From the Editors

Public health and livestock: Emerging diseases in food animals

Thierry Lefrançois* and Thierry Pineau†

*Chief Laboratory Control of Exotic and Emerging Animal Diseases, CIRAD Montpellier, France

†Head, Animal Health Division INRA, Toulouse, France

Despite public health and veterinary public health improvements within the past century, human and animal populations remain vulnerable to health threats caused by infectious diseases. Noticeably, the rate of emerging infectious diseases is increasing (one new emerging or re-emerging disease every eight months). Meanwhile, many endemic diseases have increased in incidence. Out of 1,400 microbes that could cause human infections, more than 60% are also pathogenic for wild or domestic animals (OIE, 2012). These zoonotic agents cause 75% of human emerging infections (OIE, 2012).

Since they can be contagious to humans or compromise the food safety, the infectious diseases of animals represent a direct public health issue (OIE, 2012). They also carry an indirect threat since they account for the majority of the 20% losses that affect the livestock sector at the production level and since they could severely hamper the animal traction resources that are needed to produce or transport goods. These losses raise an issue of food security to sustain an increasing demand for proteins of animal origin. By 2020, the livestock sector is expected to represent 50% of the agriculture outputs in value. In developing countries, uncontrolled re-emergence of infectious diseases threatens the main asset of families, thus preventing them to escape from poverty. Additionally, the animal morbidity and mortality generated by infections represent an unjustified emission of greenhouse gases, thus raising an environmental issue. In a growing number of countries, infections are also perceived as a primary concern for animal welfare.

The rapid pace of infection emergence is not only connected to more suitable conditions for pathogen appearance and spreading, it is also linked to improved methods and technologies for surveillance, pathogen detection, and identification. There are all kinds of pathogen agents of concern: prion, viruses, bacteria, and mono-cellular and pluri-cellular parasites. Several drivers of infectious diseases have been identified, many of which are of anthropogenic origin:

i) Indeed, the role of the expansion and intensification of animal agriculture has been pointed out. Changes in nutritional and agricultural practices, associated to the second livestock revolution (1980s through 1990s), have led to intensive production systems, the frequent use of antimicrobial agents, high densities of animals with suboptimal husbandry conditions, and a decline in genetic diversity.

ii) The ongoing global change and the resulting climate-driven environmental change, as well as natural disasters, have introduced ecological perturbations and flux shifts into finely tuned ecosystems consisting, for example, in modified interactions between pathogen vectors and hosts.

iii) The population growth, associated with a facilitated access to travel means, has a strong impact. Socio-economical determinants such as political instability and the resulting migrations should be emphasized.

iv) Fast and large-range trade of animal and food products have a major influence. Various kinds of changes in food-processing practices were also strongly influential.

v) Several shifts in land use should be mentioned such as: accelerated urbanization, deforestation, and the encroachment on wildlife with extensive and closer contacts among humans, livestock animals, and wildlife. Species barriers crossing often occur at ecological interfaces.

vi) Finally, it should be stressed that countries where a capacity breakdown occurs in the domains of public health and animal health management, become a weak link in the global effort to prevent, detect, and respond to disease outbreaks. Moreover, poor socio-economic conditions are generally associated with closer contacts between humans and animals, as well as greater exposure to vectors, thus increasing the risk of disease emergence in these countries.

In view of these main drivers, which create interconnected risks, what strategy would be appropriate to tackle the diversity of research needs and challenges? Obviously, an effective approach to emerging diseases that understands prevention and control will require a broad view of medicine. It should encompass biological, ecological, evolutionary, epidemiological, and socio-economic determinants of the microbial, animal, human, and environmental interacting compartments. Such a broad perspective is fully consistent with the "One Health" concept. Within this strategic framework, the challenges of emerging infectious diseases will be addressed at the animal–human–ecosystem interfaces. In their 2010 tripartite concept note, the three agencies, FAO, OIE, and WHO, reached a clear strategic alignment and delivered an accurate vision statement seeking "*a world capable of preventing, detecting, containing, eliminating, and responding to animal and public health risks attributable to zoonoses and animal diseases with an impact on food security through multi-sectorial cooperation and strong partnership*" (FAO, OIE, and WHO, 2010.). Many research institutions have already endorsed this vision, which provides an appropriate framework to foster all of the research needs for the future. It remains a matter of debate whether the capacities in public health management and animal health management fulfill all criteria of a global public good (non-rivalrous, non-excludable, and available worldwide).

Nonetheless, the goal to improve the capacities in veterinary public health management is consistent with the perspective to provide such a

doi:10.2527/af.2014-0001

public good provided that it is considered a worldwide issue to be treated through international cooperation. It remains crucial to tackle production diseases as well as epidemic emerging diseases. Thus, veterinary medicine services should be maintained and developed at a global scale. Such a goal is fully consistent with the One Health strategy, but it would not be properly achieved through the simplistic management hypothesis of merging veterinary services with their human health counterparts. Ideally, upstream research and field data should provide all necessary substrates for a reliable risk assessment. This, in turn, is expected to promote evidence-based decision making for efficient risk management. In order to prevent, detect, and respond to disease outbreaks, such a broad view is essential for policy making, surveillance prioritization, validation/dissemination of practices, and strategic anticipation.

A key link in the chain of knowledge is surveillance. To address sanitary issues and to strengthen veterinary public health, reliable surveillance structures are crucial to provide trustable early warnings. But surveillance implementation remains uneven at a global scale. A paradigm shift may occur in this domain if the access to high-throughput sequencing technologies would become more affordable while addressing the subsequent bottleneck represented by the data collection, processing, and mining steps. These conceptual and technological improvements may soon place the goal of global and reliable pathogen surveillance within reach. Addressing the issue of poor reporting should improve the reliability of surveillance if surveillance management is improved in parallel. Developed countries could expect valuable outcomes and returns on investments from sustaining research and capacity building in developing countries of the inter-tropical areas. Addressing, through cooperation, the infrastructure weaknesses responsible for infection emergence is a wise and beneficial strategy for countries that can afford it. International cooperation will enable use of all competencies and capacities from northern and southern countries and laboratories in tight cooperation with international organizations to maintain the objective of global public good. This will also enable research-driven developement in emerging countries.

Enablers such as genomics and bioinformatics could help close current research gaps. Thus, they strongly influence the definition of research priorities. We believe that several key features will markedly impact the future trends in emerging diseases research:

i) The challenges to address, such as the ecological interfaces between species, are increasingly complex. They will require inter- or trans-disciplinary and collaborative researches.

ii) In this respect, human sciences have to be associated with emerging diseases research. For example, in a vaccination control strategy for a given pathogen, sociologists could help to better understand the perception of risks by farmers and stakeholders, and economists would anticipate the willingness to pay for prevention measures according to how the threat intensity is perceived. In the context of climate-driven ecological change, one might expect a renewal of entomology to better address, with other disciplines, the challenges of vector-borne diseases.

iii) With high-throughput strategies, a decline in hypothesis-driven investigations would be observed whereas data-driven research would likely be promoted. These large-scale strategies, when applied to emerging diseases, should provide original causative hypotheses of disease transmission, which should be tested within a statistical framework.

iv) Researchers will be strongly encouraged to add a modeling dimension to their observational research. Then, the ultimate step would be to produce predictive outputs from their modeling efforts.

v) Although cell culture models are becoming very popular, widely used, and extremely useful, limited and controlled experimental infections on live animals will remain an invaluable source of knowledge. Investigating the complexity of animal–pathogen dialog in various organs or studying natural infections through insect or acarian vectors is only conceivable in whole organisms. Studies on vector competence or pathogen transmissions will be more frequently required while high-throughput methods will likely reveal many, yet unknown, pathogens. Therefore, high-containment animal facilities represent highly strategic assets when quick responses to pathogen outbreaks are expected. Both model species and target species remain fully necessary for several crucial steps of assessing the determinants of pathogenicity and the host specificity of emerging pathogens to produce the first sera for diagnosis tests; assess the impact on gonads, gametes, and embryos; and test vaccine efficacy and innocuity. Additionally, better than rodents, several livestock species have proven to be reliable models to study and respond to human diseases.

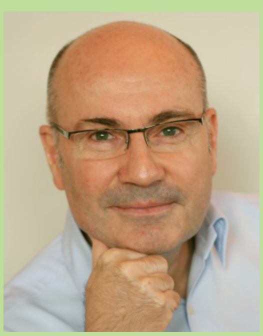
Addressing the threat of an emerging disease (zoonotic or enzootic) does not often represent a primary concern on the political agenda. Despite frequent misguiding media treatment and many non-rigorous criticisms made before a thorough assessment of impacts, the H1N1 pandemic of 2009–2010 represents the first global and full-range (from monitoring to vaccination) response to a pathogen emergence. The way all stakeholders have contributed to a collaborative process of that size represents a unique and enriching experience that should be remembered for its positive outcomes. This emphasizes how important it is that policy makers, international agencies, governments, academic researchers, surveillance specialists, diagnosis and vaccine providers, and all relevant stakeholders contribute to raise the overall level of preparedness to appropriately respond to infectious emerging diseases. In that respect, considering that resources are scarce, researchers are facing the responsibility to address the crucial question of topic prioritization. This is a mandatory step for improved coordination in research at a global scale. The priority settings for the strategic plans of influential agencies or institutions and some EU-funded projects have already contributed to research prioritization and coordination that deserves to be further pursued. Thorough foresight studies, providing various scenarios for the future of livestock production and their consequences in terms of animal health and managing emerging infections would be extremely helpful.

According to foreseen drivers and the ongoing climate-driven ecological change, numerous interferences ultimately disturb the vulnerable ecosystem equilibrium among the pathogens, hosts, and vectors. Thus, pathogens gain access to new ecological niches, territories, and hosts. Confronted to dynamic instabilities, the pathogens respond to uncertainty or threats by mobilizing their ancestral and best weaponry system: their unmatched genome plasticity and fast adaptation to changing environments. In an effort to preserve or restore the equilibrium, humans respond with improved surveillance, technological, and medical innovation for drug and vaccine research. Between pathogens and hosts, the race is still on to quickly counteract the efforts of the other party to tip the balance on its favor. Humans are racing for two objectives: securing their own health and their livestock supplies. Lederberg (2000) writes, "The future of humanity and microbes will unfold as episodes of a suspense thriller that could be titled Our Wits Versus Their Genes." Let's call for global "Human Intelligence" using international cooperation, disciplinary integration, and generosity to tackle the complex issue of pathogen emergence.

This issue of *Animal Frontiers* focuses on four different emerging diseases across the globe, including peste des petis ruminants virus (Libeau et al., 2014), *Leopeopheirus salmonis* (Igboeli et al., 2014), transmissible spongiform encephalopathy (Beringue and Andreoletti, 2014), and porcine epidemic diarrhea virus (Kehrli et al., 2014). In addition, Frederick Lantier (2014) underscores the necessity and the requirements for the development of appropriate animal models to empirically investigate emerging diseases in food animals.

About the Authors

Thierry Lefrançois is the head of a joint research unit CIRAD-INRA "Control of Exotic and Emerging Animal Disease" in Montpellier, France. For the last 20 years, he has been working on physiopathology, diagnosis, and epidemiology of emerging and vector-borne tropical diseases in France, Burkina Faso, Kenya, and the Caribbean. More recently he has been mainly involved in the development of tight interactions between research and surveillance especially within the frame of regional animal health network



Thierry Pineau is head of the Animal Health Division of the French Institute for Agricultural Research (INRA), where roughly 700 investigators work on infectious and non-infections diseases of livestock animal species. He is a pharmacist by training, obtaining a M.S. degree in parasitology and a Ph.D. in molecular pharmacology. As a researcher, his main interests are on hepatic mechanisms of detoxification towards drugs and xenobiotics. He contributed to highlight the role of several nuclear receptor-driven pathways, which sustain the biological impacts of food contaminants (i.e., plasticizers) and endocrine disruptors.

References

Beringue, V., and O. Andreoletti, 2014. Classical and atypical TSE in small ruminants. Anim. Front. 4(1):33–43.

Ducrot C. et al. 2011. Issues and special features of animal research. Vet Res 42(1):96.

FAO, OIE, and WHO. 2010. Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystem interfaces. www.who.int/influenza/resources/documents/tripartite_concept_note_hanoi_042011_en.pdf. (Accessed 2 Dec. 2013).

Igboeli, O.O., J.F. Burka, and M.D. Fast. 2014. *Lepeophtheirus salmonis*: a persisting challenge for salmon aquaculture. Anim. Front. 4(1):22–32.

Kehrli, M.E., J. Stasko, and K.M. Lager. 2014. Status report on porcine epidemic diarrhea virus in the United States. Anim. Front. 4(1):44–45.

Lantier, F. 2014. Animal models of emerging diseases: An essential prerequisite for research and development of control measures. Anim. Front. 4(1):7–12.

Lederberg, J. 2000. Infectious history. Science 288:287–293.

Libeau, G., A. Diallo, and S. Parida. 2014. Evolutionary genetics underlying the spread of peste des petits ruminants virus. Anim. Front. 4(1):14–20.

OIE. 2012. Animal health: A multifaceted challenge. www.oie.int/fileadmin/Home/eng/Media_Center/docs/pdf/Key_Documents/ANIMAL-HEALTH-EN-FINAL.pdf. (Accessed 2 Dec. 2013).