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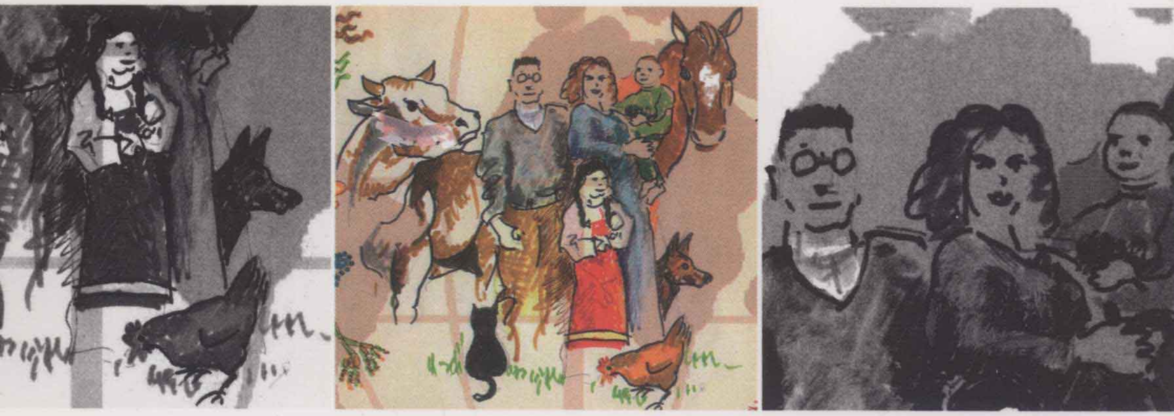

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INFLUENZA AND OTHER EMERGING ZOONOTIC DISEASES AT THE HUMAN-ANIMAL INTERFACE

FAO/OIE/WHO Joint Scientific Consultation
27-29 April 2010, Verona (Italy)

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Bernadette Abela-Ridder, Peter Daszak, Gwenaelle Dauphin, Ruben Donis, Stephane DeLaRocque, Pierre Formenty, M. Kathleen Glynn, Billy Karesh, Hans-Dieter Klenk, Vincent Martin, John MacKenzie, Elizabeth Mumford, Pierre Rollin, Alex Thiermann, and JoEllen Welter

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Executive summary

The Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE) and the World Health Organization (WHO) held a Joint Scientific Consultation on Influenza and other Emerging Zoonotic Diseases at the Human-Animal Interface from 27 to 29 April 2010, in Verona, Italy. This meeting and the first technical meeting held in Verona in 2008 were part of a recent series of international policy and technical meetings, which also included the International Ministerial Conference on Animal and Pandemic Influenza (IMCAPI) meetings, and the "One Health" meetings held in Winnipeg, Canada and Stone Mountain, United States of America. Initially the focus was on pandemic and avian influenza, but this perspective has evolved to include broader thinking on other influenza subtypes and emerging zoonoses generally. The latest meeting reflected this progression by considering not only influenza but also other emerging viral zoonoses, and by attempting to identify the commonalities among diseases, to provide a scientific basis for collaborative, multisectoral actions.

Overall, it was agreed that important lessons learned through recent experiences with zoonotic influenza emergence can be applied to other emerging zoonoses. However, it was clear that gaps remain in the global understanding of influenza. For example, neither the association between molecular structure and epidemiologic and clinical characteristics, nor the impacts of ecological and other contextual aspects are well understood. Such understanding is crucial for the valid assessment and prioritization of influenza health risks, which provide the basis for developing effective prevention and control measures.

This point - that only looking at the influenza virus itself provides insufficient information to allow effective, valid, risk assessment, prevention, and control because emergence and disease impacts are affected by context, i.e. host factors, ecology and management systems - was echoed during discussion of other emerging diseases. Thus, future data collection for any disease must aim to include a wider range of contextual information and these data must be factored into the subsequent analyses, requiring a multisectoral approach. It was agreed that modelling can be useful for understanding and even predicting some diseases, as long as sufficient appropriate data are available.

Many of the issues raised were not new, but the discussions aimed to develop new approaches to them. The following eight priority areas for action therefore include some well-known topics – data sharing and improved surveillance – along with increasingly recognized but less widely investigated ones, such as ecosystem health and the promotion of behavioural change to reduce disease emergence.

DATA AND DATA SHARING

This discussion focused both on making more data accessible and making these data accessible to a wider group, by breaking down the concept of data ownership and reducing the technical, legal and political/conceptual barriers to data sharing. More tangible and equitable incentives, rewards and benefits for contributing, using and analysing data appropriately, and technical solutions for improving data interchange would facilitate wider and more effective sharing.

SURVEILLANCE

Surveillance was identified as a long-standing challenge owing to its complexity. Although all countries conduct disease surveillance among humans and animals, the priority they give to these activities varies based on the national context. Building capacity for surveillance of known diseases is critical in enabling the detection of unusual events, and overall efficiency may be increased by using syndromic, participatory or targeted (both pathogen- and non-pathogen-based) approaches. New and innovative strategies, such as using social networking systems and engaging non-traditional partners, were recognized as opportunities for improving surveillance, especially in under-resourced settings.

ECOSYSTEM DYNAMICS

Routine inclusion of the ecosystem aspects that may underlie or facilitate disease emergence – including changes in land-use practices, agricultural impacts on ecosystems, natural resource extraction, wildlife trade and production systems – was identified as a priority for addressing disease emergence at the human-animal interface.

DIAGNOSTICS

The development of diagnostics for the early, field-based detection of emerging diseases is another long-standing challenge, especially in the identification and characterization of new or evolving pathogens. New technologies are evolving. Finding ways to achieve laboratory sustainability, to identify feasible and appropriate methods for specimen transport and collection and to link data to specimens were identified as crucial to the building of national laboratory diagnostic capacity.

BEHAVIOUR CHANGE AND COMMUNICATION

Behaviours have an impact on health and disease emergence risks. The promotion of activities such as disease reporting must therefore target all stakeholders in all sectors, including the public. Perceptions of risk and cultural motivations must be considered before effective and practicable measures for changing risky behaviours can be identified and communicated. Successful corporate marketing and communication campaigns, such as those against the use of tobacco, might be used as models. To be effective, communications must be transparent, valid and aligned among different partners and stakeholders.

CAPACITY BUILDING, EDUCATION AND RESEARCH

To be sustainable and effective, capacity building should be based on national-level needs and priorities, and should incorporate cross-training among sectors, either by modifying existing training systems or by building new multidisciplinary approaches to capacity building and education. Discussions identified the need for more basic research to fill fundamental gaps in scientific knowledge, more field research, and new research on disease emergence (including for well-studied diseases such as influenza). Such research could be conducted at the local level in affected countries.

MULTIDISCIPLINARY, COLLABORATIVE APPROACHES

The use of collaborative, multisectoral approaches that take into account the goals of all stakeholders was proposed as the solution to many existing and emerging disease issues, although significant barriers remain, including the lack of trust. Funding streams that make collaboration a condition for funding would foster inter-sector cooperation, while creative public-private and non-traditional partnerships would widen the understanding and control of disease emergence risks.

SUSTAINABLE APPROACHES

Maintaining sustainability was a consistent theme across many of the topics discussed, including the need to focus national and international efforts to maximize efficiency and sustainability when resources are scarce, and the broader application of existing principles and strategies. Leveraging assets, working proactively, building cross-cutting systems and engaging new partners were mentioned as contributing to efficiency and sustainability.

These meeting outcomes now need to be used to guide the development or modification of policies and strategies for reducing the risks from unexpected emerging zoonotic diseases, by considering how they relate to specific national interests and contexts. Other critical considerations identified by meeting participants included the need to move forward flexibly, using new strategies and paradigms and building and maintaining trust. Leadership at the international level is crucial in facilitating high-level national collaboration. A commitment to collaborate now provides the foundation on which to build the networks of expertise that are needed to ensure effective prevention of and response to current and future emerging zoonotic disease events. Multisectoral collaboration must expand to meet the needs and fill the gaps at the human-animal-ecosystems interface, and must do so flexibly, to meet expected and unexpected challenges wherever they exist.

Contents

Background

The interface between humans and animals is widely recognized as a complex but critical juncture where zoonotic diseases emerge and re-emerge. This interface is continuously affected by increased globalization; the growth and movement of human and livestock populations; rapid urbanization; expansion in the trade of animals and animal products; the increased sophistication of farming technologies and practices; closer and more frequent interactions between livestock and wildlife; increased changes in ecosystems; changes in vector and reservoir ecology; land-use changes, including forest encroachment; and changes in patterns of hunting and consumption of wildlife. Zoonoses can therefore be said to emerge at the human-animal-ecosystems interface.

Lessons learned from the emergence and response to diseases such as severe acute respiratory syndrome (SARS), highly pathogenic avian influenza (HPAI) and pandemic influenza (H1N1) 2009, indicate that new paradigms are needed at the human-animal-ecosystems interface, to improve early detection, prevention and control, and reduce the public and animal health risks from these and other emerging zoonotic diseases.

International multisectoral collaboration on health topics at the human-animal interface has been gaining momentum and support in recent years. The Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE) and the World Health Organization (WHO) have been working together to build effective partnerships and leverage resources for addressing zoonoses and diseases with high public health impacts. FAO, OIE and WHO continue to seek opportunities for expanding the knowledge base and fostering the necessary paradigm shifts to achieve increased efficacy when working on health risks at the animal-human-ecosystems interface.

In this aim, the three organizations have called on their respective experts to participate in technical consultations; two meetings in particular have focused on understanding emerging diseases at this interface. The first was organized by FAO, OIE, WHO and the *Istituto Zooprofilattico Sperimentale delle Venezie* in October 2008 in Verona, Italy[1]. This 2008 Verona consultation provided the first opportunity for a group of influenza experts from the animal and public health sectors to gather and discuss the purely scientific aspects of the zoonotic and pandemic threats posed by H5N1 and other zoonotic influenza viruses, focusing specifically on human and animal interactions that might affect these threats.

The second consultation, which is summarized in this report, was convened in Verona in April 2010 with the participation of expert scientists from a broader variety of disciplines (Annex A, List of participants)[2]. As well as following up on the first Verona consultation

[1] http://www.fao.org/avianflu/en/conferences/verona_2008.html;
http://onlinelibrary.wiley.com/doi/10.1111/irv.2010.4.issue-s1/issuetoc

[2] http://www.fao.org/avianflu/en/conferences/verona_2010.html

by summarizing and examining the progression of knowledge about the zoonotic and pandemic threats of animal influenza viruses, this second meeting also included a broader examination of other viral zoonoses, to identify the commonalities among them at the human-animal-ecosystems interface. These commonalities were intended to propose a scientific basis for developing policies to reduce the risks from these emerging viral zoonoses.

Setting the scene

Opening presentations by representatives of the Italian Ministry of Health, FAO, OIE and WHO provided background on the issues, context and goals, setting the scene and identifying the tasks for the diverse group of experts attending the meeting (Annex B, Agenda). Common themes emerged, such as the growing desire worldwide to enhance preparedness and response capacity for emerging zoonotic diseases. It was noted that scientists and governments have become increasingly aware of the need for better understanding of the connections among humans, animals, ecological systems and pathogens when considering the emergence of diseases. Maintaining productivity and sustainability were identified as important aspects.

Representatives from FAO, OIE and WHO reiterated the importance of focusing on the human-animal interface, as reflected in the rapidly growing collaboration among these three organizations, and recognized the need for new strategies and methods for solving many emerging issues. The commitment of the Directors-General of the three organizations is outlined in the Tripartite Concept Note in Annex E, "The FAO-OIE-WHO Collaboration: Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interfaces". This document was released at the Seventh International Ministerial Conference on Animal and Pandemic Influenza (IMCAPI) on Animal and Pandemic Influenza: The Way Forward, held in Hanoi in April 2010. It describes the existing work at the human-animal-ecosystems interface undertaken by the three organizations, and defines the additional collaboration, based on complementarity, necessary to put into operation the concepts outlined in the document.

This Tripartite Concept Note builds on the ideas developed and expanded in the FAO, OIE, WHO United Nations Children's Fund (UNICEF), World Bank, and UN System Influenza Coordination Strategic Framework for Reducing Risks of Infectious Diseases at the Animal-Human-Ecosystems Interface[3], released at the IMCAPI meeting in Sharm el Sheikh (Egypt) in 2008, and the report of the Expert Consultation on One World One Health: from ideas to action,[4] held in Winnipeg (Canada) in 2009. The evolution of the perspective from the 2008 Verona consultation, through the Joint Strategic Framework and to the Winnipeg consultation reflected a consistent broadening of the scope of technical and strategic thinking, as it expanded from influenza to include other emerging diseases at the human-animal interface. This progression also reflected a continuing search for alternative and innovative ways of working together optimally, to face these growing challenges by using new technical approaches, leveraging existing resources and expertise, and embracing fundamental paradigm shifts.

3 www.oie.int/downld/avian%20influenza/owoh/owoh_14oct08.pdf.

4 www.phac-aspc.gc.ca/publicat/2009/er-rc/pdf/er-rc-eng.pdf.

The structure and objectives of the 2010 Verona consultation were meant to mirror this progression of thinking. Participants were selectively invited for their expertise on the topics under discussion. After presentations of the baseline technical information on influenza and other important viral zoonoses, these experts were charged with making the conceptual transition from principles focused on specific diseases to the identification of commonalities and new perspectives that could be applied to emerging diseases more broadly. These commonalities and perspectives could provide the technical basis for developing or modifying policies and strategies to ensure more effective preparation for and response to emerging events.

The key challenge for the experts was to identify new and innovative approaches that could be applied to long-standing questions, as future threats will undoubtedly have different origins and outcomes from those already encountered. The group was reminded that the questions they were addressing were not new and would not have easy answers; ever since zoonotic diseases were first recognized, the scientific community has been striving to understand the complexity of the human-animal-ecosystems interface and its relationship with disease emergence, and to identify ways of using this understanding to improve the prevention and control of such diseases. The need to focus on these questions has been reinforced in the last decade, as the world faces zoonotic disease challenges of increased frequency and severity.

The consultation was structured to include an initial review of virological and epidemiological factors that are particularly relevant to the human-animal interface and that may have influenced the emergence of known high-public-health-impact zoonoses. Influenza, viral haemorrhagic fevers, infections with human and simian immunodeficiency viruses and other examples were used as the basis for discussions. To encourage broader participation, these concise scientific reviews were presented in plenary, followed by facilitated panel discussions and small group working sessions. The plenary sessions and subsequent panel discussions were moderated by members of the scientific committee, and each was based on a series of framing questions designed to identify concerns and solutions relevant to the session topic.

Examples of emerged or emerging zoonotic viral diseases

Specific viral zoonotic diseases were selected as examples for discussion, to help identify common factors related to disease emergence at the human-animal-ecosystems interface. The diseases selected included zoonotic diseases endemic in humans or animals in some geographic regions; diseases caused by pathogens that cross between animals and humans sporadically; and zoonotic diseases that initially involved animal-to-human transmission, but for which human-to-human transmission has since become the predominant mode of transmission. Special attention was given to zoonotic influenza viruses because many can be classified as emerging or potential zoonoses, and substantial information and experience is available for some, particularly HPAI H5N1. In addition, following the emergence of the influenza virus that led to the pandemic of 2009/2010, the international community has gained not only in-depth knowledge about the pandemic H1N1 (2009) virus but also a much deeper understanding of animal influenza viruses in general and of how influenza viruses emerge, spread and cause pandemics.

To help identify commonalities that might help the scientific community improve its preparation for upcoming emerging zoonotic events, all the presentations and discussions focused on what the selected examples have shown about the emergence (including animal-to-human transmission) and control of the diseases and the pathogens that cause them. For some diseases, the aspects most relevant to their emergence are related to specific characteristics of the viruses, so the pathogen became the main topic of discussion; in other instances, disease epidemiology - for example, knowledge of the animal reservoirs or human behaviour affecting transmission dynamics - are most relevant to current understanding of the human-animal interface. As a result, some findings focus on the pathogen and others on the disease. Summaries of the technical presentations are included in Annex C. Key points from the discussions are presented in the following sections.

ZOONOTIC INFLUENZA WITH THE POTENTIAL FOR HIGH PUBLIC HEALTH IMPACT

Technical reviews included presentations on what has been learned from H5N1 and from the 2009 influenza H1N1 pandemic, other influenza viruses of concern; the influenza gene pool; virological characteristics of public health concern; viral factors involved in reassortment and mutation; and non-virological factors that could affect influenza emergence. Discussions and experts' conclusions are summarized in the following subsections, according to whether they relate to understanding about emergence, transmission, or the prevention and control of emergence.

Factors relating to emergence

- The emergence of pandemic H1N1 (2009) virus in North America, likely from swine origin, is a reminder that the time and location for the emergence of new genetic variants, and their epidemiological characteristics in humans and other animals are unpredictable. This event also emphasized the need to be prepared for a range of influenza emergence scenarios, rather than only one, such as an H5N1 pandemic. Support to countries in improving their surveillance systems, so they can detect and respond rapidly to unusual or unexpected disease events, would be of benefit, even when it is not possible to predict with confidence the emergence of and risks from specific influenza viruses.
- Pandemic influenza viruses may arise at least months before their emergence in humans, providing a window for the identification and implementation of preparedness and response activities before a pandemic occurs. Sufficient understanding of the viral molecular characteristics indicating potential public and animal health risk would improve the effectiveness of such responses.
- H5N1 is an example of an abundant virus with vast human exposure that has not caused a pandemic since the first human infection in 1997, suggesting that in addition to the abundance of a virus in the environment and/or the level of human-animal contact, other factors are also critical to the development of a pandemic.

Factors relating to animal-to-human disease transmission

- Sequence data and associated genetic markers are helpful to understanding the epidemiology and evolution of influenza viruses, and may also indicate potential risks to humans. Expansion of existing knowledge, to include characterization of the viral and host genetic factors that affect the cross-species transmission and pathogenicity of influenza viruses, is critical. Better understanding of these genetic factors will support the earlier identification and improved risk assessment of potentially high-impact emerging influenza viruses, especially when circulation is still limited to animal reservoirs.
- Progress has been made in understanding some molecular determinants (e.g., those determining 2,6 versus 2,3 receptor binding specificity) of influenza viruses. This progress has revealed that the mechanisms underlying the host range and pathogenicity of influenza viruses in the field are more complex and subtle than is reflected in current thinking within existing dogmas (e.g., that 2,6 versus 2,3 receptor binding of the haemagglutinin strictly determines the virus host range). Consideration of the variety of gene constellations, affected species, geographic locations and animal production management contexts related to influenza genes and their markers and mutations will improve this understanding.
- Laboratory-based virological information has advanced our knowledge of influenza, which would be further enhanced using a broader assessment approach. More robust risk assessment could be achieved through assessments of the context in which influenza viruses are found (e.g., species, season, clinical presentation, transmission history, host/herd immunity level, management/environmental systems) and the viral behaviour in these different contexts, accompanied by such factors as cultural aspects, social trends and ecology.

Factors that limit, prevent and/or control emergence

- H5N1 played a valuable role in the creation of pandemic preparedness plans and strategies, leading to improved infrastructure and surveillance capacity. Despite the focus on H5-based scenarios, the world was relatively well prepared to respond to the recent influenza H1N1 pandemic.
- Substantial progress has been made in mitigating the impacts of influenza using knowledge about H5N1 and other animal influenza viruses. However, more work is needed to identify and prioritize key factors for the equitable prevention and control of emerging zoonotic influenza that take into account virological and non-virological factors and human-animal interactions. It will also be important to assess the effectiveness of using this approach for influenza and its potential for use with other diseases.
- Targeting surveillance to areas of increased risk, such as by using data from animal disease surveillance to guide and inform human surveillance, would increase efficiency and provide the potential for more sustainable and efficient influenza surveillance systems. As more is understood about molecular determinants and risk, identification of viruses with certain characteristics in animal populations arising from such targeted surveillance could be a trigger for increased surveillance in humans.
- Influenza vaccine has been used successfully in humans and animals, although important knowledge gaps remain regarding the appropriate settings for vaccination and the optimal vaccines to use. Overcoming these gaps and improving the ability to predict how influenza viruses behave will help to convince policy-makers and taxpayers to invest in the use of veterinary and human influenza vaccines and the development of new vaccine technologies.
- Much of the response to the recent influenza H1N1 pandemic was successful, although the perception of successes was not uniform. More effective and active ways of communicating success and circulating messages about ongoing risks would help build public confidence.
- Collaboration between the animal and public health sectors has greatly improved, especially at the international level, largely as a response to H5N1 influenza. This momentum must be maintained and expanded to the field level.
- The involvement of other branches of science (e.g., ecology and social sciences) and sectors relevant to the human-animal-ecosystems interface would enrich perspectives and increase leverage among existing resources and knowledge. A strong commitment to identifying and achieving mutually beneficial goals is critical for successful collaboration among existing and new disciplines and sectors. The most successful collaborations have occurred when multidisciplinary partners develop goals and objectives of a joint activity to address a scientific question or potential intervention together from the inception of the activity, rather than joining a project designed and initiated by a single partner.

EMERGING OR SPORADIC VIRAL ZOONOTIC DISEASES OF PUBLIC HEALTH CONCERN

Technical reviews at the meeting included presentations on zoonotic diseases of public health importance that were selected to represent a cross-section of issues relevant to the human-animal interface. These included West Nile fever, Rift Valley fever, Crimean-Congo haemorrhagic fever, and the diseases caused by Nipah, Hendra, Ebola and Marburg viruses and Hantaviruses. Discussion and conclusions from the experts are again summarized in the following subsections according to whether they contributing to our understanding of emergence, transmission, or prevention and control of emergence.

Factors relating to emergence

- The ecology of zoonotic vector-borne diseases is complex, and their epidemiology is driven by multifactor parameters that need to be considered in risk evaluation. For example, the impact of West Nile virus appears to be much lower in Central and South America than in the United States of America and Canada. This may be related to differences in host species and vector diversity, the presence of other flaviviruses, or a range of other biological and environmental factors.
- Predicting or measuring the likelihood of a disease emerging would be more effective when changes in ecology are incorporated, once such data become available.
- A clearer assessment of the roles of livestock and wildlife trade in disease emergence and/or spread would be useful for predicting the possibility of a known disease emerging in new locations via wildlife trade; estimating the risk of introduction to naive species; and assessing other trade-related risks.
- A greater understanding of the population dynamics of reservoir species would inform assessment of the risk of disease emergence and improve predictive capabilities. For example, studies of the population explosion in forest mice in northern Europe suggest that the availability of food (i.e., seeds) plays a role in the mice's abundance, and consequently in the dynamics of disease prevalence in rodent populations and the resulting spill-over to humans.

Factors relating to animal-to-human disease transmission

- Data on diseases in domestic animals are often limited, especially for diseases where clinical signs are mild or absent (e.g., Crimean-Congo haemorrhagic fever). This, combined with an often poor understanding of the role of wildlife, can contribute to an under-estimation of the complexity of disease transmission dynamics.
- It is important to continue monitoring sporadic zoonotic diseases for changes in transmission patterns suggesting that sustained transmission is occurring and disease incidence will rise. For example, there is evidence of sustained transmission of henipaviruses in Bangladesh, and although this is not yet fully understood, it warrants vigilant monitoring.

Factors that limit, prevent and/or control emergence

- Modelling techniques, satellite monitoring of land and ecosystem changes, and other technologies have been useful in predicting potential Rift Valley fever outbreaks in Africa, and may also be useful for other, similar diseases. The effectiveness of modelling tools depends largely on the quality of data and information available and on understanding the disease's epidemiology. In addition, the overall effectiveness and benefit of modelling depend on the existing capacity to implement an appropriate and timely response to predicted events.

- When based on scientifically valid methods, alerts based on predictive modelling approaches are valuable in that they allow the countries implicated to establish a preparedness rather than response mentality and ensure that appropriate response measures are in place. Predictive modelling approaches are still being refined, and the choice of actions taken in response to alerts should be carefully considered.
- The inclusion of a wide array of data types and sources improves the usefulness of modelling technology. Examples of valuable information include sampling results pre- and post-rainfall, livestock population maps, and aerial maps of rivers, creeks and other water bodies.
- Human behaviours contribute to the risk of exposure or infection, and modifying certain behaviours can be an effective control against emerging diseases. There is need and opportunity to define relevant behaviours and develop and implement public awareness campaigns and interventions that promote behaviour change relative to the human-animal interface.

ANIMAL-ORIGIN AGENTS THAT HAVE EMERGED AS HIGH-PUBLIC-HEALTH-IMPACT ZOONOSES

Technical reviews at the meeting included presentations on diseases that have already emerged and have led to at least one pandemic, including infection with human immunodeficiency virus (HIV) and simian immunodeficiency virus (SIV), and SARS. The following summaries of discussions and experts' conclusions are again arranged according to their contribution to our understanding of emergence, transmission, or the prevention/control of emergence.

Factors relating to emergence

- HIV type 1 (HIV-1) and HIV-2 can occur simultaneously in different human populations. Historically, HIV-2 was predominant in West Africa, but now HIV-1 is increasing, probably because of its shorter incubation period, higher viral loads and greater transmissibility. However, no single specific virological factor is known to be responsible for this trend.
- Current screening tests for HIV may not detect newly emerging virus types or strains. By sharing information about viruses from non-human primate hosts, existing partnerships and intersectoral collaboration could allow the laboratory detection of new viruses in humans to occur earlier than was previously possible.

Factors relating to animal-to-human disease transmission

- It is unlikely that the real-time detection of cross-species SIV/HIV transmission would have had an effect on disease emergence or animal-human transmission because the incubation period is long and asymptomatic infections occur. It is also unclear whether earlier determination that animal-human transmission of SARS was occurring could have helped reduce the impact of the outbreak.
- Worldwide, the bat population consists of more than 1 200 species. Bat population control and the destruction of bat reservoirs have been shown to be inefficient for the prevention of well-studied bat-borne diseases such as rabies. A deeper understanding of the triggers (e.g., ecological, anthropogenic and cultural) associated with disease

spread from bat populations to domestic animal or human populations would help identify more effective intervention points for the prevention of emerging diseases, while protecting the positive roles of bats, such as in crop pollination and agricultural pest control, through feeding.

- Substantial quantities of both legal and illegal bushmeat are purchased and consumed annually, despite the negligible sanitary regulation of bushmeat and farmed wildlife in most countries. There is a need for better understanding of the economic cycles, supply and demand for bushmeat and farmed wildlife, and for recognition that improved safety of these food sources could be crucial in preventing or minimizing disease emergence.

Factors that limit, prevent and/or control emergence

- Work with SIV/HIV has provided a good model for interdisciplinary work (involving the human and animal health, forest and natural resource sectors) to build local capacity, particularly in laboratories, and to engage and build the awareness of stakeholders at multiple levels.
- Where bushmeat and wildlife food markets (including live animal markets) exist, hygiene, biosecurity and food safety practices that are similar to those applied at domestic animal markets should be implemented.
- During the SARS response, the highest priority activity was halting transmission. However, gaps in preparedness resulted in delays in addressing broader social, developmental and ecological concerns. A key lesson learned from this experience is that preparedness should include plans for addressing the full range of issues, to allow the earlier implementation of diverse interventions.