# Could Our Main Challenge with Emerging Diseases be the Way we Look at Them? Or Maybe Even the Way we Don't Look at Them?

The history of agriculture and animal production has known many emerging and re-emerging diseases. Some of these diseases of animals have had a major impact on humans. At the moment, there seems to be a trend of (re-)emerging diseases.

## A Changing Landscape

Taking a European perspective, several unexpected outbreaks of vector-borne diseases have oc-curred in EU member states in recent years. Diseases such as West Nile fever have moved up the list of public health issues, with outbreaks in humans in Greece, Bulgaria and Croatia. In 2006, the bluetongue virus, serotype 8, was detected well outside its known geographical range. Since then, with incursions of a number of serotypes of bluetongue virus and the spread of serotype 8 to most EU member states, bluetongue has evolved from an 'exotic disease' to a more complex dis-ease situation with the potential of becoming endemic in certain previously free areas. While the situation has significantly improved in many areas over the last few years, due to efficient control measures, bluetongue remains an animal health threat to Europe.

In 2011, another vector-borne disease caused by the Schmallenberg virus emerged in ruminant animal populations and rapidly spread across Europe. More recently, Lumpy Skin Disease was re-ported from Cyprus. But also, non-vector-borne diseases have occurred in unexpected circum-stances, for example, the spill-over of Q-fever from animals to humans in the Netherlands between 2007 and 2010, with over 4000 human cases, raised serious public concerns and questions about factors contributing to the development of this outbreak.

Many reviews of infectious diseases at the human-animal interface show that more outbreaks, both new and already known, are to be expected in the future. In some of these reviews, Europe has been characterised by authors as a hot-spot for emergence, mainly as a result of socio-economic practices and changing climate patterns, since we Europeans live in a changing landscape. The contention, however, would apply well beyond European boundaries and it is high time to look at emerging diseases' mergence as an "expected unexpected".

The year of 2014 and the beginning of 2015 have been branded by the Ebola virus. The outbreak of the Ebola virus disease, which has been affecting several countries in Western Africa since December 2013, is by far the largest ever documented, with reported cases and deaths that have exceeded previous historical outbreaks; it is also the largest outbreak in terms of geographical spread. The outbreak is generally considered to have happened after a single spillover event, with the index case believed to be a very young child living in a village of Guinea's southeastern forest region. It has spread to the neighbouring countries, Liberia and Sierra Leone. Scientists usually consider that transmissions of the Ebola virus to humans occur by contact with dead or living infected animals. There is, however, uncertainty around all modes of transmission of the virus. Hunting, scavenging and butchering infected animals certainly leads to intimate contact with infected organs, body secretions and other fluids. Such contacts are a potential source of infection in humans. Although we believe we understand the mechanisms of the spill-over, the question remains why the Ebola virus turned active in West Africa, that far from its usual territory in Central Africa? As some have put it in simpler terms: why there and why now?

A better understanding of environmental, epidemiological and social factors that could lead to an outbreak such as the one of Ebola virus disease in Western Africa, and a better understanding of the spatial and temporal interconnections of these factors across the affected region and beyond, may help to prevent future outbreaks. Looking in the mirror, the lack of understanding of these drivers may simply hamper our capacity to prevent similar outbreaks in the future. A shortsighted view is probably to concentrate on hunting activities and use of bushmeat as a resource for food. Indeed, Africa is another changing landscape and our efforts should be to better understand the sequences of events which have gradually make such a spillover possible. Some of these sequences have their roots miles away and years ago.

This reminds us about the urgent need to explicitly take into account socioeconomic and environmental aspects along with epidemiological aspects of emerging diseases. It reminds also of the need to consider the interactions between factors belonging to such different aspects of reality.

## Powerful Drivers

We know that human activities are often the ones driving the appearance of emerging diseases, either directly or indirectly, sometimes even remotely. We increasingly use the concept of drivers: drivers have been defined as issues shaping the development of a society, organisation, industry, research area, technology, etc. They can be classified in categories such as social, technological, economic, environmental, and political. An important characteristic of drivers is that they can modify the onset of emerging diseases. They can either amplify or attenuate the magnitude or frequency of risks arising from various sources. A large body of literature is available on drivers

in different fields, including economy, social sciences, technology, health and environmental sciences. Drivers are very helpful to retrospectively analyse outbreaks; they similarly have potential for horizon scanning.

Just recently I attended a conference on the bluetongue virus, and found myself citing Jacqueline de Romilly on ancient Greek philosopher Thucydides: '…The future will always be unpredictable to us, but the continuities and analogies in history can serve to alert us to understand better what may well happen. So it is not about predicting the future, nor even about any practical utility, but rather about understanding events once they have happened on the base of an exact knowledge of the past. In a way, the use of drivers in emerging risk walks the same thin line between past and future.

The more humans expand the footprint of the global population, encroach onto natural habitats, alter these habitats to extract resources, intensify food production, and move animals, people and commodities and the pathogens they carry, the greater the potential for emerging or reemerging pathogens. Producing food plays a major role in this since food production is a human activity which has the largest impact on our planet. As an example to illustrate this, it is estimated that food production uses twice the amount of water compared to all other human activities combined. The risk of emergence and spread of existing and new pathogens has also increased as a consequence of global changes in the way food is produced, transformed, transported and consumed, as well as many other factors that characterise the Anthropocene. This is probably both a long-standing and a long-term trend if we consider that by 2050 the global population is expected to be over 9 billion. Not only is the global population expected to grow dramatically, but a substantial part of this population's income is expected to be nearly three times what it is today with expected changes in food habits, such as an increased demand for meat, for example. The shifting demand will result in an increase in food production, which is likely to place a greater burden on the resources of the planet.

Of course, food production is far from being the only sector providing effective drivers for emerging diseases. For example, climate change is likely to provide newly suitable environmental conditions for species to broaden their geographical distribution. This concerns not only invasive species but also a number of pests and pathogens. Climate change will also increase pressure on the availability of food because of reduced reliability on seasons, and extreme climatic events such as droughts or heavy rains. Climate change is a strong source of drivers for emerging diseases. At the same time, population displacements due to multiple and overlapping political and humanitarian crises which have occurred over the last few years and continue to occur in several parts of the globe will be a feature of our future and will also represent a potential for emerging infections and spread of pathogens.

As a matter of fact, trying to list potential drivers for emerging diseases in a world of change inevitably results in a long list of items, most of which are related to each other. Many such lists have been prepared here and there in the context of preparedness or in desperate attempts at forecast. One should admit though that the question remains to know how to put these drivers into play.

**One Health of Course, and Beyond**

It is usually estimated that about two-thirds or three-quarters of infectious diseases in humans have their origin in animals. However, the connections between human and animal health are going well beyond this. The link between public and veterinary health is also recognised in the area of non-communicable diseases, such as, for example, asthma among farmers or occupational cancer among meat workers. Emerging diseases are not only a threat to animals, or the environment, but may have direct and indirect consequences on public health, either because of food shortage or because of the zoonotic impact such as new pathogens to humans or antimicrobial resistance. Indeed, those knitted implications, as well as the existence of overlapping drivers of emerging diseases and environmental changes do point towards the concept of 'One Health', an integrated view and approach to human, animal and environmental health. The One Health concept has gained momentum over the past years and an increasing number of initiatives have engaged in fostering synergies and bringing together public and animal health, development, ecology, economics, and other sectors to investigate connections between health and environmental change to generate science and policy outputs.

We would easily agree that long-term planning should take into consideration the unique nature of diseases at the human-animal interface and their emergence must involve the entire relevant scientific community. Looking at the drivers for emergence, this entire scientific community seems to grow dramatically and embraces the entire field of biological and social sciences.

Yet, we often miss the social sciences part. In the case of the Nipah virus disease and its emergence in Malaysia in the late 1990s, most of us have in mind a series of drivers such as forest fire of unprecedented magnitude, massive displacement of bat populations, encroachment of orchards and pig farming. However, less is often known about farmers belonging to ethnic minorities in some parts of the country, or farmer response to outbreak management measures put in place by the central authority.

Working on drivers opens a new dimension to the One Health concept because drivers drive for many different outcomes - animal and public health, ecosystem integrity, plant health, etc. and drivers belong to any category featuring the reality of the changing world. Working on drivers simply forces us to forget for a moment about our scientific disciplines and take a fresh look at the reality.

The challenge remains to understand the influence of human activities and behaviours, and to in-corporate this understanding into our approach to emerging diseases because human activities are often the drivers of emerging diseases.

**The Power of Representation**

In our attempt for a holistic approach accounting for relations between drivers, potentially belonging to different families, the linear and causal relation between risk factor and disease emergence is no longer applicable. On the contrary, the aim is to examine the multidimensional links between a broad range of ecological, biological and socio-economic factors. Back to the example of Nipah virus disease, there was a network of interactions between several events which created favourable conditions for the emergence in 1997. Such events encompass deforestation, war, or migration of bat population, and some authors have proposed the use of spidergrams as a methodological tool based on a visual network representation. The spidergram also includes conditions such as poverty or level of containment of pigs. Working on similar representations, we came to realise that spidergrams were often interpreted as causality networks, where indeed interactions between drivers do not necessarily belong to this category, leaving space for other types of relations such as conjunction, correlation and even coincidence. This requires manoeuvring in a complex tissue of relations which constitutes another conceptual challenge that we only discovered while working on drivers for emerging diseases.

Many drivers can contribute to the emergence of infectious diseases and drivers of an emergence rarely act single-handed. Several authors have proposed conceptual frameworks for the holistic and interdisciplinary investigation of disease emergence and the underlying drivers. Most of these frameworks combine perspectives from both natural and social sciences, linked to public health, land use and conservation. However, the figurative representations they propose of zoonotic diseases are very often focused on the spillover event, demonstrating a strong influence of biology in those representations. Multi-disciplinarity - where experts from a variety of disciplines work together but keep separate questions, conclusions, and even disseminate in different journals - is therefore not enough any more. Trans-disciplinarity is defined as a collaboration process in which the exchange alters discipline-specific approaches, and integrating disciplines achieves a common scientific goal. Typically, a trans-disciplinary project brings experts to work entirely outside their own discipline, at least for some time. Trans-disciplinarity makes it possible to transcend the disciplines to capture complexity, and create new intellectual spaces. Let's face it, inter- and multi-disciplinarity have gained traction, but there are still very few, too few, trans-disciplinarity approaches to animal health.

Working with drivers for emerging diseases has brought us to the importance of visualisation. The way we represent systems and the way we display our conceptual models both tell a lot about the way we see and represent the world. They are cosmograms, i.e. formal representations of the world. Looking at the representations made of recent events of emerging diseases show that our mental maps are still mainly driven by biology. What we may have learned from the exercise is that a main challenge of emerging diseases is the way we look at them. We should also recognise that what applies to emerging diseases, probably applies equally well to any disease.

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