while precaution concerns potential risks and uncertainties. Precaution should not be equated with an inaction principle prompted by excessive caution.

reactions into account (but not necessarily related to the signal intensity). Diseases can also be manipulated by actors taking advantage of the scientific uncertainty situation for reasons of economic or political expediency.

Control of EIDs (animal, human or zoonotic), as compared to more conventional risks, thus boosts the challenges facing collective action – as it involves coordinated mobilization of increasingly numerous and heterogeneous stakeholders and groups of stakeholders who are called upon to act quickly despite a limited knowledge base. Hereafter we will examine the terms of and barriers to this coordination between individuals, and then between collectives.

Motives and barriers to collaboration between individuals

Individuals represent the first scale for collective action analysis. Informed rational individuals sharing a common interest are usually expected to become organized in mutual defence of this interest. But several barriers have been identified. Individuals may not be aware of the common interest. There may also be no common interest in the absence of 'win-win' situations. Moreover, even if there is a common interest, individuals conciliate all of these interests according to the range of different associated constraints or favoured values. Finally, the sum of rational individual behaviours can produce aberrant results from a collective standpoint. These three aspects will be successively examined here.

From individual interests to the common interest

Individualist and culturalist approaches generally consider that individuals may not perceive their common interest due to a number of barriers associated with cognitive[23] (linked with information gaps), psychological[24] (linked especially with emotional factors) or cultural[25] (linked with traditional elements that hamper individual behavioural changes)[26] biases, which in turn contribute to the lack of awareness of the common interest. These factors are particularly important when dealing with a novel situation never before

23. From a cognitive science standpoint, several phases are involved in behavioural changes to adapt to a new situation. These phases differ according to the theoretical models (knowledge-attitude-behaviour, planned behaviour theory, health belief model, etc.). Information and education always have key roles in these models, by successively orienting individuals' attitude and behaviour.

24. Psychologists have shown that acceptance of a new traumatizing situation involves five stages of grief: denial/panic and anger/bargaining/depression/acceptance (Kübler-Ross model).

25. The existence of more or less conscious and explicit beliefs, routines or behavioural heuristics may hamper an individual's adhesion to the belief that action is possible. This could lead to rejection of explanatory models related, for instance, to modern medicine (veterinary). So-called premodern or traditional societies are sometimes characterized by a fatalistic attitude.

26. Behavioural economics also identify many other psychological aspects, such as risk aversion, perceived probability distortion, etc.

encountered by the individuals, as in the case of the onset of emerging or re-emerging diseases.

These cognitive, psychological and cultural factors are often put forward to distinguish emotional, traditional and subjective approaches of ordinary individuals from rational, modern and objective approaches of experts. From a less binary and normative perspective, it should also be considered that everyone in a society of individuals (experts and ordinary individuals) is subject (but not necessarily in the same way, with the same intensity or simultaneously) to these cognitive, psychological or cultural factors.

It should also be mentioned that discussing barriers to taking a common interest into account requires taking a top view stance to state a truth, i.e., the existence of a common interest, which otherwise would be overlooked by the social stakeholders. Yet the very existence of a common interest should also be questioned. The definition of the common interest is not immune to the power relationships and impacts of authority that structure societies. All stakeholders do not have the same power to define the common interest.

In France, animal disease management terms were recently redefined under the new governance for animal health (*Nouvelle gouvernance sanitaire,* NGS) concept (resulting from discussions during a national consultation on health issues, in 2010 and formalized in an Agricultural Orientation Law).[27] This new health governance concept outlines the respective roles of the state and livestock farmers so as to increase the accountability of farmers and professional organizations. Endemic low or noncommunicable animal diseases (so-called category 3 diseases) are managed via individual initiatives. Endemic diseases communicable between livestock farms (category 2 diseases) are managed through a voluntary collective programme (state approved). However, direct state authority intervention is required in the event of highly communicable epidemic diseases, and when the associated health risk could "seriously harm public health or the production capacity of an animal sector" (category 1 diseases).

This disease categorization is not solely based on the objective structure of the problems at hand. The abovementioned French Agricultural Orientation Law admittedly categorizes these diseases according to intrinsic features (endemic or epidemic, more or less communicable). It also incorporates the biological and economic impacts according to whether they are of private (category 3) or collective (category 2 or general category 1) interest (Rat-Asper and Krebs, 2013). In actual practice, however, these categories and the roles they assign are also the result of negotiations. As for other types of risk, animal diseases sometimes prompt social mobilization to demand recognition and management of the problem by public authorities. For animal diseases, an example concerns the demand of French livestock producers (involved in export sectors) for stricter regulations on infectious bovine rhinotracheitis (IBR), which is currently ranked as a category 2 disease but could, as a result of this pressure, be reclassified as a category 1 disease. Examples regarding

27. Decree 2011-862 of 22 July 2011.

human diseases include the mobilization of associations of AIDS or Lyme disease victims. It is hence both the mobilized collective that defines the problem and the 'nature' of the interest and the problem that determines the collective to be mobilized (Mormont, 2009).

Let us now look at the situation regarding an animal disease managed by livestock producers' collectives.[28] It may be of interest for all livestock farmers to vaccinate their animals against this disease, especially since the individual vaccination cost is offset by productivity gains. These farmers could also benefit by forming collective groups to facilitate vaccine supply and a vaccination scheme. Several livestock farmers' collectives have thus been organized as animal health protection groups (GDS) in France.

However, the cost-benefit ratio of a vaccination scheme varies among farms because the extent of loss associated with a given disease is dependent on the livestock production system (Chilonda and Van Huylenbroeck, 2001). The vaccination benefits are therefore not the same for everyone because members of a group do not necessarily have the same cost-benefit structure. For instance, in Corsica, farmers running extensive livestock farms offset productivity losses associated with the presence of Aujeszky's disease[29] by rearing a greater number of pigs (thus upholding the farmer's labour productivity), whereas more vaccinations are performed on intensive livestock farms where the aim is to maximize the production of each animal.

Another example concerns foot and mouth disease control in southern Africa. Control of this disease is a public policy priority in several countries in this region. This control mainly benefits livestock producers who export to the most profitable international markets, since this condition must be fulfilled to gain access to these markets. The disease actually only affects livestock to a limited extent, especially on extensive livestock farms. However, the indirect costs of this control burden all of the livestock farmers even if they do not export their products: limited animal movement (which can be highly restrictive during drought periods and for marketing), or quarantine and sanitary slaughter (Figuié and Fouilleux, 2013; G.R. Thomson, 1995; Scoones and Wolmer, 2007).

Recommended measures, rather than the actual goals, are also often debated amongst those responsible for their implementation. Livestock farmers can strive to control an animal disease but differ on the choice of measures taken by the veterinary authorities, especially when these authorities recommend preventive culling. The same holds for animal protection associations, and society in general, shocked by the image of animal slaughters carried out during the last foot and mouth epidemics in the UK. Although the importance of controlling animal diseases is recognized throughout communities, the priorities may differ between individuals, their immediate economic interests (especially their cost-benefit structure, as discussed above), but also according to the norms and values that guide their actions.

28. This is the case in France regarding endemic low or noncommunicable animal diseases (category 3).

29. Aujeszky's disease (also called pseudorabies) is a non-zoonotic viral disease that mainly affects swine.

A case of altruism? Rationales and values

Adherence to common values or social norms promotes the pooling of individual behaviours into collective actions.

Neoclassical economics calculations pit personal interest against altruism or solidarity and selfish individuals against altruistic individuals.[30] Sociologists, on the other hand, compare different types of rationale (rather than individuals), while highlighting the variety of rationales and logics that guide the behaviours of single individuals.[31] In Vietnam and Thailand, in several villages where poultry rearing was the main activity, farmers reportedly exchanged information on the health status of their animals (Paul *et al.*, 2015; Figuié and Desvaux, 2015). This constituted an informal farmer-formed epidemiological surveillance network that was relatively independent of the systems set up by the veterinary health authorities. The information exchanged informed everyone on the poultry diseases present, thus enabling them to take preventive (increased surveillance of their own birds, restricted entry on the farm, cleaning of the premises, etc.) or mitigation (advanced sale of animals) measures.

Farmers are altruistic when they inform their neighbours about the outbreak of an infectious disease causing high mortality, such as avian flu. What drives these farmers is also the hope of being paid back, i.e., to be informed when there is a disease outbreak on a neighbour's farm.[32] Moreover, if the farmers in the case mentioned above adopt altruistic behaviour with regard to other members in their community, then this behaviour is selfish with regard to non-community members. Social (family, professional network) and geographical (within a few kilometres) proximity facilitates information flow within a small network (Figuié and Desvaux, 2015). Disease outbreaks are, however, not revealed to potential buyers outside the collective – it is essential to quickly sell animals exposed to the disease to curb economic loss. This comes with the risk of contaminating the livestock of external buyers or jeopardizing consumer health. Moreover, this information is not transmitted to veterinary authorities – livestock farmers expect little support from these authorities and strive to avoid potential coercive measures (sanitary slaughter, set up of a quarantine area, etc.).

30. So-called 'rational selfish' individuals give preference to their own interests over those of the group, hence to the detriment of the construction of collective goods, whereas more cooperative individuals with altruistic and solidarity values focus on the group interest, with their own personal interests taking a back seat.

31. The sociologist M. Weber drew up a typology of forms of rationality and distinguished between instrumental rationality (oriented towards the result of actions) and value/belief rationality (favouring behaviours in line with values, independently of the result of this behaviour). In the first case (instrumental rationality), the individual alone makes decisions on an isolated risk, while only considering the consequences of his/her decision. In the second case (value/belief rationality), the individual favours a behaviour that is in line with the values of his/her group, regardless of the consequences.

32. The distinction between value/belief and instrumental rationality is not entirely satisfactory. Value/belief rationale actions could serve individual interests in the long term. A calculation and the expectation of receiving a return payment could justify solidarity.

Similar examples have been reported by Paul *et al.* (2015), who studied avian flu management by Thai fighting cock breeders, and by Prete (2008), in a study on tomato disease surveillance in France.

The often over reductionist and decontextualized *Homo economicus* viewpoint overlooks the broad range of rationales and complex behaviours driven by multidimensional logic. The conflict does not solely concern the opposition between personal interest and collective values, but also between the many different rationales and values that pilot the behaviour of a given stakeholder in relation to his/her multifaceted social allegiance. This could explain the resistance of young South African veterinarians during an avian flu outbreak in 2004 who were torn between their veterinary public health mission, animal protection mission, the nature of their relationships with their customers and their overall relationship with animals. Several of these veterinarians thus refused to carry out preemptive slaughter of ostriches due to avian flu outbreaks because, in addition to being reared for production, these birds are also pets (35-year lifespan in captivity). The veterinarians did not overlook the fact that these birds have emotional value for farmers.

Animal health free riders

Many obstacles have to be overcome before all individuals are ready to adopt a behaviour conducive to the collective interest, even when there actually is awareness of the common interest. Economics game theory applications can highlight these obstacles. But the aim here is limited to illustrating the complicated convergence of individual behaviours, not to discussing all of the explanatory frameworks put forward by this theory.

It is generally of interest for farmers to eradicate, from their area, any disease affecting their livestock. Animal disease eradication can both reduce animal losses (mortality or reduced productivity) and avoid the cost of vaccination which is no longer useful. When a vaccine is available, however, eradication can usually only be achieved if all farmers agree to vaccinate their livestock against the target disease over a period of several years.

Farmers who vaccinate their animals help reduce the prevalence of the disease while reducing the exposure of neighbouring livestock to the causal agent, thus generating a positive externality (Rat-Aspert *et al.*, 2008), i.e., herd immunity. Optimal vaccination coverage is around 70%–80%, which is sufficient to halt (but not eradicate) disease transmission, while reducing the risk of contamination of unvaccinated animals. Some farmers may be tempted to benefit from this herd immunity without vaccinating their own livestock, thus avoiding the vaccination cost and exposure to possible side effects – in this way they benefit from the commitment of other farmers to the vaccination scheme.

Economists call this ‘free riding’ behaviour, claiming that it is one shortcoming of collective action. This shortcoming arises because collective action generates a positive externality, i.e., a good for which those who have not contributed may benefit (in economics, this is referred to as getting a ‘free ticket’).

Farmers who do not vaccinate their livestock benefit from this vaccination coverage as long as a sufficient number of farmers do vaccinate their livestock. Paradoxically, the extent of free riding can increase with the success of the collective action, with everyone taking the success of the results of this action for granted, thus jeopardizing the follow-up (Siegal, 2009). Moreover, cooperative farmers may be discouraged by this free riding behaviour and may, in turn, stop cooperating.

Some authors, such as Olson (1978), thus consider that collective action is improbable in the absence of external pressure. Rat-Aspert *et al.* (2008), in a theoretical modelling study on bovine viral diarrhoea (BVD), also showed that vaccination coverage leading to disease eradication can only be achieved when vaccination is completely free and compulsory.

Problems may even also arise with regard to epidemiological surveillance. Surveillance in informal surveillance networks, as described above, helps generate health information that is available for the entire collective. The cost can be high for farmers who report a disease outbreak in their livestock if the information leaks out of the network and comes to the attention of health authorities (animal marketing restrictions, stigmatization, even total slaughter, etc.). Farmers therefore have to trust the farmers' community and will only benefit later from their behaviour on condition that all of the other farmers adopt the same behaviour. Given these unknowns, it is tempting for some to take advantage of information supplied by other farmers while not contributing personally.

Confidence (in being repaid the cost of being collaborative) is a prime factor of collective action. Different economics games based on social dilemma have shown, amongst other factors, that individuals tend to increase their cooperative behaviours as the game time increases (and is known by the players) (Isaac *et al.*, 1994, cited by Ostrom (2000).[33]

Here it should be stressed that one feature of emerging diseases is that they are new for stakeholders affected by them. Moreover, these diseases are often managed in an emergency setting without the application of sound intervention rules. Hence, there are substantial information asymmetries, with uncertain reciprocal behaviour expectations. These different elements further add to the collective action challenge regarding EID management.

Challenges facing the expansion of collectives

THE BARRIERS DISCUSSED ABOVE MAINLY concern horizontal coordination between individuals, i.e., without any hierarchical relationship. Many also concern collaboration

33. Ostrom (2000) suggested that cooperative behaviours are the result of a dynamic process and underlie certain social norms. Cooperation is thus quite 'natural' [Ostrom thus counters the opinions presented in Olson (1978), and Crozier and Friedberg (1977)]. Collective action is widespread according to Ostrom, despite the identified barriers. It gives societies an evolutionary advantage and is more effective when the rules of this action are defined by the collective rather than by an external authority.

between collectives, as we address in this section. Our analysis thus involves a change of scale from between-individual to between-collective collaboration.[34]

Regarding emerging zoonotic diseases (i.e., most EIDs), collaborations are expected to increase due to the systemic nature of these diseases, thus calling for intersectoral action (human and animal health, ecology, etc.). Moreover, an increasingly broader spectrum of collectives are involved worldwide as these diseases are associated with globalization. Collective action studies have, however, revealed that small-scale collectives are conducive to collaborative behaviours – confidence is based on interpersonal knowledge and individuals can more readily anticipate each other's behaviour.

Increasing the size of collectives involved in emerging zoonotic disease control therefore presents a genuine challenge. This expansion brings social stakeholders from various backgrounds into contact (e.g., see the example below of human health and veterinary health institutions). Social stakeholders may be confronted with possibly diverging reactions (e.g., stakeholders of a market chain). It may also establish contacts between stakeholders with contrasting political strategies and practices regarding health crises (governments, NGOs, etc.). Here we look at these three aspects.

Organizational and cultural silos hampering intersectoral cooperation

As for individuals, the more or less conscious attachment of a collective (health agency, ministry, international organization, etc.) to a legacy of beliefs and know-how can hamper its adaptation and response capacity when a new problem arises.

The thrust of the One Health concept developed by international organizations is that emerging diseases are not restrained by interjurisdictional boundaries and that human, animal and environmental health must be considered as a joint unit.

However, both knowledge production and public intervention are relatively tightly organized by scientific disciplines and lines of activity. This organizational division of labour hampers the assessment of complex, hybrid and systemic problems such as EIDs. Jerolmack (2013) refers to organizational silos when discussing barriers to collaboration associated with organizational cultures. These cultures have the advantage of facilitating the adaptation of organizations to the specific problems they have to deal with (human health, animal health, agriculture and environment). However, they are also limited by the reduced capacity for renewal of cognitive and analysis frames needed to cope with new and more complex problems. These silos thus diminish opportunities for interagency cooperation.

Jerolmack (2013) illustrates this silo phenomenon via avian flu control in the United States. Several mechanisms hamper collaboration between US agriculture and wildlife

34. This also broadens the horizontal coordination challenge by incorporating that of vertical coordination, i.e., between hierarchically organized collectives.

agencies. First, the specific missions of these agencies differ, i.e., protecting farmers for the former and protecting wildlife for the latter. Secondly, paying attention to the agency's reputation overrides the disease control goal, i.e., the former seek above all to avoid livestock (poultry) slaughter, while the latter are focused on avoiding wildlife slaughter (as wild birds are vectors in the spread of avian flu). They therefore mutually reject the blame for any new outbreaks.

Alignment and misalignment of interpretive frames

The organizational silo concept refers to a certain degree of immobility linked to cultural heritage. But collectives can also be more reactive. This raises the problem of the diversity of reactions, which could be linked to the interpretive frames of the social stakeholders involved.

In sociology, frames serve as interpretive schemes for perceiving, interpreting and assessing events and situations. Moreover, frames adopted by individuals guide their reactions to these events and situations (Goffman, 1991; Cefaï and Trom, 2001). Collective action is possible if collective stakeholders share a common frame or at least compatible frames (referred to as 'frame alignment'; Snow *et al.*, 1986). This phenomenon is clearly illustrated in the following example.

As mentioned above, EID management requires mobilization of a broad and heterogeneous collective. Studies on avian flu management in Vietnam amongst consumers, farmers, sector stakeholders, policymakers and the international community highlighted the variety of frameworks through which different stakeholder groups grasped and defined the avian flu problem.

International organizations (FAO, OIE, WHO) perceived the emergence of the H5N1 virus as an unprecedented major risk. These agencies called for widespread mobilization to control this virus, especially via poultry flock surveillance (as it is a zoonotic risk). Different studies conducted in Vietnam showed that this framing of the H5N1 virus and the associated disease (avian flu[35]) was far from being shared by everyone, or was for only short periods.

The Vietnamese village farmers studied by Figuié and Desvaux (2015) and at the forefront in combating this virus (which emerged in the region in 2003) suffered massive poultry mortality on their farms. They also feared for their own health in the presence of this disease, which they initially compared to severe acute respiratory syndrome (SARS, which had spread from China to Vietnam in 2003).[36] This prompted them to collaborate with a national online surveillance system set up by the Vietnamese authorities, in line with the recommendations of international organizations (Figuié, 2013). In particular, they notified veterinary authorities when outbreaks occurred on their farms (they readily

35. Other viruses may also cause avian flu.

36. SARS emerged in China in 2003 and spread to 29 other countries within a few months, causing over 900 deaths worldwide.

reported these events in the hope of obtaining support from the authorities to help them deal with this new disease). There was hence alignment at first, with agreement between the different analytical frameworks (national authorities, farmers) on considering avian flu as a pandemic risk, which paved the way for potential collaboration.

With time, however, especially marked misalignment occurred in villages that had experienced several avian flu outbreaks. Farmers in these villages became familiar with the disease and stopped fearing for their health. The number of human cases was actually quite small.[37] The pandemic threat diminished as farmers realized that the comparison with SARS was less relevant – they then changed their viewpoint on avian flu, considering it simply as an epizootic disease which they compared to Newcastle disease (rather than SARS) which regularly decimated their poultry flocks (without harming humans). Hence, they stopped reporting outbreaks to the authorities (in this way avoiding the negative impacts discussed above), thus disconnecting their informal surveillance system from the official one.

This same alignment/misalignment phenomenon was observed in consumers surveyed in Hanoi by Figuié and Fournier (2008). At the start of the avian flu outbreak, consumers massively stopped eating poultry. This contributed (by halting the demand) to enforcement of the government ban on poultry marketing (a ban that was subsequently limited to the marketing of live poultry). However, they quickly ruled out the food-risk aspect since no cases of such transmission had ever been officially confirmed. Then the zoonotic risk (associated with contact with live poultry) was excluded. Poultry purchases and consumption, including live poultry purchases, therefore gradually resumed in Hanoi, regardless of the ongoing bans.

The pandemic or zoonotic potential of the virus which triggered the international efforts is currently not taken into account in the local framing of the disease and associated health risk. This explains farmers' and consumers' low adherence to the recommendations issued by the authorities (case reporting, halting live poultry trade in urban areas).

Crises used for political ends – state of emergency versus technical democracy

The two previous points highlighted cultural stagnation or haphazard reaction situations. However, there are other more strategic reactions from stakeholders making use of the new problem to make background changes (organizational, economic, political, etc.) that emerge, whereas other stakeholder groups may oppose these changes, thus impeding collective action.

37. No human cases were reported in the villages studied by Figuié and Desvaux (2015). There have been few cases in Vietnam and elsewhere in the world in comparison to the number of deaths associated with other diseases: 64 people have died from H5N1 avian flu in Vietnam since 2003 (454 people worldwide) according to WHO (on 25 January 2018).

Because of their global nature, EID management requires the expansion of collectives responsible for this management, as well as their reconfiguration to promote collaboration. Broader collaboration can be achieved by obligation or enticement.

Emergency measures can be instituted and a state of emergency declared in order to achieve overall behavioural alignment. This 'conventional' management strategy, via quarantine and isolation, was used in the past to manage major epidemics like the plague. This strategy is still widely used for animal disease outbreaks, sometimes accompanied by mitigation measures (especially compensation for farmers). In the late 1990s and early 2000s, management of mad cow and foot and mouth disease in the UK relied on massive compulsory slaughter, which greatly shocked the public. Meanwhile, there has been a return to some of these coercive measures to manage outbreaks of contemporary emerging diseases affecting humans.[38] Management of the Ebola outbreak led to travel bans (disease buffer zones), meeting bans (including a ban on Christmas festivities in Sierra Leone in 2014), curfews and home confinement measures forced on inhabitants over several-day periods (e.g., over six million Sierra Leoneans were obliged to remain at home from 19 to 21 September 2014).

The systems may voluntarily encompass more than just disease control. Fintz (2010) studied avian flu (H5N1) management in Egypt in 2005–2006 and showed how the accompanying rhetoric was conducive to the development of strong dynamics, leading to the imposition of emergency measures serving an authoritarian political regime (and used to electoral ends), and an agricultural modernization vision. These systems have also been exploited in community conflicts, e.g., massive violent slaughter of pigs belonging to Coptic communities.

Other less authoritarian and more democratic avenues could help meet the collective action challenge. Democracy (based on transparency, accountability and inclusion principles) is thus presented as a response to prevailing uncertainty, not to emergencies.

Modern risk management involves the participation of a broad network of stakeholders involved in various scientific, administrative and political domains. This idea is advocated by the science, technology and society (STS) movement, which calls for 'technical democracy' (Callon *et al.*, 2001) based on a mutual understanding of collectives (i.e., recognition that they are made up of already organized stakeholders that can legitimately define common action regulations).

Use of the governance concept in research on modern risks reflects a similar idea (Van Asselt and Renn, 2011). According to this concept, which emerged in the early 21st century, modern risk management requires the integration of different fields of knowledge (multidisciplinary, expert and layman knowledge), in addition to the incorporation of social

38. For instance, this excerpt from an article in *Le Monde* (18 May 2003): "On Thursday 15 May, China published an interpretation of the Communicable Diseases Act, stating that anyone opposing a quarantine measure and disseminating severe acute respiratory syndrome (SARS) is liable to the death penalty or life imprisonment." During the Ebola outbreak in 2014, an Ivorian was sentenced to five years' imprisonment for consuming rat meat (*Koaci*, 28 August 2014).

values and concerns in the decision-making process. Moreover, for similar reasons, Beck (2009) points out how modern risks can be conducive to a democratic turn.

Some researchers are nevertheless more critical of the potential impacts of a new risk governance approach. Borraz (2008) underlined that this broader range of stakeholders does not necessarily bode for more democracy, but it is an acknowledgement that the definition and management of modern risks are no longer monopolized by scientists and technocrats. In this encouragement for participation, other researchers who flaunt Foucault's approaches in terms of governmentality see a new form of power based on increased surveillance (O'Malley, 2008) and policies based on 'good citizens' who have internalized the idea of moral responsibility (Ewald, 1996).

In all events, the management of emerging diseases, large-scale risks, and sometimes associated crisis situations has political transformation potential that may involve many stakeholders.

Emerging diseases therefore pose the challenge of building broader collectives to cope with complex associated large-scale risks. But here is also an opportunity for setting up new forms of government.

A new paradigm for animal health?

State recognition of the importance of collaborating on health issues is longstanding but has been further confirmed in the recent disease outbreak context. International (human and animal) health agencies stress that emerging diseases know no geographical boundaries. Due to the intensity and speed of trade – an outbreak can spread from an isolated area in the world to a remote city in less than 36 hours (Otker-Rob, 2014) – there are direct and indirect global impacts (including those related to measures taken to control them) because of economic and social interconnectivity.

International mobilization may be explained by moral duty and responsibility for the protection of a common good rather than pressure. There are, however, several obstacles to collaboration between states on this common good, including those related to different national priorities and interests and the willingness of states to defend their sovereignty.

Animal health – the advent of a new global public good

In the light of recent SARS, flu and Ebola outbreaks, various stakeholders (international organizations, NGOs, etc.) involved in human or animal health management have argued that the management of these diseases should be considered as a global public good.

This latter term is borrowed from economists, who distinguish between public goods and common goods on the basis of two features:
– non-rivalry: consumption of a good by an individual does not prevent its consumption by another individual;

– non-exclusion: no one is excluded from the good, which is available for everyone.

Public goods are non-rivalry and non-exclusive goods, such as air or solar energy and outbreak control. Common goods involve rivalry but are non-exclusive, such as fish stocks, water, etc.[39]

The global public good concept is used in the international relations field (Gabas and Hugon, 2001), while some authors consider that the global health concept is simply a health field variant (Kerouedan, 2013).

However, disease prevention and control systems are actually considered as global public goods more than health itself. Economists refer to intermediate public goods in such cases. Moreover, disease prevention and control are a specific type of global public good, and referred to as the 'weakest-link global public good'. Perrings *et al.* (2002) illustrated this with regard to the control of biological invasions, including pathogens: the level of control implemented by a country has implications on the risk facing other countries; and the level of protection of all countries is hampered by the resources available in the poorest of these countries.

Considering human health as a global public good is not a new idea (Boidin 2014), but it is more so with regard to animal health, and this is virtually driven by emerging diseases.[40] The global public good concept is nevertheless complex. In the EID context, international organizations essentially apply this concept to prevention via epidemiological surveillance. In a document published in 2008 following an avian flu (H5N1) outbreak and outlining a joint strategy for reducing human and animal infectious disease risks, major international organizations (FAO, OIE, WHO, World Bank, etc.) stated:

> "Preventing emergence and cross-border spread of human and animal infectious diseases is considered to be a global public good… Surveillance systems that underpin the prevention of emergence and spread of such diseases are also recognized as a global public good" (FAO *et al.*, 2008).

The document also stated,

> "As it is not clear what a disease's potential is until after it has emerged, surveillance for potentially pandemic EID is clearly a global public good…" (FAO *et al.* 2008).

39. Sociologists generally use the term 'common good'. In sociology, the issue is less about focusing on the intrinsic nature of a good than on the way it is constructed and managed. Reference to a common good suggests that there is a general interest based on shared values or even universal rights (so the meaning differs from that of economists).

40. Regarding animal disease control, Gabas and Hugon (2001) mentioned that, "the control of epizootic diseases in Africa is clearly threatened by states with the least effective policies and within which disease outbreaks are ongoing – hence the efficiency in management of this public good will be markedly altered". They then added, "However, vaccines developed against major diseases, particularly AIDS, fall in the category of 'best shot goods' that are produced by the richest countries and their businesses." So-called 'additive goods' are the result of the sum of the efforts of all stakeholders, such as climate stability (Gabas and Hugon, 2001).

Epidemiological surveillance generates health information, which has a complex status. In 2007, Indonesia decided to no longer share flu virus samples collected within the country with WHO on the grounds that the country did not benefit from this sharing, especially access to vaccines developed from the supplied samples.[41] This decision sparked a debate on the status of virus samples – should they be considered as biological resources and therefore covered by the Convention on Biological Diversity, which affirms that states have sovereignty over their genetic resources? Or otherwise should they be considered as epidemiological information and thus covered by the International Health Regulations, which oblige states to share this information[42] (Fidler 2008)?

Another element of complexity is the merger of human and animal health via the zoonotic disease issue in the global public good concept. Human health is considered a public good since it concerns the universal right to health, but the status of animal health is less clear-cut. Animal health via zoonotic diseases does concern human health, but not solely. Animal health also comes under sectoral objectives of productivity, industry competitiveness and compliance with trade standards. Making animal health a global public good tends to mask the diversity of interests involved. The reference to a common good and an accountability ethic rallies states behind a common international health (and zoosanitary) governance project. The concept is nevertheless complex, applied *de facto* to a range of issues while concealing diverse interests. Many aspects must be adjusted to ensure its practical implementation. Emerging disease prevention and control are thus global public goods, but this categorization has yet to be clearly outlined.

Diversity of national interests in addressing zoonotic disease risks

As previously analysed on an individual level, setting up global health governance raises the question on whether or not there is a common interest.

A modelling study conducted by Colizza *et al.* (2007) highlighted the benefits of an international collaborative infectious disease control strategy, even for countries with the greatest technical and financial healthcare capacities. These authors modelled a pandemic influenza situation resembling that of the H5N1 virus emergence. Only a few countries produce and have access to antiviral agents needed to curb outbreaks, but they are not the main countries affected by outbreaks. The authors developed and compared different antiviral agent sharing scenarios on a worldwide scale. These scenarios differed in terms of the quantity of antiviral agents that producing countries provide to build up a global stock, which in turn is distributed to different countries according to the outbreak spreading pattern. The authors showed that the altruistic cooperative sharing of antiviral

41. Indonesia then signed a bilateral agreement with Baxter, a transnational pharmaceutical company, for the exchange of genetic material (flu virus) and vaccines.

42. An international agreement was subsequently signed (PIP agreement) to clarify the issue of sharing access to infectious agents and vaccines.

agents enhances outbreak control to the benefit of all countries, including donor countries. Moreover, rolling back the outbreak peak gives more time to prepare a suitable vaccine.

This altruistic cooperative sharing behaviour is, however, far from being common practice, as shown during the H1N1 outbreak in 2009, and the much deadlier Ebola virus outbreak in 2014–2015. In the latter situation, the most affluent countries like the United States built up strategic reserves of caregiver protection equipment (suits, masks, overshoes)[43], which momentarily led to shortages in countries with more Ebola patients (over 26,000 patients in West Africa, and four in the United States[44]). This shortage fortunately did not last very long, as otherwise it would have increased the risk of international spread of the disease.

As for the farmers mentioned above, there is also a problem of the costs borne by countries that are transparent in declaring the diseases present or even just suspected within their borders (EIDs provide an opportunity to strengthen early warning initiatives). Export or even air transport restrictions[45] may follow, often with a concomitant disastrous impact on the country's economy, as well as on social and political stability, which could be even worse than the impact of the disease itself (Otker-Rob, 2014). Nuzzo and Gronvall (2011) cited a suspected case of a plague outbreak in India in 1994, which was ultimately unconfirmed but cost the country billions of dollars.

The goal of the global governance initiative set up by international organizations (FAO, OIE, WHO) is indeed to avoid the implementation of unwarranted restrictions. These organizations are nevertheless not immune to criticism of states which, when directly concerned, may find the implementation of international recommendations economically detrimental on a national scale – during a SARS outbreak, Canada thus strongly criticized WHO for advising against unnecessary travel to Toronto, which resulted in heavy financial losses for the country. However, it is hard to assess the cost (health, economic, etc.) that all countries would have had to bear if these trips had not been advised against.

Ambiguities in global health governance

There is quite broad consensus on the need for global health governance, but many conflicts of interest still have to be resolved.

Scoones (2010) showed that Western country priorities dominated the new global health governance initiatives set up during recent emergencies, while overlooking structural inequality in resource access and risk exposure. Moreover, according to Calain (2007), this governance forces poor countries to focus on potential disasters despite not having sufficient resources to cope with 'standard' infectious diseases such as meningitis and malaria.

43. http://www.slate.fr/story/95051/equipement-anti-ebola-penurie#xtor=RSS-2

44. According to a WHO report on the Ebola outbreak situation published on 22 April 2015.

45. See the *Le Monde* article of 11 May 2003, "SRAS : le coût pour les transporteurs aériens est deux fois plus élevé que celui dû à la guerre d'Irak".

Similarly, Kerouedan (2013) studied the global health concept. She showed that the international health concept which preceded the global health concept in international organizations was focused on problems encountered by developing countries, especially on diseases that weigh most heavily on communities. Under the global health concept, these problems are secondary, with organization interventions being oriented more on global issues, i.e., related to both developed and developing countries, even though this means no longer dealing with the national health priorities of developing countries.

Animal health agendas also sometimes differ: the priority given by FAO and OIE to foot and mouth disease (FAO and OIE, 2012) addresses the interests of meat exporting countries already free of the disease more than those of subsistence livestock farming countries whose production is domestic market oriented (Figuié and Fouilleux, 2013; G. R. Thomson *et al.*, 2013; Scoones *et al.*, 2010).

As noted by Gabas and Hugon (2001), these examples show that common goods differ according to societies, their level of development and integration into the global economy. Their production involves state coordination in a potential setting of conflicts of interest, power relations, hegemony and dependency.

Moreover, based on the example of the H1N1 flu situation, Nuzzo and Gronvall (2011) showed that many counties 'do not play the game' nor do they apply the recommendations of international organizations, despite being members. Some – against WHO recommendations – restrict air exchanges and place travellers in quarantine. Several have also prohibited swine imports from affected countries despite joint WHO, FAO, OIE and WTO recommendations.

This last example raises the issue of the necessary balance between global governance and sovereignty in response to global risks.

Collaborative yet sovereign states

International cooperation in the health sector is not new but has taken on a new form with the onset of emerging diseases. Minimalist treaties in the fourteenth century established the basis for such cooperation to facilitate trade and travel – the aim was to harmonize border control and quarantine measures while promoting information sharing.

WHO was founded in 1948 as an offshoot of existing organizations. One of its main tasks is to coordinate epidemiological surveillance activities through the collection and dissemination of epidemiological information provided by states (Fee *et al.*, 2008). OIE was created in 1924 under the name *Office international des épizooties*. The event that triggered its creation was a rinderpest outbreak in Europe following the transit, via the port of Antwerp, of zebu animals from Southeast Asia on their way to Brazil. The countries that founded these organizations did not want the fear of the spread of devastating diseases to impede global trade. These countries thus committed themselves to reporting, through these organizations, all relevant information on changes in the health situation within their countries.

Research on public health policies highlighted a paradigm shift that took place during the last decades of the twentieth century. King (2002), as part of a US administration project, studied the emergence and rise in popularity, in the late twentieth century, of an 'emerging disease paradigm' in the American understanding of the international health situation. In the same vein, Brown *et al.* (2006) analysed the history of WHO between 1948 and 1988 and described its role in the transition from an 'international health' paradigm to a 'global health' paradigm. Fidler (2003), based on studies on the public health impact of globalization, also described the weakening of a Westphalian system and shift to a post-Westphalian system in the 1990s, thus marking the end of the noninterventionism dogma in national public health policies.

Former paradigms discussed in these studies were modelled on sovereign states protecting their countries against the introduction of infectious diseases through border controls. This cooperation was based on a principle of non-intervention against the activity or inactivity of states against diseases (Fidler 2003). New paradigms emerged in a globalization setting and stressed the need for new:

> "[...] institutional fluidity in response to the increasing economic, political, and social interdependence of the modern world and the resulting common dangers and opportunities in the form of diseases, products, and ideas that readily cross borders" (Fee *et al.*, 2008, p. 632).

These new paradigms urge preservation of traditional border control measures implemented by sovereign states to protect their countries, while simultaneously mobilizing deterritorialized networks to contain diseases at their source (King, 2002). New paradigms replace international cooperation between independent territorialized states by, "global projects conducted by coalitions of public, private and nongovernmental organizations" (King, 2002, p. 774). Beck (2009) went further by suggesting that global risks open, "a moral and political space that can give rise to a culture of responsibility that transcends borders and conflicts".

These developments thus raise the state sovereignty issue. Recent emerging diseases (SARS, H5N1) led to the signing of an agreement between states regarding the revision of the OIE Terrestrial Animal Health Code and the WHO International Health Regulations (IHR)[46] to further strengthen the commitment of countries to collaborate, especially on animal disease surveillance, while increasing state transparency on their epidemiological status.[47] In particular, this involved dealing with the reactions of relatively uncooperative states, such as China at the onset of the SARS outbreak, whose government had refused to communicate some so-called 'state secret' information (*Le Monde*, 9 April 2003).

46. The latter defined a new disease category: public health emergencies of international concern (PHEIC), requiring coordination of an international response and for which IHR requires countries especially to enhance capacities for coordination, preparation, field surveys, risk communication and social mobilization.

47. http://www.afro.who.int/fr/centre-des-medias/communiques-de-presse/item/5136-renforcer-les-principales-capacit%C3%A9s-pour-pr%C3%A9venir-la-propagation-internationale-des-maladies.html (available in French only).

This limited state cooperation could be explained by countries' intention to protect their immediate economic interests, as discussed earlier. However, it could also reflect a determination to defend their national sovereignty by releasing their national policies from the control of international authorities, including that which extends beyond the health sector. This control can reflect a deliberate attempt by international organizations to seize the opportunity of health crises to make profound changes in the concerned countries. These changes are an attempt to set up a development ideology aimed at achieving good governance with the participation of civil society and primarily NGOs. This is what Atlani-Duault (2005) showed through an anthropological approach to AIDS control projects implemented in new Central Asian countries.

Tools currently used internationally are not very binding. The idea of drawing up an international health intervention right has been briefly discussed.[48] This right would have been based on the humanitarian intervention right advocated in the 1980s by NGOs, such as Doctors Without Borders, in the name of moral urgency. However, the idea of humanitarian or health intervention raises substantial criticism that it is associated with a new form of imperialism of powerful states over the weakest states. But this was not followed up as the respect for state sovereignty remains a major concern with regard to international relations.

Setting objectives for collective action against emerging zoonotic diseases

Emerging infectious disease control is a major collective action challenge. It requires the mobilization of a set of local and international stakeholders whose actions must be coordinated in an uncertain emergency setting.

Public authorities (national and international) support this mobilization by focusing on cognitive and cultural issues, while also striving to boost awareness on the collective interest and public goods.

This dominant view tends to depoliticize the health issue, ignore potential conflicts of interest, power games, voluntary resistance, etc., whereas we have tried to highlight them here through animal health and zoonotic disease examples.

Local stakeholders have their own specific rationales that are geared towards protecting their immediate interests (e.g., avoiding slaughter of their herds), while also avoiding the stranglehold of authorities (national, international, public, private). These authorities are often tempted to seize the opportunity of a health crisis to interfere and make various

48. In France, in 2006, a National Assembly debate was focused on the need to set up an international intervention right in response to the fact that some states, such as Turkey and China, under-declared cases of flu. This was to avoid "national rationales that could have major (international) impacts", according to a member of government involved in the Assembly debate.

changes, which may include the implementation of a policy to 'modernize' the livestock farming sector. This modernization process is inevitably accompanied by a redistribution of added value and power in these sectors, in addition to increased control over the economic stakeholders.

Mormont (2009) suggested mobilizing sociologists in a research-intervention approach to deal with collective risks. The first step of this approach is to recognize that the stakeholders are organized and then to conduct a joint assessment of the situation with the concerned stakeholders: "This assessment aims to highlight the different viewpoints on the situation, while specifying the differences and even tensions, for instance in the definition of the risks and liabilities.[49]"

At national and international levels, states must arbitrate between defence of their sovereignty and achieving international integration, between health and other socio-political issues. Major economic actors may also seek to protect themselves from any trade disruptions that could occur following the potential implementation of health measures. Moreover, beyond their concern for efficiency, international organizations are also driven by their own sometimes competing rationales (see Chapter 2).

EIDs have provided health stakeholders with an opportunity to advance the idea – sparked in the 1980s – that infectious disease management is a global public good. With the advent of the emerging disease issue, management (initially focused on human diseases) has been broadened to encompass animal diseases with zoonotic potential, while strengthening the role of epidemiological surveillance in management schemes.

International organizations (FAO, OIE, WHO) are now focused mainly on endemic diseases. They have, however, also gauged the scale of the challenges raised by emerging diseases, their catastrophic potential and the need for wide-ranging mobilization for emergency action, despite the uncertainties that prevail. They underpin this global public good framework. In association with the scientific community and the media, they have succeeded in achieving changes by configuring cause, consequence and intervention at different geographical and political representation scales (according to the scale politics concept; King, 2004).

The global public good concept can be used to achieve cognitive change to nurture collective mobilization on health issues. There are still, however, several hurdles to overcome with regard to its application in the collective action field.

The public good framework is currently focused more on the means, and especially on surveillance of diseases (or even events) that could become international public health

49. In collaboration with all stakeholders, new forms of coordination that could help change the situation are then sought, such as changes in relationships between protagonists, development of an action-research programme upon which all stakeholders could agree. "This involves collective (although not necessarily joint) capacity building on problem management. In this process, the sociologist – instead of simply outlining the stakeholders' motives and goals from a deterministic perspective – investigates potential redefinitions of their practices, skills and relations and the necessary conditions" (Mormont, 2009, p. 12).

risks[50], than on health per se. This framing has the advantage of orienting actions towards specific concrete objectives rather than meeting general moral principles (e.g., health rights) by focusing on the structural and logistical problems that hamper effective disease prevention and control.

However, considering the means of health surveillance and control – hence intermediate goods – as global public goods, rather than health per se overlooks the debate on final goods and shared interest (serving whom and what?). The global public good concept reflects a willingness to focus on global diseases to the detriment of diseases more specific to certain socioeconomic categories, such as so-called 'neglected diseases', i.e., endemic diseases specifically affecting poor people in developing countries. The reconciliation of human and animal health issues should not conceal the economic issues pertaining to international livestock market chains. There is also a major challenge to ensure that international collective action does not become disconnected from local settings but instead finds legitimacy in local collective action.

Health itself rather than the means for its management should be classified as a global public good in order to put health forward as a universal right, while reconnecting health policies with humanitarian and social policies. By defining infectious disease control as a global public good, there is a risk that the collective action coordination principle will become too focused on defending an assumed shared interest (here we have discussed the shortcomings of this assumption) rather than promoting an ideal of solidarity so as to make health a universal right.

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50. In line with the WHO Public Health Emergency of International Concern (PHEIC) concept.

5. Surveillance of emerging diseases: challenges and contradictions

François Roger

Are we now on the brink of a fourth global epidemiological upheaval? The first, which took place in the Neolithic era, was associated with the domestication of animals and the establishment of larger permanent human settlements. The next two upheavals were linked to urbanization and commercial trade and led to "microbial unifications", one beginning in the fifth century in Eurasia, the other starting in the fifteenth century in the New World. Pandemic influenzas, viral haemorrhagic fevers in animals and humans, and antimicrobial resistance are, rightly or wrongly, emerging or feared 'microbial storms' induced by a broad range of environmental and socioeconomic factors and increasingly frequent and intense contacts between humans and animals. In this context, it has become necessary to assess all of the factors involved in epidemiological dynamics, including not only biological factors (which all too often are the only factors considered) but also economic, social and environmental factors, and particularly the decline of biodiversity. Moreover, surveillance and control systems must be developed based on risk assessments integrating human and social dynamics, including the cost-effectiveness of these systems and how they are perceived and accepted by livestock farmers, health professionals, and society as a whole.

While the International Commission on Stratigraphy (International Union of Geological Sciences) has not officially validated the term 'Anthropocene', it is increasingly being used by researchers and the media to describe a period where, "for two generations, humanity has become a geological force on a global scale, altering human and ecosystem health[51]" (Steffen *et al.*, 2015). In animal health, profound changes in livestock farming practices in many regions of the world, combining genetic standardization with high domestic animal densities, and in parallel the destruction of natural habitats in certain areas, could lead to the emergence and spread of new diseases. This Anthropocene era may also be linked to a sixth mass extinction of animal and plant species (Ceballos *et al.*, 2015; Kolbert, 2015), one much more rapid than past extinctions and with a major impact on biodiversity that could play a role in the occurrence of infectious events.

51. The starting point of the Anthropocene is a particular topic of debate: while some authors consider it to have begun with the Industrial Revolution, others wish to go back to the Neolithic era, or even earlier (Lewis and Maslin, 2015).

Two major and opposing trends have been shaping the evolution of infectious diseases over the past two decades:

– First, United Nations international agency programmes, particularly the public health objectives of the Millennium Development Goals (Dye, 2014), and animal health programmes focusing on strengthening veterinary services (OIE[52]), alongside research institutions and centres are contributing to a reduction in the incidence of certain diseases (even eradication, as for rinderpest[53]) and the strengthening of public and veterinary health systems, although results continue to vary significantly across regions and diseases.
– Second, environmental, climatic and zootechnical changes and the internationalization of goods and trade are favouring the emergence, spread and maintenance of new human, animal and zoonotic diseases. These disturbances also are inducing increased interference and interactions between 'epidemiological compartments', meaning between human groups, domestic and wild animal populations, and the environment. Lastly, the development of antimicrobial resistance is now leading some authors to sound the alarm on the risks of what could be a public health 'time bomb'.

This has led to the development and strengthening of management capacities, namely the surveillance and control of infectious diseases. More efficient health surveillance is deemed indispensable to react swiftly to an emergence, but also to measure the effectiveness of control measures implemented (for example, vaccinations). It is difficult to anticipate abrupt outbreaks of infectious diseases, although monitoring certain biological and non-biological determinants (human behaviour, social events) of diseases and health statuses can warn of the risk of emergence (Olson *et al.*, 2015). The outbreaks, epizootics and epidemics of bluetongue, a ruminant disease in northern Europe, Ebola fever in West Africa, and the H5N1 strain of highly pathogenic avian influenza, etc. were not anticipated. Nor was the emergence of AIDS, which can be considered as a true black swan (Paté-Cornell, 2012), meaning that the emergence of the HIV virus from the equatorial forest was a completely unforeseen event (see below).

Epidemiologic rupture or transition?

> *"Global disease burden has continued to shift away from communicable to non-communicable diseases and from premature death to years lived with disability. In sub-Saharan Africa, however, many communicable, maternal, neonatal, and nutritional disorders remain the dominant causes of disease burden."* (Murray *et al.*, 2012)

Alongside global changes, including upheavals in terms of land use and globalization, biodiversity's role in health is discussed in Chapter 1 by Serge Morand. He examines

52. OIE PVS Pathway, http://www.oie.int/en/support-to-oie-members/pvs-pathway/
53. http://www.oie.int/en/for-the-media/press-releases/detail/article/no-more-deaths-from-rinderpest/

the ambivalent role of biodiversity loss, which research indicates may favour or hinder emergence. However, according to the author there is a confusion of scale in numerous studies, i.e., between actual emergence (e.g., primary transmission between a reservoir and a host) and spread (role of movements, globalization of trade). More broadly, there is a need to clearly distinguish between the potential emergence of pathogens (detected through analyses, monitoring, etc.) and the emergence of a disease in its clinical and epidemiological forms. Many questions remain with regard to the relationship between biodiversity loss and disease. However, a recent meta-analysis (Civitello *et al.*, 2015) suggests that the maintenance of biological diversity reduces disease risks. If this is the case, health, and its corollary, health protection, could be added to the list of ecosystem services provided by biodiversity.

The role of wildlife, which is frequently associated with emergences (avian influenza and wild birds; Ebola and bats and great apes; SARS and bats and civets), probably should be qualified (Tompkins *et al.*, 2015). Furthermore, certain diseases also impact amphibians, birds and mammals (Grogan *et al.*, 2014). For example, the Ebola virus disease had devastating consequences for great ape conservation plans in Central Africa (Bermejo *et al.*, 2006); white-nose syndrome decimated bat colonies in the United States (Boyles *et al.*, 2011), which could lead to major farm losses due to the positive role played by bats in relation to crop pests; canine distemper (a disease of domestic dogs) infected lions in East Africa (Viana *et al.*, 2015); bovine tuberculosis, an animal disease transmissible to humans (zoonosis), affects cats and other species in southern Africa (de Garine-Wichatitisky *et al.*, 2013); rabies and canine distemper (Gordon *et al.*, 2015) affect Ethiopian wolves, considered an endangered species (red list) by the International Union for Conservation of Nature (IUCN). Wildlife conservation policies should more fully consider these risks of infection in keeping with the "One Health" concept, which advocates for a global approach to human, animal and environmental health. More specifically, better defined research and surveillance strategies are needed at the interface between wildlife and domestic animals (Wiethoelter *et al.*, 2015).

We propose to distinguish between epidemiological, global, major and above all infectious and parasitic ruptures (or upheavals, or shocks) – of which there have been three since the first during the Neolithic agricultural revolution 11,000 to 12,000 years ago – and epidemiologic transitions, which pertain rather to recent, modern transformations of societies in terms of demographics, technologies, and health (shift from infectious diseases to chronic, degenerative diseases) and which are continuing with the economic development of societies (Table 2).

Over the past two centuries, numerous countries experienced a significant drop in mortality combined with a considerable increase in life expectancy as they developed. In terms of public health disease burden, chronic diseases (generally non-infectious) have replaced acute infectious diseases. There are several reasons for this: improved hygiene and care, vaccinations and antibiotic treatments, biosecurity on farms, improved nutrition and food security. However, urbanization, more sedentary lifestyles, dietary changes, etc. accompany these transitions towards primarily non-infectious and chronic pathologies.

Table 2. Epidemiologic ruptures and transitions: a preliminary typology

	Epidemiologic ruptures (or upheavals or shocks)	Epidemiologic transitions
Periods	Neolithic (agricultural revolution), fifth century (Africa-Asia including Europe) then fifteenth century (New World)	Since the end of the 19th century
Geography	Regions (Middle East, China, etc.), continents	Countries undergoing demographic and economic transitions; achieved for developed countries, underway for middle-income countries and emerging economies (BRICS)
Mode	Gradual (domestication) or brutal (colonization of the New World). Also "exchanges" (e.g., syphilis) towards Europe	Gradual over several generations
Diseases	Wide spread of infectious diseases (microbial pools, new viruses for immunologically naive populations)	Move from parasitic, infectious diseases to chronic, degenerative diseases
Impacts	Major impact on societies (e.g., epidemiologic shock on the Americas)	Increased life expectancy
Present day	*Potential rupture? Consequence of climatic, ecological and therapeutic changes (antibiotic resistance)*	*Epidemiologic transitions continuing in middle-income countries and emerging economies: towards a globalization of health?*

However, bacteria, viruses and parasites continue to exist, and infectious diseases are particularly pernicious in the Global South, in both human and animal populations. For animal diseases, there is considerable geographic diversity, with sharply contrasting situations between developed countries, countries in transition and middle-income countries, and the poorest countries, principally in Africa, which are the most dependent on livestock farming and most at risk from a health perspective (Perry *et al.*, 2013). Consequently, we also could apply the concept of epidemiologic transition, initially developed in public health,[54] to animal health, and say that there are transitions between an ensemble of parasitic and infectious diseases predominating in traditional systems and a pathology related to livestock intensification.

A study (Jones *et al.*, 2013) shows that agricultural intensification and environmental changes – and the evolution of the link between the two – are correlated with the risk of emerging zoonoses. Some authors suggest that micro-organisms may also play a role in the development of important chronic diseases in developed countries and those in

54. The concept of epidemiologic transition was proposed by Omran (1971).

Box 2. Pathocenosis

The concept of pathocenosis – based on the notion of biocenosis but applied to a community of diseases – proposed by Grmek in 1969 aims to provide a logical framework to analyse these transitions and disease emergence. A recurring but controversial theme in epidemiology linked to this concept is that each pathogenic agent occupies an ecological niche, and its elimination leaves room for new pathogens. According to Lloyd-Smith (2013), the elimination of a pathogen leads to a vacant niche that could be re-invaded by the original pathogen. However, if other pathogens attempt to move in, other factors intervene in a dialectic of competition and evolutionary adaption without necessarily leading to the emergence of a new disease.

transition, for example heart diseases, cancers and diabetes (Rosenthal, 2015). The use of antibiotics is rising sharply in livestock farming worldwide, causing the development of transmissible resistance in bacteria affecting humans. Van Boeckel *et al.* (2015) estimate that antimicrobial consumption will increase by 67% by 2030, linked particularly to the growing demand for meat products in middle-income countries. Given the major risks posed by this surging and uncontrolled use of antibiotics in animal production and health, as well as in individual medicine, self-medication and public health, coupled with weak new product development, Woolhouse *et al.* (2015) liken antimicrobial resistance to climate change and suggest that an intergovernmental group similar to the Intergovernmental Panel on Climate Change (GIEC) should be created.

Will the history of infectious diseases soon come to an end with the latest upheavals correlated with a massive loss of biodiversity? Or are we going through a new epidemiological rupture (new viruses jumping the species barrier and causing new diseases in first epidemic and then endemic forms; antimicrobial resistance)? Or is it the case that epidemiologic transitions are continuing in public and animal health, varying with the economic situations of countries? Influenza viruses, responsible for animal and human influenza, could contribute to this discussion; new strains appear regularly, sometimes jumping the species barrier between birds and mammals, including humans, and causing epizootics or epidemics or even panzootics and pandemics.

What ever happened to the seventh pandemic?

"Massive deadly epidemics have disappeared. They have been replaced by just one: the proliferation of humans themselves." Cool Memories 1980–1985, Jean Baudrillard, 1987

A POSSIBLE INFLUENZA PANDEMIC was reported in the sixteenth century in Europe and Africa. The twentieth century witnessed the Spanish influenza pandemic of 1918–1919

caused by the H1N1 virus (over 40 million dead); the 1957 Asian influenza caused by the H2N2 virus (1 to 4 million dead); and the Hong Kong flu in 1968 caused by the H3N2 virus (1 to 2 million dead). The appearance in the twenty-first century of the panzootic and zoonotic H5N1 avian influenza revived the threat of a major pandemic. The H5N1 virus, a strain highly pathogenic for birds, is transmitted to humans with very high rates of case fatality (mortality/morbidity) but with thus far very low overall mortality. However, due to the genetic plasticity of influenza viruses and the possibility of recombination with other strains, researchers, experts and international agencies rapidly launched a pandemic risk alert. H1N1 influenza A (H1N1pdm09), which emerged in 2009, had a pandemic character in terms of geography and contagiousness but its mortality rates cannot be compared to the pandemics of the twentieth century. As mortality linked to the influenza virus is mainly due to secondary infections (Jamieson *et al.*, 2013), improved hygiene and care of flu patients has certainly contributed to the overall reduction in mortality during the last pandemics. However, given the weakness of health systems in some countries and the unpredictability of certain highly pathogenic strains (for example, H7N9 in China, which is proving to be weakly pathogenic in birds but highly pathogenic in people), it would be unwise to let down our guard.

While some authors[55] consider that the emergence of highly pathogenic H5N1 avian influenza overall led, in terms of public health, to "much ado about nothing", it should be noted that the disease had major direct and indirect socioeconomic impacts on livestock farms in countries of the Global South (Alders *et al.*, 2014). These impacts are linked to the disease itself, but also to the responses of different stakeholders in the poultry sector, to consumers, and to the measures taken by governments. H5N1 is now endemic in many Asian countries and in Egypt, and since 2015 has re-emerged in Africa with serious consequences for poultry value chains. Some authors argue that we will never again be faced with a devastating influenza pandemic due to effective early warning and surveillance programs, better care for patients and secondary infections, etc. However, given the recent multiplication of bird and pig zoonotic strains, particularly in China where livestock farming conditions facilitate the spread and genetic evolution of these viruses, and the economic and health risks for the least developed countries, continued vigilance is necessary (Von Dobschuetz *et al.*, 2014). Bluetongue disease and Ebola haemorrhagic fever, which never should have left their natural areas – respectively the inter-tropical region and the forest of Central Africa – should incite us to be cautious in terms of projections.

For Brender and Gilbert (Chapter 2), WHO actually emerged as an international organization by restructuring itself through the management of a pandemic, influenza A(H1N1)pdm09, and of the pandemic risk of H5N1 avian influenza. This crisis made it possible to strengthen links between health sectors and start developing the 'One Health' approach (Pfeiffer *et al.*,

55. "It is not necessary to set fire to the planet due to some zoonotic infection, nor to spend billions of euros, nor to create a governmental crisis; ultimately it is 'much ado about nothing'". Raoult, 2015.

2013). In animal health, this panzootic had a positive effect on the overall strengthening of veterinary capacities in many countries through programmes and projects financed and implemented by international agencies and donors. These avian influenza epizootics led animal health sector managers to further develop dialogue with livestock farmers (Alders *et al.*, 2014).

Recently, WHO was sharply criticized for its management of the ongoing Ebola epidemic in West Africa. An expert report dated 7 July 2015 emphasizes that the organization indeed failed to "provide an urgent public health response to a grave epidemic" (Maurice, 2015). Twenty-some recommendations have been proposed to re-establish "WHO as the lead guardian of global public health". Among these recommendations is a proposal to strengthen GOARN,[56] a global outbreak alert and response network. Jeremy Farrar, the Director of Wellcome Trust, vigorously supports this idea and emphasizes that this mechanism "should be truly independent, outside any political influence" (Maurice, 2015).

The management of infectious diseases at the international level requires robust and interconnected international agencies. The One Health paradigm ratified by OIE and United Nations agencies (FAO, WHO, UNICEF), which postulates that the epidemiological dynamics and interplay of actors conditioning the health of animal and human populations should be studied in their ecological, socioeconomic and political context at the interface of human health, animal health and ecosystem health, should facilitate this management.

The real or imagined consequences of an epidemic or epizootic, fear of a pandemic, media coverage and the hype that can follow must be held up against the reality of health and epidemiological data (morbidity, mortality, and lethality rates, economic and social impacts) by a broad range of medical scientists working in both animal and public health.

The Horseman on the Roof

> *"What?" said the young man, "You don't know? Where are you from? It's cholera. It is the finest case of Asiatic cholera that has ever been seen! Go there one more time," he said, holding the vial. "Trust me, I am a doctor."*
>
> *The Horseman on the Roof,* Jean Giono, 1951.

The "plague" in Athens in 430 BC was a major epidemic in ancient Greece. It has been the subject of discussion in recent years among doctors, microbiologists, epidemiologists, paleo-pathologists and other experts who debate the origin and etiology of this disease. *A priori* from Ethiopia, this infectious disease, characterized by a gastrointestinal haemorrhagic-like fever, could have been typhus, influenza, a viral haemorrhagic fever like Rift Valley fever or, some argue, even Ebola (Olson *et al.*, 1996). Animal mortality was

56. http://www.who.int/ihr/alert_and_response/outbreak-network/en/. At the end of 2014, CIRAD offered GOARN its expertise in the fields of ecology, epidemiology and veterinarian sciences for certain zoonoses.

reported during the same period. The events are recounted by the Greek politician and historian Thucydides (fifth century BC), who considered that fear and panic both disrupted Greek society at the time and amplified the spread and consequences of this disease.

The destructive nature of fear is without doubt a signature of the plagues which have since taken societies by surprise: the black plague (*Yersinia pestis*) in medieval times, AIDS in the 1980s, pandemic influenzas and Ebola virus today. The cholera epidemics of the nineteenth century in Europe and North America share several similarities with the ongoing Ebola epidemic in West Africa: inadequate health services, populations' fear and beliefs about the means of contamination, riots, unrest and suspicion of the medical community (Sheard, 2014). While Ebola killed fewer people during the epidemic in West Africa (since 2014) than many endemic diseases like malaria or measles during the same period of time, it had an amplifying effect on other diseases (e.g., malaria) and more broadly on health (for example, refusal to go maternity clinics for fear of contamination; Hessou, 2014). More broadly, for Ebola, the public health crisis was transformed into a multi-sectoral crisis affecting people's food security and livelihoods and national economies while threatening the geopolitical stability of the region (FAO-CIRAD, 2015).

Against this backdrop, to act more effectively on the chains of transmission, the cooperation of sociologists and anthropologists would have been warranted from the start of field interventions during the Ebola epidemic in Guinea, Liberia and Sierra Leone (Chandler *et al.*, 2015; Brown *et al.*, 2015). More broadly, an understanding of epidemics, surveillance and disease control can benefit from multidisciplinary approaches that do not limit themselves to biological and medical sciences (Stärk and Morgan, 2015).

Black swans and perfect storms

> *"What complicates everything is that which does not exist works hard to make everyone believe otherwise."*
>
> *Vendredi ou les limbes du Pacifique*, Michel Tournier, 1966

Black swan and perfect storm are two buzzwords in the English-language press, which often uses them as shorthand to describe financial and weather-related disasters. In probability theory, they refer respectively to a 'rare event' (black swan[57]) which can have wide ranging consequences if it occurs, and to a convergence of apparently unrelated, rare circumstances that drastically aggravate a situation (perfect storm, or 'worst-case scenario').

The emergence of an animal pathogen with zoonotic potential can be a rare event in terms of probability. An example is the zoonotic form of Ebola, with the original animal-

57. Referring to black swans which had been assumed to be non-existent in Europe until they were discovered in Australia. The use of the term 'black swan' was proposed by the philosopher Nassim N. Taleb in the field of finance.

to-human transmission for the index case being a rare event (Pigott *et al.*, 2014). The subsequent human-to-human spread, facilitated by weak health systems and ineffective international coordination, can cause, as shown by the epidemic still underway in January 2016 in West Africa. Highly localized outbreaks of vector-borne diseases (the first case of West Nile fever on the American continent in the Bronx Zoo in New York in 1999; Lanciotti *et al.*, 1999), a new influenza strain on a livestock farm (Baudon *et al.*, 2014), or a disease emerging in wildlife (Wiethoelter *et al.*, 2015) may also be considered as rare events. The wide spread of an emerging pathogen in a new socioeconomic system (Ebola in West Africa), and the risk of an antibiotic resistance 'pandemic', can be seen as perfect microbial storms underway or in the making. This notion of a perfect storm converges with the concept of emergence in its first, philosophical definition, namely, "the whole is greater than the sum of its parts".[58]

Can a black swan or perfect storm be predicted?

Paté-Cornell (2012) argues that while the attack on the twin towers of the World Trade Center in New York on 11 September 2001 was not a black swan – there were warning signals that could have been analysed – the emergence of AIDS in the 1980s truly was one, as was the Ebola haemorrhagic fever outbreak in West Africa in 2014 (Osterholm *et al.*, 2015).

Major virus detection campaigns (USAID PREDICT-1 followed by PREDICT-2[59] which will also explore possible determinants more deeply) in ecosystems considered to be hotspots of biodiversity – and consequently of viruses (South-east Asia, Central Africa) – and the metagenomic analysis of the biodiversity of viromes are not analogous to surveillance, but rather a snapshot of a community of pathogens at a specific point in time. Yet will these viruses jump the species barrier, locate a receptive host community and foster the emergence of a disease? The exploration of these 'viral loads', as well as of environmental and human behaviour parameters within ecosystems, could help define priorities for the surveillance of pathologies.

Current research is not adequately addressing the complexity and interdependence of the environmental, biological, economic and social dimension of pathogen emergence. This is considerably limiting our capacity to anticipate, prevent and respond to the emergence of infectious diseases. However, prediction and simulation models are becoming increasingly sophisticated (Heesterbeek *et al.*, 2015). They combine the spatial and temporal dimensions of population-based, individual-based, social (contact networks), economic, etc. mathematical models, but they should be handled with caution: "All models are wrong, but some are useful" (Box, 1976). This underscores the need to

58. http://plato.stanford.edu/entries/properties-emergent/

59. http://www.usaid.gov/what-we-do/global-health/pandemic-influenza-and-other-emerging-threats/programs

better communicate the limits of these models to decision makers and health managers, especially with regard to one type of modelling, risk analysis.

Risk analysis, which does not consist in predicting events, but rather in understanding the probability of possible scenarios, is a probabilistic modelling tool – unlike the scenario planning method described by Patrick Zylberman in Chapter 3 – developed in the veterinary and then medical fields, and which should be consolidated, particularly with regard to its communication component. Indeed, too few tangible studies on the communication of risk have been conducted (Figuié and Fournier, 2008). Risk analysis involves both scientists, who estimate and assess risks and propose alternative scenarios to mitigate these risks, and managers in charge of developing control strategies. A lack of effective communication between these stakeholders, as well as with the general public and the media, limits the relevance and effectiveness of these models and fuels confusion and misunderstanding about the risks involved.

For certain diseases such as influenza, the prediction of the occurrence of a new strain seems unrealistic given current knowledge about mutations and recombinations of influenza viruses and the tools available.[60] Surveillance systems capable of detecting rare events and the precursors of these events are needed. They require innovative methods to detect and identify an unusual event capable of generating epidemics or epizootics. Syndromic surveillance, non-specific surveillance based on the collection of data that can be outside the medical field,[61] could enable the early detection of emergences or the warning signs of emergence. These approaches also are being studied to warn of the risk of an imminent terrorist attack.[62]

Surveillance at all costs?

"Hidden diseases are the most difficult to treat."

Chinese proverb

Health surveillance is a field that requires input from a wide range of disciplines: pathology, epidemiology, microbiology-immunology, sociology, economics, anthropology, modelling, ecology, communication sciences, etc. It is not the prerogative of epidemiologists alone, who contribute to the definition and evaluation of surveillance systems through methodological input (samples, statistical and epidemiological analyses) and the proposal of new collection, analysis and assessment methods (Goutard *et al.*, 2012; Vergne *et al.*, 2012; Collineau *et al.*,

60. In time, the Chaos Theory (modelling of deterministic chaotic systems) could nevertheless be an interesting method (https://www.ncbi.nim.nih.gov/pmc/articles/PMC2465602/). Tools have also been developed to assess the pandemic potential of the H7N9 strain and other influenza viruses (https://doi.org/10.1017/S0950268815001570).

61. Triple-S guidelines on syndromic surveillance: www.syndromicsurveillance.eu/Triple-S_guidleines.pdf.

62. American CDC: http://emergency.cdc.gov/bioterrorism/).

2013; Delabouglise *et al.*, 2015). A surveillance system based only on laboratories and information systems, which are now very powerful but rely on equipment that is expensive to obtain and maintain, cannot be sustainable, particularly in the difficult socioeconomic context of countries in the Global South. The key issue remains access to the field and to 'epidemiological units', which are individuals or groups of animals or people, for the collection at the source of health information and samples in sufficient quantities and quality and on a regular basis to be able to derive elements for monitoring and alerts. It is also clear that the information which is compiled and analysed must be regularly provided back to system stakeholders for the system to operate in an optimal manner. Innovations in this field, particularly in the least developed countries and the most isolated regions, are critical (Goutard *et al.*, 2015). These include in particular participatory approaches which rely, in animal health, on the knowledge of livestock farmers, for example.

Surveillance leads to action. In animal health, this involves vaccination, treatment, and quarantine measures, as well as slaughtering and controlling animal movements, etc. If these interventions have negative or adverse effects, this reduces the effectiveness of surveillance and the involvement of stakeholders, or induces the emergence of parallel systems. The actual (in the case of slaughtering) or feared (dissension within social networks) risks of sanctions following the suspicion of animal or zoonotic diseases do not encourage livestock farmers to report suspicions or become part of a surveillance network. Alongside a top-down approach, in which no consultation process is involved, it may be interesting to use participatory approaches developed in the social sciences. This would enable discussions, communication, negotiations and a sharing of knowledge in order to lead to the joint identification of priorities and socially acceptable solutions. Participatory surveillance thus could certainly supplement a surveillance system by addressing the shortfalls identified by evaluation processes. These approaches also render it possible to avoid surveillance systems that stigmatize farmers. They made it possible to identify the last outbreaks of rinderpest before the disease was eradicated from the planet (see inset 2).

In the big data era, weak signals can be detected and identified within a huge mass of data to alert, anticipate (Olson *et al.*, 2015) and contribute to non-specific syndromic surveillance. For animals in the Global South, however, we are dealing rather with small data, although the extraordinary coverage of mobile networks holds some promise for the potential to collect data that could be used in a surveillance framework in collaboration with livestock farmers. Numerous recent initiatives in this area in public and animal health and through One Health approaches for the surveillance of zoonoses confirm the value of this tool. However, digital surveillance raises a certain number of confidentiality and ethical questions given that mechanisms guaranteeing the rights of citizens (for example, data protection and freedom of information) are currently lacking in numerous countries.

The evaluation of surveillance systems is essential for their improvement (Calba *et al.*, 2015). Beyond technical elements (efficiency of data transmission), such evaluations must consider economic issues – what are the benefits, what utility can be drawn from a

system which is by definition long-term in nature, how can it be measured? – as well as social, even psychological questions regarding the populations involved, whether in public health or animal health for livestock farmers and animal sector actors. Surveillance can effectively lead to ostracism and stigmatization for target populations whether in human health (for example, the start of the AIDS epidemic) or animal health (the identification of a herd with tuberculosis, or an industry infected by a pathogen, can have significant social consequences). For wildlife, an effective surveillance system can have indirect consequences for traditional hunters and the bush meat supply chain.

Broadening the battlefield

> *"But in all frankness, how long can we maintain the wall separating the department of biology from the departments of law and political science?"*
>
> *Sapiens: A Brief History of Humankind*, Yuval Noah Harari, 2015

While the Global North is broadly protected from the incursion and spread of known pathogens thanks to effective health systems, the Global South is more exposed and less equipped to fight epidemics and epizootics, and especially endemic and enzootic diseases, whether recognized or neglected. Global attention is focused on emerging diseases, but neglected diseases – meaning ones neglected by public authorities, donors, the scientific community, and the private sector – affecting vulnerable populations in the Global South have major medical, economic and social impacts. The 17 tropical diseases and a subgroup of eight zoonoses the WHO considers neglected are also neglected in terms of surveillance. The official, ratified extension of this concept to strictly animal diseases should be examined, as greater attention on the part of donors, decision-makers and researchers would enable better investments in animal health in cold spots (Perry *et al.*, 2013), meaning areas where the most vulnerable populations live.

Opposition between the vision of donors and politicians and the interests of livestock farmers may limit the effectiveness of surveillance and control. For example, foot-and-mouth disease, an animal disease that is highly contagious but causes little mortality, hampers regional and international trade. The management of this disease may be imposed although livestock farmers in countries where the disease is enzootic (sub-Saharan Africa, South-east Asia) do not consider the disease important, even though it has indirect economic consequences (production losses) (Bellet *et al.*, 2012). In addition to incorporating participatory approaches that can help improve surveillance and control systems in certain contexts, when possible these systems should, rather than focusing on a single disease, be able to monitor diverse health conditions and be capable of detecting unexpected events. More broadly, and this was emphasized for the ongoing Ebola epidemic in West Africa, surveillance mechanisms should be better integrated into overall health systems (Dhillon and Yates, 2015) and not be dependent on funding obtained through time-limited projects. Surveillance requires permanent mobilization.

For a surveillance system to operate smoothly, it must be based on a network of stakeholders: patients, livestock farmers, health professionals, etc. Under this framework, the One Health concept adopted by international regulatory agencies (OIE and UN agencies) and supported by major donors can be applied to surveillance, particularly to zoonoses and health conditions linked to the environment. One Health surveillance would have the advantage of being able to pool strengths and resources. In Cambodia, the fact that avian influenza was detected first in people before the infected farms which caused the human cases is indicative of important weaknesses in the field of veterinary surveillance.

Are we moving towards a new end of infectious diseases, like that announced in 1967 by the United States Secretary of Health, or are epidemiologic transitions continuing with the gradual replacement of infectious diseases by chronic diseases as countries develop? Or are we on the verge of an epidemiological rupture with the emergence of new pathogens hitherto 'buried' in certain ecosystems and animal reservoirs, including intensive livestock farms and, in parallel, the efficacy of antimicrobials reaching its limits?

We do not understand all of the parameters of diseases and we can only partially, or on a very short term basis, predict the occurrence of new diseases. Appropriate surveillance systems can help us understand and analyse ecological changes and epidemiological trends while improving the control of emerging and endemic diseases. Such systems must be efficient, specific and non-specific, syndromic and etiological, operating on diverse geographic scales, but also firmly rooted in the field in the most vulnerable regions, collecting health information as well as environmental, climatic, and behavioural metadata.

"Why does health, regularly described as a global public good [or global common good, see Chapter 4]–remain an area where international inequalities are so profound?" (Gadreau, 2014). South-South and North-South cooperation in the fields of public health and animal health must be strengthened through joint research platforms, health networks, and integrated surveillance systems. The joint action of international agencies is crucial. Avian influenza, for example, enabled a "return to an integrated human and animal health approach" (Vagneron, 2015) between WHO, OIE and FAO and to set down the concrete foundations of One Health in action.

Four of the Millennium Development Goals (MDG), launched in 2000 for a 15-year period, refer explicitly to health. Despite significant progress, the burden of infectious diseases, in general endemic and for some neglected, remains heavy, particularly in the least developed countries. For the period after 2015, when the MDGs will be replaced by a new set of poverty reduction and sustainable development goals (Sustainable Development Goals, SDG, 2015–2030), the Director-General of WHO (Dye, 2014) is focusing on five aspects of the fight against infectious diseases:

– study of the biological links between infectious and non-infectious diseases;
– control of infections in urban areas;
– improvement of the response to international health threats;
– expansion of vaccination programmes for children to prevent acute and chronic diseases in adults;
– development of universal health coverage.

However, the post-2015 health era must not neglect the improvement of animal health which, combined with strengthening the productivity of livestock farming, is a major lever for poverty reduction (Pradère, 2014), and must broaden its vision of health by integrating sectors and disciplines outside the strictly medical field.

Even though some risks are known – antimicrobial resistance, unceasing evolution of influenza viruses – it is difficult to see what the future holds. Major rupture based on increasingly frequent emergences? Transition and end of infectious diseases? Either way we must have warning systems and be able to respond in real time.

A multi- and interdisciplinary approach to health, combining biological, human, social and mathematical sciences, is essential, whether to address the interdependence of animal, human and environmental health (One Health) (Lapinski *et al.*, 2015) or to be able to transfer research outputs to decision-makers, particularly in the field of health management.

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Acronyms

BVD	Bovine virale diarrhea
CDC	Centers for Disease Control and Prevention
CIA	Central Intelligence Agency
CIRAD	French agricultural research and international cooperation organization
CRBN	Chemical, biological, radiological and nuclear
DILGA	French interministerial delegate for avian influenza control
FAO	Food and Agriculture Organization of the United Nations
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
GOARN	Global Outbreak Alert and Response Network
GPHIN	Global Public Health Intelligence Network
IBR	Infectious bovine rhinotracheitis
IHR	International Health Regulations
IUCN	International Union for Conservation of Nature
MERS	Middle East respiratory syndrome
NGO	Nongovernmental organizations
NGS	New governance for animal health (*Nouvelle gouvernance sanitaire*)
NPPC	National Pandemic Planning Committees
OIE	World organisation for animal health
OPEP	Organization of the Petroleum Exporting Countries
PHEIC	Public health emergencies of international concern
SARS	Severe acute respiratory syndrome
UNSCOM	United Nations Special Commission (regarding Iraq)
USAID	United States Agency for International Development
WHO	World Health Organization
WTO	World Trade Organization

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From SARS to avian influenza, Ebola virus and MERS-CoV, infectious diseases have received increasing attention in recent decades from scientists, risk managers, the media and the general public. What explains the constant emergence of infectious diseases? What are the related challenges?

In five chapters, experts from different scientific fields analyse the ecological, social, institutional and political dynamics associated with emerging infectious diseases. This book discusses how the concepts, scientific results and action plans of international or governmental organizations are constructed and coordinated.

In clear straightforward language, this book explores the continuities and discontinuities that occur with emerging infectious diseases, both in terms of collective action and in our relationship to the biological world.

This book — coordinated by Serge Morand (Ecologist) and Muriel Figuié (Sociologist), and prefaced by Frédéric Keck (Anthropologist) — includes contributions from Claude Gilbert and Nathalie Brender (Political Scientists), François Roger (Veterinary Epidemiologist) and Patrick Zylberman (Health Historian).

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