World Health Organization

Food and Agriculture Organization of the United Nations

World Organisation for Animal Health

Report of the WHO/FAO/OIE joint consultation on emerging zoonotic diseases

in collaboration with the
Health Council of the Netherlands

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1. Introduction

A joint consultation on emerging zoonotic diseases was held in Geneva, Switzerland, from 3 to 5 May 2004 by the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE), in collaboration with the Health Council of the Netherlands. The consultation was opened by Dr Asamoa-Baah, Communicable Diseases, WHO; Dr Knottnerus of the Health Council of the Netherlands; Dr Martin of FAO; and Dr Sibartie of OIE. Dr Joshi and Dr Ruitenberg were selected as co-Chairpersons and Dr Willingham III was appointed Rapporteur.

This report provides a summary of the outcome of the consultation and provides direction for the development of programmes to address better the threat posed by emerging zoonotic diseases at the international, regional and national levels.

2. Background

Recent outbreaks of severe acute respiratory syndrome (SARS) and avian influenza have shown once again the potential of microorganisms from animal reservoirs to adapt to human hosts. During the past decades, many previously unknown human infectious diseases have emerged from animal reservoirs, from agents such as human immunodeficiency virus (HIV), Ebola virus, West Nile virus, Nipah virus and Hanta virus. In fact, more than three quarters of the human diseases that are new, emerging or re-emerging at the beginning of the 21st century are caused by pathogens originating from animals or from products of animal origin. A wide variety of animal species, domesticated, peridomesticated and wild, can act as reservoirs for these pathogens, which may be viruses, bacteria, parasites or prions. Considering the wide variety of animal species involved and the often complex natural history of the pathogens concerned, effective surveillance, prevention and control of zoonotic diseases pose a real challenge to public health.

Although history shows that the cascade of events leading to the emergence of a new disease is different each time, several factors are known to favour such emergence. These include microbiological adaptation; environmental changes; globalization of agriculture, food production and trade; and human behavioural factors. The decline of public health systems and the increasing number of people who are potentially more susceptible to opportunistic infection by agents of animal origin are important as well. A database analysis of 1415 human pathogens showed that protozoa and viruses are particularly likely to emerge, whereas helminths are unlikely to do so. It is difficult to predict from which geographical areas or which animal reservoirs the greatest risks to human health originate, the main risk factors involved, and exactly how these risks develop. Nevertheless, a careful review of past events could help to identify key trends and provide guidance for the future.

Effective surveillance, prevention and control of newly evolving threats from animal reservoirs require that strong links between the different sectors involved be in place. International organizations and their partners need to strengthen the capacity of countries and the international community to share information across disciplines and sectors. This will eventually contribute to minimizing the impact of such threats on public health. The aim is to detect and contain the spread of zoonotic diseases where and when they occur. In this context, national and regional networks have an important role to play. Steps must be taken to improve the surveillance and control of human communicable diseases, including zoonoses, at the regional level.

3. Objectives of the consultation

The purpose of the consultation was to give direction and issue recommendations to the international community to improve preparedness, develop and strengthen surveillance systems, and identify means of assessing the risks of zoonotic disease emergence, in order to better prevent or contain them.

In plenary sessions, invited speakers reviewed the recent and current situation of emerging zoonotic diseases; the public health consequences; the economical, sociological and political implications; and the key risk factors for emergence. Current reporting and early warning systems were reviewed along with new technologies and methods for predicting zoonotic disease events. Finally, methods of controlling and responding to zoonoses and the need for intersectoral collaboration were presented. Through small group discussions, the main themes of the plenary session were explored in depth to develop recommendations for future actions to improve the detection, prevention and control of and response to emerging zoonoses. Then, working in regional groups, participants discussed and identified the key issues and recommended actions needed to control and prevent zoonoses regionally.

4. Conclusions

The participants agreed on the following definition of an emerging zoonosis:

> *An emerging zoonosis is a zoonosis that is newly recognized or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range.*

It was noted that some agents causing such diseases may evolve further and become effectively and essentially exclusively transmissible from human to human (e.g. HIV).

The main conclusions of the consultation were as follows:

1. Emerging zoonotic diseases are increasingly recognized as a global and regional issue with potentially serious human health and economic impacts and their current upward trends are likely to continue.

2. Coordinated international responses are therefore essential across veterinary and human health sectors, regions and countries to control and prevent emerging zoonoses.

3. Predicting which zoonotic diseases may arise in the future is extremely difficult, due to the multifactorial and constantly evolving nature of the risk factors involved. Anthropogenic factors such as agricultural expansion and intensification to meet the increasing demand for animal protein, global travel, trade in domestic or exotic animals, urbanization, and habitat destruction comprise some of the major drivers of zoonotic disease emergence.

4. Given the unpredictable behaviour of emerging zoonotic diseases, case tracking and outbreak investigations should be done, taking into consideration a broad range of potential modes of transmission from animals, including indirect modes such as foodborne and waterborne transmission, even if these are not considered to be main modes of transmission at the outset.

5. While zoonotic disease outbreaks are often characteristically dynamic and unpredictable events, vector-transmitted infections may be the exception, as they are strongly influenced by environmental factors. These vector-borne diseases and their associated risk factors can often be monitored and some forecasting methods applied. Further research is needed to validate these methods.

6. Shortfalls in public health infrastructure and policy, and in scientific studies to answer public health questions and to build expertise were identified as contributing risk factors for emergence, along with a lack of integration between human and animal health surveillance.

7. New mechanisms of surveillance and response are required: using new approaches (e.g. syndromic surveillance), using new tools (e.g. geographic information systems, remote sensing data and molecular epidemiology) and bringing together different sectors and disciplines (e.g. medical, veterinary, population biology, information technology, economics, social science and diagnostics).

8. Studies to understand fully the underlying causes for disease emergence, and the ecology of the agents and their hosts will assist in the effective prevention or rapid containment of future emergence events.

9. Given the transboundary nature of zoonotic diseases, emphasis must be placed on building the appropriate preparedness and response capacity in countries and linking the capacity to regional and international networks.

10. FAO, OIE and WHO were identified as important partners to lead improvements in intersectoral collaboration and to strengthen country capacity to detect and respond to zoonotic diseases. A new FAO/OIE/WHO initiative called GLEWS (global early warning system for transboundary animal diseases) was identified as a possible platform for enhancing global surveillance and response to zoonotic diseases.

11. While the regions are faced with different priority diseases, each identified a systematic lack of integration between public and animal health with respect to disease surveillance, response and control.

12. Although forecasting which zoonotic disease may emerge in the future may be difficult, most regions were able to identify likely candidates from known zoonoses.

13. Data on animal health exist but are often fragmented or inaccessible to public health authorities, and are not used in public health surveillance or early warning systems.

14. In most countries, there is inadequate support for building public health and veterinary core capacities in the zoonoses field, including a lack of basic training and education, database templates and standards, risk management and assessment, and communication skills.

5. Recommendations

5.1 Global recommendations

1. International organizations (e.g. WHO, FAO and OIE) should elicit political awareness of and support for the implementation of a public and animal health infrastructure to address zoonotic disease issues.

2. International organizations (e.g. WHO, FAO and OIE) should further develop a joint communication and information platform, including a common surveillance and reporting system for emerging zoonotic diseases, as well as joint strategies and resource mobilization for scenario development, planning and research.

3. Integrating the early warning and alert systems of international organizations (e.g. WHO, FAO and OIE) should be undertaken to facilitate early detection of potentially linked animal and public health events

4. International conservation organizations (e.g. the World Conservation Union and World Wildlife Fund) should be included in research, monitoring and reporting of wildlife health issues.

5. WHO should develop an international network to support countries in analysing their particular emerging zoonotic disease situation.

6. International organizations (e.g. WHO, FAO and OIE) should develop technical guidelines on issues such as regulation of international import and export of live exotic animals and regulation of live-animal markets, and the definition of core competencies required to assess the risk for emerging zoonoses.

7. Networks that include public health, research, medical and veterinary laboratories working with zoonotic pathogens should be established or strengthened.

8. When a new zoonotic agent emerges, two multidisciplinary teams should be dispatched, wherever necessary: one to investigate and contain the human health threat, and the second to investigate the ecology of the agent. Longer-term research should be undertaken to identify all factors contributing to the emergence of the new agent and the scope of the agent's host range, so that appropriate control and prevention strategies can be developed.

9. Anthropologists and social scientists should be included in the multidisciplinary teams to assist in studies on the ways local people manage wild and domestic animals, their perception of animal and human diseases, and related risk factors.

10. International organizations (e.g. WHO, FAO and OIE) and their partners should establish emergency funds for rapid response efforts and for conducting essential scientific studies to answer public health questions when a new disease emerges.

11. Resource-rich countries should contribute to strengthening the capacity of resource-limited countries to control and prevent zoonotic diseases.

5.2 Regional/national recommendations

1. Regional and national intersectoral committees for zoonosis preparedness and control, including non-traditional partners (e.g. nongovernmental organizations, wildlife organizations and zoos), should be established or strengthened. Such committees should aid in integrating animal and human health data at regional and national levels, and addressing regional issues after an outbreak has occurred.

2. Programmes for sustained personnel interchange between ministries of agriculture and ministries of health should be developed, to facilitate long-term communication, collaboration and programme development across the sectors.

3. Countries should educate farmers, animal health workers, people working with wildlife, zoo personnel, and local human and animal clinicians about the importance of reporting events of potential zoonotic importance. All suspected zoonoses should be reported from medical or veterinary sources within 24 hours of detection to all relevant agencies.

4. Incentives should be offered to improve timeliness of reporting. Adequate compensation should be provided to farmers whose animals are destroyed as part of the containment of a zoonotic disease epidemic.

5. When promoting mixed animal farming or large-scale, single-species animal production systems, or promoting a change in policy (e.g. introduction of a vaccination programme), an assessment of their possible negative impact on the environment, endemic wildlife species, and ultimately public health should be conducted. This assessment should include the potential to manage the risk of new zoonotic agents.

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Annex 2 – Agenda

Monday 3 May 2004

9:00–9:20	Opening and introduction Election of co-chairpersons Appointment of rapporteur Adoption of the agenda	Dr Anarfi Asamoa-Baah Dr Dewan Sibartie Dr Vincent Martin Dr André Knottnerus
	Session I : Keynote speeches	
9:20–10:00	Recent examples of emerging zoonotic diseases: SARS and avian influenza	Dr Marion Koopmans
10:00–10:30	A review of emerging zoonoses and their public health implications (including consensual definition of emerging zoonosis)	Dr François-Xavier Meslin and Dr Pierre Formenty
10:30–11:00	*Break*	
	Session II: Risk factors for the emergence of zoonotic diseases	
11:00–11:20	Microbiological risk factors	Dr Albert Osterhaus
11:20–11:40	Environmental, climatic risk factors	Dr Jan Slingenbergh
11:40–12:00	Social, behavioural and cultural risk factors	Dr Alain Froment
12:00–12:20	Economic risk factors and impacts	Dr Richard Bennett
12:20–13:30	*Lunch*	
	Session III: Detection, surveillance, response and control	
13:30–13:50	Review of the OIE early warning and reporting systems	Dr Karim Ben Jebara
13:50–14:10	Existing early warning systems and their application to emerging zoonoses	Dr Vincent Martin
14:10–14:30	Monitoring systems	Dr Asasaf Anyamba
14:30–14:50	Predictive mathematical modelling Complexities of seeking agents in wildlife reservoirs Control strategies: implementation of generic safety measures	Dr Roy Anderson Dr Jonathan Epstein Dr Harvey Artsob
15:30–16:00	*Break*	

16:00–16:20	Partnership between animal and public health for the control of emerging zoonoses	Dr Frans Van Knapen
16:20–16:40	Improving preparedness and response to emerging zoonoses	Dr Cathy Roth
16:40–17:00	Summary and introduction to working group sessions	Dr Durga Datt Joshi
17:00–19:00	*Reception*	

Tuesday 4 May 2004

09:00–10:30	**Working group sessions** Risk factors for zoonotic disease emergence Alert and early warning systems and surveillance Domestic and wildlife reservoir studies, early warning and control strategies Improving international responses to emerging zoonoses	
10:30–11:00	*Break*	
11:00–12:30	Working group sessions *(continued)*	
12:30–14:00	*Lunch*	
14:00–15:30	Reports from working groups	
15:30–16:00	*Break*	
16:00–18:00	Discussions of regional working groups on future concerns: WHO European Region WHO Western Pacific / WHO South-East Asia Regions WHO Eastern Mediterranean / WHO African Regions WHO Region of the Americas	

Wednesday 5 May 2004

09:00–10:30	Regional working group sessions *(continued)*	
10:30–11:00	*Break*	
11:00–12:30	Reports from working groups	
12:30–14:00	*Lunch*	
14:00–15:30	Final discussion and recommendations Close of meeting	Dr François-Xavier Meslin Dr Durga Datt Joshi

Annex 3 – Abstracts of keynote speeches

A3.1 Recent examples of emerging zoonotic diseases: SARS and avian influenza

Dr Marion Koopmans

The recent outbreaks of SARS and avian influenza have served as a wake-up call for the world. They serve as examples of the potential seriousness of emerging zoonotic diseases and how even countries with highly developed public health infrastructures struggle with controlling such diseases. Since the outbreaks of group A subtype H5N1 (A/H5N1) avian influenza viruses (AI) in China, Hong Kong Special Administrative Region in 1997, which claimed the lives of 6 persons, we learned that not only pigs but humans themselves might serve as mixing vessels for the next pandemic influenza virus. The recent outbreaks of AI A/H7N7 in the Netherlands and the unprecedented expansion of AI A/H5N1 in Asia, reinforced that message: in the Netherlands, 89 persons working with infected poultry were infected, in Asia infection was confirmed in 34 persons but possibly more. The AI A/H7N7 virus in one fatal case had accumulated numerous amino-acid changes, some of which in positions that are important for viral traits, such as host specificity and virulence. A review of the outbreak and the control efforts in the Netherlands highlights important lessons for preparedness: while separate systems are in place to signal and control animal diseases and human diseases, an outbreak of a zoonotic disease illustrates the importance of coordination between the two. In the Netherlands, the 89 infected persons were recruited from a wide geographic region, including foreign poultry workers. While movement of animals was restricted, these persons, shedding virus, were not under control of the public health authorities while infectious. Serological studies suggest that virus was transmitted to a significant proportion of household contacts. Preventive measures, such as the use of goggles, masks, and antivirals, were recommended in the early stages of the outbreak, but compliance was minimal. Conflicting messages in the public domain about the potential risks to human health may have contributed to this.

While the disease in humans is more severe for A/H5N1, both AI outbreaks illustrate that crossing the species barrier is less restricting than previously recognized, that AI virus adaptation occurs rapidly, and that IF such species jumps occur human behaviour in the broad sense contributes to dissemination. Given the geographic range of the A/H5N1 outbreak, this calls for extreme vigilance, especially when with control of outbreaks in commercial poultry holdings the epidemic disappears from the headlines.

Similar points can be made by reviewing the example of the SARS outbreak, with an important addition: while emerging diseases have been high on the agenda in public health institutes, no one would have predicted that the next emerging health threat would be a coronavirus. This illustrates the difficulty of predicting what is next, and therefore the need for preparedness by having adequate surveillance and response mechanisms. By definition, studying an emerging (zoonotic) disease should be done with an open mind to alternative explanations: SARS quickly was considered a respiratory disease, and the potential role of fecal transmission was not considered seriously in the international coordinated effort to control SARS. Nevertheless, data from the many studies that were done build the case for such transmission, given the right circumstances. Thus, the emerging zoonotic diseases control and research agenda should be shaped in coordination not only between animal and human disease control systems, but also organizations involved in food- and water safety.

A3.2 A review of emerging zoonoses and the public health implications

Dr François-Xavier Meslin, Dr Pierre Formenty

Many of the human diseases that are new, emerging and re-emerging at the beginning of the 21st century are caused by pathogens originating from animals or from products of animal origin referred to as zoonotic diseases. Emerging zoonoses are zoonoses that have newly appeared or have occurred previously but are increasing in incidence or geographical range. A number of examples from various parts of the world (cutaneous zoonotic leishmaniasis in Manaus, Brazil; Ebola, monkeypox, Rift Valley fever in Africa and the Arabic Peninsula; Crimea Congo haemorrhagic fever in the Middle East; BSE in Europe and the rest of the world; West Nile fever in the United States of America and Canada; paramyxoviruses in Australasia) demonstrate that a wide variety of animal species, both domesticated and wild, act as reservoirs for these pathogens, which may be viruses, bacteria or parasites. These infections have clearly shown that new zoonoses are emerging in both the developed and the developing world.

There are many factors that can lead to the emergence of zoonotic diseases. For example, microbiological factors associated with the agent, the animal hosts/reservoirs and the human victims can result in a new variant of a pathogen that can jump the species barrier. Environmental changes resulting from environmental degradation, human and animal demography, changes in farming densities and practices, including climatic variations and change, can also play a major role. Social, behavioural and cultural risk factors such as food habits, religious beliefs, risk perception and management patterns can also encourage the emergence of zoonoses, as can economic factors such as economic growth or economic hardship. Several of these examples underline the importance of the anthropogenic risk factors for zoonoses emergence.

So far, emerging zoonoses have taken us by surprise and the complexity of the interactions between agents, animals hosts species and the environment represent a challenge for effective forecasting, surveillance, prevention and control of zoonotic diseases. Their capacity to occur very unexpectedly in new places and new animal species underscores the need for stronger international cooperation in ensuring better local, regional and global networks for communicable disease surveillance, which must be integrated across the human and animal health sectors.

A3.3 Risk factors for the emergence of zoonotic diseases

A3.3.1 Microbiological risk factors

Dr Albert Osterhaus

In the past century, pandemic outbreaks of influenza and AIDS have cost the lives of tens of millions of people. These events were all caused by multiple introductions of animal viruses, influenza A viruses and SIV of birds and non-human primates respectively – into the human population. Besides these introductions causing major pandemics in humans, a large number of other virus infections have spilled over from animal reservoirs to humans or other susceptible species, resulting in considerable morbidity and mortality as "virgin soil" epidemics. The most recent examples in humans are the introduction of SARS coronavirus and influenza A viruses (H5N1 and H7N7) from the animal world, which caused global concern about their potential to be at the origin of new pandemics. Over the last decades there seems to be a dramatic increase in the emergence or re-emergence of virus threats in humans and animals worldwide. A long list of exotic names like Ebola, Lassa, Rift-Valley, Crimea-Congo, Hendra, Nipah and West-Nile is the illustration of names of just some of the places associated with the origin of viruses that crossed the species boundary to humans, with dramatic consequences in the last ten years alone. Similarly, recent mass mortalities among wild aquatic and terrestrial mammals caused by previously known and newly discovered morbiliviruses, as well as outbreaks of hog cholera, foot-and-mouth disease and fowl plague among domestic animals, highlight this trend.

Although improved detection and surveillance techniques, as well as increased media attention may have contributed to our perception of an increase in the incidence of outbreaks of virus infections, it is becoming more and more clear that major changes in our modern society increasingly create new opportunities for virus infections to emerge: a complex mix of changes in social environments, medical and agricultural technologies and ecosystems continues to create new niches for viruses to cross species boundaries and to rapidly adapt to new species.

In combating this global threat, we should make optimal use of the new tools provided by the unprecedented advances made in the research areas of molecular biology, epidemiology, genomics and bioinformatics. Serious investment in these areas in the future will not only be highly cost-effective but will also save many lives of humans and animals.

A3.3.2 Environmental, climatic risk factors

Dr Jan Slingenbergh

Disease ecology, defined here as the interplay between pathogens, hosts and environment, including also anthropogenic factors, may hold important clues to the understanding of disease emergence.(*1*) Disease emergence may be viewed as an evolutionary response to novel environments.(*2*) Understanding this process requires that we identify the links between environmental change, new forms of disease and microbial adaptation.

A strong link between pathogen biology and epidemiological pattern is found for most OIE List A + B diseases.(*3*) Whilst currently under review, this List has remained curiously static throughout most of the 20th century despite dynamic farming systems, erosion of the genetic diversity of farm animals, and major animal disease control campaigns. Microbial responses to environmental change in animal agriculture and related food chains does result in the generation of new pathogen species but mainly so when placed in a larger timeframe, spanning across centuries or millennia(*4*) In the short to medium term we mainly distinguish within species adjustments.

Animal disease emergence mostly concerns increase in disease incidence, invasion into new areas or changes in the host range, rather than a novel disease agent appearing for the first time. It follows that the analysis of disease emergence may benefit from methods used to study the ecology of invasion. Successful vertebrate invaders are known to rapidly disperse, showing high reproduction rates. Colonisers are flexible, competitive, and fit a broad range of conditions. This compares to the list of pathogens associated with the emergence of zoonotic diseases, counting a relatively high number of small RNA viruses with high mutation rates.(*5*)

Disease emergence may also be related to r-and-K selected strategies. This helps to explain the pathogen development-reproduction trade-off. In order to maximise fitness in a predictable environment, it pays to invest resources in long-term development and long life (K selection); in a risky environment, it is better to produce as much offspring as quickly as possible (r selection).(*6*) Translated to emerging livestock diseases this could mean that the dynamics in the livestock sector and food chains may favour selection of r-strategists. Paradoxically, it takes significantly large, susceptible host populations before r-strategists may evolve. For childhood microparasitic infections, the positive association between the basic reproductive rate, Ro, and community size has been known for many years.(*7*)

Similar to the study of invasive plant and animal species(*8*) we may discern sequential stages necessary for successful pathogen introduction and subsequent invasion and disease spread:

- introduction (also by non-biological factors),
- initial colonisation,
- successful establishment,
- spread.

We may apply these steps to better comprehend how disease agents in farm animals may turn either more aggressive or milder depending on the changing conditions in the animal production environment.

Ecology may also explain disease seasonality and annual cycles of retraction and expansion, as driven by climatic and geographical factors.(*9*) In this regard, the phylogeography of pathogens, any prevailing vectors and host animals, coupled with information on the local livestock production structure and landscape mosaic may constitute the basic elements explaining epidemiological patterns in a given area of interest.(*10,11*) This notion deserves to become incorporated in Early Warning Systems.

Climate change forms a special topic given that it may affect the areas where primary agricultural production takes place, including animal husbandry.(*12*) Climate change alters vector distribution and abundance, migration patterns of birds and other wildlife, and the survival time of pathogens outside the host.(*13*) In fact, climate change – perhaps more than any other factor – is likely to contribute to the emergence of novel forms of disease and pathogens.

A further area of interest is the accelerated livestock production in areas where protein demand increases on an exponential scale. This trend is particularly pronounced in East and Southern Asia(*14*) and coincides with the development of megacities around which large-scale, industrial-type poultry and pig production units develop to secure local supplies of meat and eggs(*15*). The contraction and concentration of production in mainly peri-urban environments forms a major risk factor in disease emergence particularly when viewed in conjunction with the centrifugal demographic force causing more widespread and denser rural populations in some Asian countries. Demography, land pressure, economic development and agricultural intensification are all intertwined(*16*) and may result in imbalances in livestock production structure, both in terms of the distribution of holding sizes as well as in geospatial terms. This translates into a most heterogeneous risk landscape and it may be argued that this development has contributed to the emergence of the 2003/2004 H5N1 HPAI epidemic in Asia.(*17*)

"Global change" is increasingly used as collective noun for a wide array of issues believed to contribute to disease emergence in humans. The problem here is that the analysis of risk factors at this aggregate level is not always sensible. Still, it remains that the combination of factors such as globalization, increase in trade and traffic, geography, economic and biotechnological developments, urbanization, land use, climate change, and the "livestock revolution" form causal links with the reported increases in the spread of transboundary animal diseases, food safety hazards and other veterinary public health risks.(*18*)

When UN Agencies advocate that the issue of emerging zoonotic diseases is a matter of growing importance, one particular area of concern may be highlighted: the structure of the livestock industry in the Old World. While the Green Revolution enabled crop productivity increases commensurate with the rapid demand for cereals as staple food, livestock sector developments appear less balanced, at least in geographical terms. Bulk volumes of feed are increasingly moved to areas of high demand.(*19*) With the disconnection of the "land-feed-animal production-processing-distribution" circuitry, it turns out that the highest density of intensive animal farms is now in the proximity of urban centres.

Global pork production becomes retracted to a few hotspots. The EU-25 and East Asia increasingly form global epicentres for monogastric production. The ruminant street stretching from South Asia towards the Middle East, Horn of Africa and eastern Mediterranean will count an ever-increasing number of sheep, goats, cattle and buffaloes.(*20*) In epidemiological terms this transect presents a gradient in disease occurrence from full endemicity for most OIE List A + B diseases in India and Pakistan and also the Horn of Africa, to disease freedom in southern European Mediterranean.(*21,22*)

Disease ecology shows us that disease spread and the emergence of zoonotics are largely the product of human activity and, therefore, of human choices.

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A3.3.3 Social, behavioural and cultural risk factors

Dr Alain Froment

In the field of epidemiology, anthropology is everywhere and nowhere. Everywhere, because most diseases need some behavioural factors in order to be transmitted.

Even ecological changes in very remote areas, like the greenhouse effect, can be related to an anthropogenic origin. Nowhere, because anthropologists are rarely included in teams involved in emerging diseases studies, and because epidemiologists sometimes believe that they are able to practice anthropology by themselves. However, anthropology requires specialist training and specific tools that cannot be overlooked. Fortunately, the involvement of anthropologists is increasing, as illustrated by the recent Ebola outbreaks in Central Africa, where professional medical anthropologists such as Alain Epelboin (*1*) Barry Hewlett (*2*) and Norbert Gami (*3*) could be present with virologists during the epidemics. The perspective they brought was useful at every level of the disease, from corpse management to prevention. Though the concept of emergent disease is recent, it has long been known (*4*) from historical sources that in the past transmissible diseases have been able to surge suddenly, and to disappear just as suddenly.

Sudor anglicus, a brutal series of epidemics in Tudor England, is a classic example of a previously unknown disease that vanished without clear identification (*5*). The real new diseases, as well as re-emerging ones, are many, and no stereotypical anthropological approach can be used, as each agent has its specific mode of transmission.

This mode is often referred to as the natural history of the germ, but it also encompasses much cultural component. In the emergence process of viral infections, several stages occur:

1. accidental event (ancient or recent), like a mutation or a recombination in pre-existing zoonotic viruses,
2. breakage of the species barrier, and a first human infection,
3. phase of amplification (epidemisation) among humans (directly or through a vector),
4. identification of the disease, either by occidental or traditional knowledge,
5. representation of the disease, of its nature, origins and consequences,
6. strategy of elimination or prevention.

At each stage, behaviour and social factors are more and more involved, and therefore the role of anthropology has increasing weight. Some examples were given.

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A3.3.4 Economic risk factors and impacts

Dr Richard Bennett

The economic impacts of zoonoses (and their control) include (i) reduction in the level of outputs from animal production (lower productivity), (ii) reduction in (perceived or actual) output quality (e.g. food safety), (iii) waste of inputs to animal production (e.g. feed), (iv) resource costs of disease prevention and control, (v) negative animal welfare effects, (vi) international trade restrictions, (vii) human health costs (human life and quality of life, treatment costs, loss in productive output etc.) and (viii) a range of other possible impacts such as effects on the environment, tourism and rural livelihoods. Some examples of these impacts are given in relation to zoonotic diseases, in particular Bovine Spongiform Encephalopathy (BSE). The concept of optimal disease control is presented using the 'loss-expenditure frontier', where the total costs associated with a disease are minimized. The economic risks associated with emerging zoonoses relate to the potential magnitude of the economic impacts together with the probabilities that these impacts will occur.

The problem with the decision-making process concerning emerging zoonoses is that (to greater or lesser extents) it is usually characterised by (i) lack of information on the disease in terms of rates of infection and the links between animal and human cases of the disease (BSE is a prime example of this), (ii) high levels of risk in that these diseases may potentially result in very high economic impacts (e.g. resulting from pandemics of high animal and/or human mortality), (iii) given (i), a high level of uncertainty in that the probabilities of different disease/economic outcomes are unsure (including the effect of disease control measures).

There are a number of economic factors that are likely to have increased the risks faced from emerging zoonoses. These include the increasing demand for animal products (especially in lower/middle income countries experiencing relatively high income growth), the increasing competitiveness of global markets and the drive for low cost production, the intensification of animal production with larger flock/herd sizes, increased trade liberalization and the increased movement of animals and people globally.

Assessment of the economic impacts of emerging zoonoses prior to choice of disease control strategy would be useful information for the response decision-making process. Historically, many economic analyses of disease control decisions have been undertaken after the event. Prior assessment requires the modeling of disease spread, information on the effects of the disease on livestock production and human health, and information on the strategy options for controlling or preventing the spread and/or impacts of the disease. Such information is necessary to be able to undertake cost-benefit analysis of policy options. Cost-benefit analysis involves identification of the main economic impacts and their magnitudes, appropriate valuation of these impacts and estimation of the costs of control strategies. The problems of modeling 'new' zoonoses, with the inherent uncertainties, together with the need for rapid response, require an appropriate procedure for economic analyses set up for rapid assessment of the disease problem. Such a procedure will need to use both disease and economic modeling, and be able to take account of the risk and uncertainty aspects of the decision problem, perhaps by the use of simulation/'what if' modeling and expert panel assessments of risk. The estimation of the costs of control options in terms of the benefits of disease control that would need to be achieved (benefit 'breakeven' points) has proved useful for decision makers in situations where estimation of the expected benefits of disease control measures is difficult due to uncertainty. The role that economic analysis might play in decision making concerning the response to emerging zoonoses might usefully be further considered by the relevant national and international agencies.

A3.4 Detection, surveillance, response and control

A3.4.1 The OIE early warning and reporting systems

Dr Karim Ben Jebara

The OIE's Early Warning and Monitoring System started in the early eighties. Its main objective is to improve transparency of the world animal health situation, including zoonoses. OIE Member Countries have agreed to fulfil their international commitments for disease notification as laid down is Chapter 1.1.3 of the Terrestrial Animal Health Code. This Code states that member countries shall make available to other countries, through the OIE, whatever information is necessary to minimize the spread of important animal diseases and to assist in achieving better worldwide control of these diseases.

In an effort to improve transparency, OIE also conducts a systematic, active search and verification of non-official information in an effort to improve the efficiency of the OIE Early Warning System. Active search for information is conducted using various search engines and list-serves including ProMED; newspapers; literature; OIE Collaborating Center, Colorado, United States of America; and most recently the Global Public Health Intelligence Network GPHIN which is an intelligence gathering software from Health Canada. All information gathered is then carefully evaluated and verification sought from Member Countries. In 2003, verification was sought for 29 correspondences which resulted in 26 responses and 14 alert messages have been disseminated.

Dissemination of alert messages and follow-up reports to delegates of all Member Countries occurs via e-mail or facsimile, through the OIE's web site and through an open distribution list. Registration can be done through the OIE-Info website http://www.oie.int/eng/info/en_listserv.htm. During the recent avian influenza crisis in poultry in Asia, a special section for easy access to the latest emergency and follow-up reports was created on the website. In the time of the crisis, more than 40 000 visits per week were logged. This number is equivalent to the number of visits by month in 2003.

The legal basis of the OIE's Early Warning System is outlined in chapter 1.1.3 on *Notification and epidemiological information* found in *the OIE Terrestrial Animal Health Code*.

According to this chapter Urgent Notification, meaning notification by telegram, fax or e-mail, must occur within 24 hours, for the following events:

a) diseases listed by the OIE, the suspected or confirmed first occurrence or re–occurrence of a disease, if the country or zone of the country was previously considered to be free from that particular disease;
b) diseases listed by the OIE, evidence of changes in the epidemiology of a disease (including host range, pathogenicity, strain) if this represents important new information of epidemiological significance to other countries, in particular if a disease may have a zoonotic impact;
c) diseases not listed by the OIE, if there is information of exceptional epidemiological significance to other countries, for example if a disease may be a zoonosis.

Follow-up reports are expected weekly by telegram, fax or e-mail subsequent to a *notification* as described above, to provide further information on the evolution of an incident which justified urgent *notification.* These reports should continue until the disease has been eradicated, or the situation has become sufficiently stable that monthly reporting under will satisfy the obligation of the country to the OIE.

New criteria for Urgent Notification are to be presented for approval by the International Committee in May, 2004. Under these new criteria the events of epidemiological significance that should be notified immediately are as follows:

- the first occurrence of a listed disease or infection in a country or compartment;
- the re-occurrence of a listed disease or infection in a country or compartment following a report by the Delegate of the Member Country declaring the outbreak closed;
- the first occurrence of a new strain of a pathogen of a listed disease in a country or compartment;
- a sudden and unexpected increase in morbidity or mortality caused by an existing listed disease;
- emerging disease with significant morbidity/mortality or zoonotic potential;
- evidence of a change in the epidemiology of a listed disease (including host range, pathogenicity, strain of causative pathogen), in particular if there is a zoonotic impact.

In conclusion, the OIE Early Warning System has been working well and producing good results for more than two decades. In 2003, 61 alert messages from 46 Pays Members were disseminated. In addition, there was the Weekly Information Publication (emergency and follow-up reports received from Member Countries) which produced 240 papers from 78 countries, 296 pages in the three official languages.

The foreseen amendments to the chapter on notification and epidemiological information would improve its efficiency and coverage for identifying changes in serious animal health and zoonotic disease situations worldwide.

A3.4.2 Existing early warning systems and their application to emerging zoonoses

Dr Vincent Martin

Early and accurate detection of new outbreaks of epidemic livestock diseases including emerging zoonoses, and the capacity for prediction of spread of such diseases to new areas, is an essential pre-requisite to their effective containment and control. As experienced recently throughout much of the globe, weaknesses of disease surveillance systems and the inability to control major diseases at their source, along with the globalisation of trade, has been held responsible for the spread of diseases such as foot-and-mouth (FMD) and classical swine fever (CSF). Other diseases continuously threaten the livestock sector on a worldwide basis, some with public health implications. Recently, the emergence of a highly pathogenic strain of Avian Influenza has demonstrated the vulnerability of countries facing recurring disease threats that affect human and animal health.

In an effort to adapt to a changing world, several initiatives have been developed recently to anticipate or mitigate the negative impact of animal diseases or natural disasters on the livestock health and production as well as on human population that depend on animal production for sustenance and commercial enterprise. The Famine Early Warning system (FEWS), the Livestock Early Warning System (LEWS) and Regional early warning activities for the surveillance of Rift Valley fever in West Africa are some examples.

At international level, Early Warning systems usually set in motion a cascade of other EWSs related to anticipated second-order effects as the hazard's impacts ripple through society. However, these systems do not always perform as they should to prevent repeated shocks from major disease events, and illustrate the need to improve the coordination among a wide variety of early warnings.

For this reason, FAO, OIE and WHO have decided to join their efforts and developed a Global Early Warning System for transboundary animal diseases aiming at providing national animal health authorities with epidemiological information enhanced by an in-depth analysis on the occurrence and spread of major diseases.

This System is defined as a tool to be co-developed by FAO/OIE/WHO for the international community and stakeholders alike to assist in predicting and preventing livestock animal disease threats, including emerging zoonoses through epidemiological analysis and the integration of additional factors that might have an impact on the occurrence and spread of such diseases (e.g. socioeconomic factors, human migration, animal movement, civil unrest, climatic changes, etc.).

A3.4.3 Monitoring systems

Dr Assaf Anyamba

Emerging and re-merging zoonotic diseases pose a profound challenge to global public health. The episodic and sometimes erratic nature of outbreaks of zoonotic diseases requires a systematic method observation and monitoring of conditions associated with such outbreaks. Satellite remote sensing of land surface conditions and atmospheric dynamics can provide important information relevant in understating the coupling between climate variability, ecological dynamics and zoonotic disease outbreak patterns. Satellite remote sensing products from a variety of platforms can provide information on cloudiness, rainfall, temperature and vegetation conditions that are relevant to the emergence, propagation and abundance of vectors that transmit various zoonotic diseases. At coarse spatial resolution data provided by the Advanced Very High Resolution Radiometer (AVHRR) instrument on board the National Oceanographic and Atmospheric Administration Polar Orbiting Environmental Satellite (NOAA-POES) series has provided high temporal frequency data important in studying the historical patterns of Rift Valley fever (RVF) outbreaks over Africa since 1981.

RVF outbreaks are closely coupled with above normal rainfall that is associated with the occurrence of the warm phase of the El Niño / Southern Oscillation (ENSO) phenomenon over East Africa. Outbreaks elsewhere in west and southern Africa are also linked to elevated rainfall patterns. Normalized difference vegetation index (NDVI) data derived NOAA/AVHRR measurements has been used as a proxy indicator of ecological dynamics to map areas with a potential for an RVF outbreaks by characterizing the patterns of interannual variability in RVF endemic areas. The results from these analyses show that regions of potential outbreaks have occurred in savanna ecosystem-type complexes predominantly during warm ENSO events in East Africa and during cold ENSO events in Southern Africa. Results provide a likely historical reconstruction of areas where RVF may have occurred during the last 23 years.

There is a close agreement between areas of persistent greenness and confirmed outbreaks between 1981 and 2000, particularly in East Africa, In areas of complex topography and sparse vegetation, the 8km footprint of NOAA/AVHRR may not be adequate in resolving subtle changes related the ecology of RVF outbreaks such as was the case in Yemen and Saudi Arabia in 2000 and Senegal/Mauritania and Egypt in 2003.

In dry environments where irrigated agriculture and episodic flooding of dry river beds creates conditions necessary for vector emergence, moderate to high resolution data sets such as those from LANDSAT (30 m), Moderate Resolution Imaging Spectral Radiometer (MODIS) on board AQUA and TERRA Satellites (250 m to 1 km) and from the Vegetation instrument on the Systeme Probatoire pour l'Observation de la Terre (SPOT) (1 km) satellite can provide sufficient spatial resolution to characterize and study habitat conditions and the temporal dynamics of outbreaks in such dry environments. Although satellite remote sensing may be a useful tool in monitoring conditions associated with disease outbreaks, it is important to understand the complexity of sources, the biology of animal reservoirs and their interactions with the environment that results in erratic and catastrophic diseases such as Ebola.

Long time series satellite measurements of tropical forest ecosystems and rainfall measurements can provide a baseline for studying coupled climate-environment perturbations in the forested ecosystems that may aid in understanding near simultaneous emergence of Ebola virus across large geographic areas of equatorial Africa. Recent advances in seasonal climate forecasts such as those from International Research Institute for Climate Prediction (IRI) can aid the global public health community in determining on areas of likely health concern depending on the likelihood (precipitation or temperature) of extreme conditions associated diseases outbreaks. The availability of a wide range of remote sensing data, associated derivative products and analyses can complement ground surveillance activities and assist public health officials in targeting investigations and control activities from national to global scale. To this end a coordinated effort organized by WHO can provide a framework for gathering data and information products from various agencies to adapt their tools and analyses to near real time monitoring of conditions associated with zoonotic disease outbreaks as a contribution to global public health surveillance systems.

A3.4.4 Predictive mathematical modelling

Dr Roy Anderson

The study of the transmission dynamics and control of infectious diseases is increasingly based on simple or complex mathematical or computational frameworks. The goals in model formulation and analysis can be many and varied. They include delineating what needs to be measured to better understand observed pattern, what are the key determinants of this pattern, and how might different interventions introduced at varying times post the emergence of an epidemic influence the future incidence of infection and associated disease? For a new pathogen the first of these goals is of central importance in guiding data collection and analysis, and in the formulation of policies to protect public health.

The presentation discussed recent advances in mathematical and statistical approaches in formulating models of spread and control and illustrated their application for a variety of infectious diseases including influenza A, HIV-1, schistosome infections and pathogens of livestock such as the Foot and Mouth virus, BSE and avian influenza. The talk concentrated on the epidemiological principles and policy implications, and the mathematical content was limited to facilitate understanding by biologists, physicians and policy makers.

A3.4.5 Complexities of seeking agents in wildlife reservoirs

Dr Jonathan Epstein (presenter) and Dr Hume Field

We have entered a period in history where the rate of discovery of novel infectious agents is unprecedented. Nearly 75% of all infectious diseases classed as *emerging* are zoonotic, and many of these have spilled over from natural wildlife reservoirs into humans either directly or via domestic or peridomestic animals. Diseases such as Severe Acute Respiratory Syndrome (SARS), Avian Influenza, Nipah virus, West Nile virus, and HIV/AIDS are examples of zoonoses that have had significant impact on human health. The emergence of many zoonotic diseases can be linked to anthropogenic factors such as global travel, trade, agricultural expansion, deforestation/habitat fragmentation, and urbanization – where the interface between humans, domestic animals, and wildlife is increased, creating more opportunities for spillover events to occur. The epidemiological study of wildlife requires a broad-spectrum approach that includes understanding the ecology of the target species so that appropriate study designs can be implemented.

Wildlife studies involve uncontrolled populations, and many of the complexities that arise from surveying wildlife are related to the inherent difficulties of capturing, re-capturing, sampling, and running diagnostic tests on species that often have never been studied. Working in remote locations also makes the collection, storage, and transport of biological samples difficult, especially when optimal diagnostic results depend on maintaining a cold chain. Identifying appropriate diagnostic tests and facilities that have the technology to test samples represents another challenge, especially when working in developing countries or with agents that require the highest level of biosecurity, such as Nipah virus. Finally, ethical considerations must come into play when working with animals, and the conservation status of the target species should influence the type of sampling techniques (destructive vs. non-destructive) that are used. This discussion will use Nipah virus and SARS investigations as examples of the challenges and complexities that occur when surveying wild animals for zoonotic agents.

A3.4.6 Control strategies: implementation of generic safety measures

Dr Harvey Artsob

Zoonotic diseases have multiple routes of transmission a reservoir hosts and are caused by many different types of infectious agents ranging from prions to parasites. To address human and animal heath issues, elements that need to be considered include wild animals, food and farm animals domestic pets, exotic animals and arthropods.

Hence implementation of control strategies provides great challenges. Several general strategies may be considered including reservoir neutralization (removing infected individuals from the reservoir, manipulating the environment where the reservoir lives), reducing contact potential between the agent and susceptible host, increasing host resistance, consumer protection initiatives, domestic animal identification and communication and education campaigns. Measures may need to be implemented on individual/herd, Local/community and national and international levels. Individual/herd control measures potentially include chemoprophylaxis, institution of arthropod avoidance and control measures, personal hygiene, vaccination boiling water, properly cooking food, avoiding crowds during epidemics and disinfection of fomites. Local/community measures include, arthropod and rodent control, education, mass chemotherapy, eradication of domestic animals restriction of animal movement, vaccinations/prophylactic immunization, pasteurization, isolation of patients and the institution of appropriate infection control procedures: National/international measures include institution of quarantines, restriction of importations, prevention of movement of potentially infected animals, international notifications, use of international networks and the formation of international response teams.

A3.4.7 Partnership between animal and public health for control of emerging zoonoses

Dr Frans Van Knapen

Veterinary Public Health (VPH) is that component of public health activities devoted to the application of professional veterinary skills, knowledge and resources to the protection and improvement of human health. This includes a wide variety of veterinary involvement in different geographical areas depending on the health and wealth status of such area. In third world countries it is concentrated on basic needs such as poverty reduction by improvement of food production, transport and tractive power by animals. In our western world it is about meat inspection, food safety and control of some zoonoses as regulated by law. In a sophisticated, modern society with private enterprises in food production/

exportation, VPH is dedicated to quality assurance systems using monitoring and surveillance throughout food production chains.
It is clear that modern Veterinary Public Health is oriented towards healthy feed – healthy animals – healthy food – healthy humans. It is interesting to note that the ten top successes in the 20th century public health effects have for more than 50% largely been influenced by veterinary sciences. An under estimated area is the preventive measures that may be taken to prevent or control emerging zoonoses. The debate between the disciplines human and veterinary medicine may be summarised by a discussion between such representatives about the same disease; the physician: this is very rare, I've hardly seen it in my career. The veterinarian: thanks to our initiatives and efforts this problem is under control. It is the difference between curative and preventive medicine. There is little or no bridging at all between the two complementary ways of handling zoonoses. As long as not sufficient data are available about potential emerging zoonoses or even zoonoses at large in terms of social impact, economic costs or disability adjusted life years (DALY'S) the issue will never arrive at the political agenda.

There are sufficient examples to suggest that preventive programmes to control zoonotic diseases are considerably contributing to public health at lower costs as compared to letting the actual disease burden get along and treat the patients (e.g. African trypanosomiasis, brucellosis, tuberculosis). The contribution of veterinarians to existing public health systems is again dependent on the developmental stage mentioned above. In third world countries with remote medical and veterinary health centers, if at all existing, it should be reconsidered to link human and animal systems ("one medicine" concept). In our western world it should be normal to include veterinarians in community health centers as experts in zoonotic prevention, environmental health, food and water safety issues. In the modern industrialised countries veterinary and medical monitoring and surveillance systems should be linked and data used by either party.

In such areas "life expectancy" will be changed in "health expectancy", where veterinary skills are widely used in collective prevention programmes.

A3.4.8 Improving preparedness and response to emerging zoonoses. WHO's Global Alert and Response: current approach and future needs

Dr Cathy Roth

As the 21st century starts, we continue to witness the emergence of new or newly recognized pathogens (e.g. avian influenza, Ebola, Marburg, Nipah, SARS viruses) and the resurgence of well-characterized outbreak-prone diseases (e.g. cholera, dengue, measles, meningitis, shigellosis, yellow fever). There is also great concern regarding the accidental or deliberate release of a biological agent (e.g. BSE/vCJD, anthrax). Epidemic threats continue to be characterized by unexpected events with unstable or poorly understood patterns of transmission and pathogenesis, and bring with them the potential for large public health and economic impact. In addition, with increasing global trade and travel infectious disease outbreaks anywhere potentially represent an international public health emergency.

This global threat requires a global response to investigate, characterize and assess the threat, reduce human suffering, contain national/international spread, and minimize the impact on travel and trade. WHO brings partners together to focus global resources on outbreaks. The International Health Regulations provide the framework for the protection of developing countries, developed countries, transportation infrastructure and industry. This is achieved through national and international epidemic alert and response, and relevant routine preventive measures. These serve to protect Member States from public health emergencies, avoidable travel restrictions and economic loss.

The opportunity to reduce morbidity and mortality and to control and infectious disease outbreaks is greatly influence by our ability to detect outbreaks early and respond rapidly. To meet this need, WHO's Outbreak Verification team conducts a systematic gathering of epidemic intelligence, followed by rapid verification with countries involved. After an assessment of the risk and communications with the Member State(s), WHO may be asked to provide coordination of international technical support. Both official and unofficial information is used to gather epidemic intelligence. Formal, official sources include WHO laboratory networks, regional/sub-regional networks, WHO country representatives, ministries of health and other UN organizations. Informal, unofficial sources include the Global Public Health Intelligence Network, which scans electronic media reports and nongovernmental organizations. These informal sources are being increasingly recognized for their timeliness and accuracy in detecting important events. Between 1 January 2001 and 31 December 2003, 636 events of potential international public health importance were detected in 136 countries. Two thirds of these were originally identified through unofficial sources and one third occurred in Africa. Of the 636 events during 2001–2003, 482 (75.8%) were verified, 86 (13.5%) were unverifiable and 68 (10.7%) events could not be substantiated (no outbreak verified) through usual means of verification. The overall median time between reported onset of an outbreak and the Outbreak Verification team being able to verify the events was two days and when an event was considered important, verification usually took less than 24 hours after a report about an event had been received.

Information is disseminated to a global audience using "Disease Outbreak News" on the WHO web site and the Outbreak Verification list, which is sent out weekly to a closed participant list. When an outbreak arises that might require WHO assistance, WHO ensures operational readiness by identifying members of the Global Outbreak Alert and Response Network (GOARN). Given that no single institution has all the capacity, this network acts as a technical partnership, coordinated by WHO, to provide rapid, international, multidisciplinary, technical support for outbreak response. Partners include national centres, nongovernmental institutions, WHO collaborating centres, public health institutions, regional networks and specialized networks Members provide expertise in epidemiology, laboratory science, clinical management, infection control, environmental health, health education, medical anthropology, risk communication and logistics. WHO acts as secretariat for the steering committee and provides operational support for missions. The primary aims of such missions are to: i) assist countries with disease control efforts by ensuring there is appropriate, rapid technical support for affected populations; ii) investigate and characterize events and assess the risks of rapidly emerging epidemic disease threats; and iii) sustain containment and control of outbreaks by contributing to national outbreak preparedness and ensuring that acute responses contribute to sustained containment of the epidemic threat.

During 2000 to 2004, the GOARN has worked in 26 countries responding to 30 different outbreaks. These investigations have involved over 40 GOARN partners and over 350 experts. The following is a list of outbreak events by agent or condition that GOARN has been involved with in the past four years (the number of events are in parentheses):

- cholera (1)
- Crimean Congo haemorrhagic fever (2)
- avian influenza (2)
- Ebola haemorrhagic fever (4)
- epidemic meningitis (2)
- influenza (1)
- mass hysteria (1)
- Nipah viral disease (2)
- plague (2)
- pertussis (1)
- Rift Valley fever (2)
- SARS (6)
- yellow fever (3).

Some of the key technical elements for making this partnership work have included WHO information technology support as backbone; WHO's Event Management System; Health Mapper/Global Atlas; a Field Information Management System, which is under development; and the GOARN secure web site. These systems have contributed greatly to ensure timely information exchange. Some areas where we would like to do better include increasing the use of mapping for human/animal/climate surveillance data, and finding fora for regular data sharing and coordinated data analysis. There is also an increasing need to work with anthropologists to apply knowledge of beliefs regarding disease causation and management, agricultural practices, wildlife and the natural world. This should be coupled with an effort to create a complementary research agenda and to find funding to encourage collaboration and political will.

Today, countries expect faster responses, more systematic interventions and a more defined contribution to sustained control. Partners expect a stronger operational platform in the field, and the opportunity to engage in consultations from home institutions. Ensuring that the global community can rapidly share information, mobilize resources and implement rational control measures in the face of a major epidemic disease threat has been a major challenge. WHO has met these needs by facilitating immediate access to global expertise, and utilizing and focusing that knowledge, from all appropriate sources, to support countries facing disease threats. Our goal is to turn knowledge gained into effective interventions in time to make a difference.

Annex 4 – Improving detection, prevention and control of and response to emerging zoonoses

A4.1 Risk factors for zoonotic disease emergence

There are various categories of risk factors which may contribute to the emergence and spread of zoonotic disease agents including social (e.g. human behaviour, mobility, demography and public health measures), technological (e.g. in food production and medicine), ecological (e.g. animal contacts, agricultural practices, fisheries, environmental pollution and global warming) and microbial (e.g. mutation and recombination/reassortment). A distinction is made between primary risk factors and amplification risk factors. Primary risk factors are those associated with emergence of a zoonosis (e.g. change to an agricultural production system or consumption patterns), which may result in the transfer of an agent from one species to another, while amplification risk factors are those that affect the magnitude of the resulting impacts (e.g. the mobility and degree of susceptibility of human populations), which affect the rate of spread of the disease. Subsequent adaptation of zoonotic disease agents to allow human-to-human transmission is a major determinant of the magnitude of importance of emerging diseases.

Table 1 contains recent examples of emerging zoonoses and the main risk factors for their emergence and spread. A number of common themes can be seen, as follows.

- Increasing demand for animal protein, leading to changes in:
  - farming practices (e.g. large "open" poultry production units in Asia)
  - animal markets
  - bush meat consumption
  - global trade
  - natural animal habitats (e.g. encroachment on forests)

- Human behavioural changes, including changes in:
  - extent of ownership and movement of pets
  - extent of air travel
  - extent of ecotourism, hunting, camping, etc.
  - food preferences (e.g. wild animals and raw milk)
  - demographics (e.g. producing older, more susceptible populations)
  - level of compliance with recommended prevention measures

- Shortfalls in public health infrastructure and policy, resulting from the lack of:
  - integration with animal health surveillance
  - funding in the public health sector
  - sustained funding on scientific studies to answer public health questions and build expertise

- Factors associated with the disease-causing agent:
  - adaptation to new vectors and hosts
  - mutation and recombination/reassortment in humans and other animals after exposure to multiple pathogens (e.g. foodborne viruses, influenza viruses)
  - development of increased virulence or drug resistance

It is clear that a large number and variety of risk factors affect the emergence and spread of zoonotic diseases, and that these factors vary according to the agent involved and the particular circumstances. This highlights the difficulty of predicting zoonotic disease emergence and spread, given continual changes in an interacting array of risk factors – this being particularly true where human behavioural factors are concerned.

One possible exception to the unpredictability of the influence of risk factors for emergence of zoonoses is vector-transmitted infections, which are strongly influenced by a number of known environmental factors, and changes in these can be monitored using geographic information systems. Thus, in some cases, it may be valuable to monitor particular risk factors to help to predict the possible emergence and spread of zoonoses.

Given these considerations, there is clearly a need to be able to respond to unexpected zoonotic diseases. Thus, the greatest risk factors for the emergence and spread of zoonotic agents may be the existence of public and animal health systems that are inadequately resourced and ill-prepared, as well as the lack of a well-coordinated and effective global surveillance and response mechanism.

Table 1. Risk factors for the emergence and spread of selected zoonoses

Disease, disease category or causative agent	RISK FACTORS Social	Technological	Ecological	Microbial
Leishmaniasis (*Leishmania* spp.)	Peri-urban settlements in slum areas (e.g. Afghanistan, Central America) Intravenous drug use (e.g. Spain)	—	Deforestation (e.g. South America) Global warming (Italy)	—
Arthropod-borne diseases (pathogen carried by flies, mosquitoes, ticks, and midges)	Human encroachment on natural environments (e.g. forests) Tourism and air travel Live animal trade and traffic	Ruminant husbandry	Climate change (e.g. increase in temperature)	—
Lyme disease	People being outdoors Introduction of deer into parks (the Netherlands)	—	Movement of ticks	Possible adaptation of bacterial agent to other arthropod vectors
Monkeypox virus	Increased trade of wild animals Increased air travel Waning human immunity as a result of vaccinations being stopped	—	Introduction of non-native animals to a country	—
Foodborne diseases	Consumption of new or wild animal species (e.g. civets) Population growth and increased demand for meat Lack of quality controls Changes in consumer demand Risk-seeking behaviour	Globalization Food-chain control mostly focused on bacteria, not viruses Current risk assessment cannot incorporate changes rapidly	Experiments in food production (e.g. co-cropping of rice and ducklings) Immune-deficient populations	Recombination of viruses possible following faecal contamination of food with multiple pathogens
Alveolar echinococcosis (*Echinococcus multilocularis*)	Increased movement of pets in the European Union, resulting in increased contact between humans and animals Control measures not implemented uniformly for dogs Increased trade in fresh mushrooms and berries	Difficult to detect emergence as long lag time between infection and onset of symptoms and diagnosis Humans hard to treat (require liver transplants)	Increase in fox population	—

Severe acute respiratory syndrome	Consumption of wildlife Mobility Air travel Population density Social economic status Increased wealth and protein consumption Lack of infrastructure (relative)	Medical interventions (e.g. intubation) Food production	Increased close contact of humans with wild animals through wildlife farming and at markets Close contact between animal species in markets and farms	Virulence Host range
Avian influenza	Mobility of people, animals, animal products and faeces Increased wealth and protein consumption Lack of infrastructure in public health and animal health and lack of integration Expanded markets for poultry exports	Food production (e.g. large poultry-processing plants) Agricultural practices (e.g." open" production, multiple species)	Contact between wild and domestic species Climate change Migration routes of possible reservoir hosts	Virus changes and reassortment
Human immunodeficiency virus	Promiscuity Lack of compliance with recommended precautions Social economic status Bush-meat consumption (factor for emergence)	Blood transfusion	—	—
Ebola virus	Bush-meat consumption Specific practices leading to human-to-human transmission	Nosocomial transmission	Reservoir unknown	—
Mycobacterium	Changes in food preferences (e.g. consumption of raw milk)	—	Increased contact between deer and badgers (carriers of the pathogen) Human contact with zoo animals	—
West Nile virus	Air travel Illegal marketing in wild animals Lack of adequate quarantine for exotic birds Insufficient infrastructure and expertise for vector control	—	Climate change Adaptation of vector species to new areas/continents	Different degrees of virulence between strains (e.g. highly virulent strain that invaded North America)

A4.2 Alert and early warning systems and surveillance

It is important to distinguish between surveillance systems and early warning and alert systems. Surveillance systems constitute a systematic collection and interpretation of data for action, and usually the epidemiological analysis is tied to laboratory-generated data. Early warning and alert systems may be based on surveillance systems, but are primarily focused on methodological issues (e.g. defining an indicator for when further public health action is warranted, determining the particular incidence of a syndrome, developing of a plan of sequential action, formally confirming an event, carrying out an epidemiological investigation, and implementing control measures).

An ideal surveillance system should be rated for its usefulness, simplicity, flexibility, data quality, acceptability, sensitivity, positive predictive value, representativeness, timeliness and stability. In the context of emerging zoonoses, it is recognized that the majority of countries do not have systems that adequately meet these criteria. Given the limitations, the following elements are considered important for surveillance or early warning and alert systems for emerging zoonotic diseases.

Syndromic surveillance of humans and animals
Such surveillance should:
– be representative of the population under surveillance,
– detect unusual clusters of morbidity and mortality in space and time,
– be species, region and disease dependent,
– be based on sentinel surveillance,
– include syndromes of the gastrointestinal, respiratory and reproductive tracts; central nervous system; and skin,
– include hemorrhagic and high mortality syndromes,
– use both passive and active surveillance as appropriate,
– include public health personnel, veterinarians, wildlife ecologists, farmers and animal health workers,
– be independent of government/political interests.

Syndromic surveillance of animals
In addition to the above, syndromic surveillance of animals should also include:
– decreases in production (e.g. milk or egg),
– both domesticated and wild animals.

Animal and public health diagnostic laboratories, with a capacity to determine the cause of disease, should:
– carry out active, structured, laboratory-based surveillance of diseased humans and animals and, where appropriate, surveillance of healthy animals for zoonotic agents (serological or agent detection);
– use linked systems of national and regional reference laboratories to support Member countries when unexplained deaths occur among their animal populations.

A national formal structure for coordination and communication should be in place for zoonoses, to ensure timely communication between human and animal systems, involving:
– regulatory agencies,
– national reference laboratories,
– livestock producers,
– other stakeholders.

It is important to educate farmers, animal health workers, people working with wildlife and zoo animals, and clinicians at the local level about the importance of reporting events of potential zoonotic importance. This type of surveillance relies on a wide variety of animal and public health intelligence data, such as:
– official reports,
– Internet reports,
– traditional media reports.
This needs to be complemented by a system to investigate and confirm unofficial information.

Advanced surveillance systems exist in a few countries but most countries, especially developing countries, are ill equipped to develop, implement and maintain such systems. Emerging zoonotic diseases are likely to occur in countries that have the weakest infrastructures for detection and response. In light of recent global events (e.g. emergence of SARS and outbreak of avian influenza), there is an urgent need to enhance the capacity of these countries, and subsequently to connect the various surveillance and early warning and alert systems at the regional and international levels. The following recommended actions could facilitate this needed capacity strengthening.

- Resource-rich countries should invest in the establishment and strengthening of surveillance systems in resource-limited countries, given the international significance of emerging zoonoses.
- International organizations (e.g. WHO, FAO and OIE) are encouraged to promote the value of surveillance to Member countries. Much knowledge and information relevant to detection of emerging zoonotic events of public health significance already exists in many countries. Countries should establish a system to obtain, collate and analyse relevant data centrally. The system should incorporate information from relevant people in the field.
- It is important to capitalize on the unique strengths of the early warning and alert systems in WHO, FAO and OIE, but they should also be further integrated to allow detection of potentially linked animal and public health events. Full implementation of the joint GLEWS is recommended.
- A prioritized list of agents and syndromes of potential public health significance that should be included in the GLEWS should be distributed to Member States.
- International organizations (e.g. WHO, FAO and OIE) should encourage research to investigate the usefulness of surveillance data from novel systems (e.g. vector population monitoring, meteorological data, land surface scanning, and animal and human demographics) for advanced warning of zoonotic public health events. Where applicable, such systems should be implemented at the national level, for example, early warning systems for Rift Valley fever, based on climatic data.
- International organizations (e.g. WHO, FAO and OIE) should maximize opportunities for rapid transfer from research of novel surveillance systems to their integration into surveillance and early warning and response systems.

- Once an unusual disease event is detected, modelling and prediction of potential spread should be incorporated in national preparedness plans for an outbreak response.
- New approaches to transport laboratory specimens, based on transporting inactivated samples containing DNA and RNA, and handle pathogens, should be encouraged. Research should be carried out to analyse the biodiversity of potential pathogens in animal populations to support the upstream detection of agents of potential zoonotic significance.
- Inexpensive, sensitive and specific rapid diagnostic tests for field situations should be developed and used.
- Animal and human health data should be integrated at national and regional levels. In each country, there should be an intersectoral committee for zoonoses preparedness and control. Such committees should include representatives of relevant public and animal health agencies, and national reference laboratories. Countries should include non-traditional partners, such as nongovernmental organizations (e.g. wildlife organizations) and zoos, in their networks to detect and respond to emerging zoonotic infections.
- Countries should establish sustained personnel interchange between ministries of agriculture and ministries of health.
  If veterinary and public health personnel become familiar with each other before a crisis, they will be better positioned to resolve inevitable differences that arise during an animal or human health emergency.
- Member States should implement systems for the identification and localization of commercial animal herds/flocks and for tracking national and international livestock movements.
- Changes in known or potential risk factors for emergence of zoonotic disease should be monitored.
- Cost–benefit assessments, including animal health and productivity data as well as public health costs, should be conducted to demonstrate to countries the benefits of surveillance to prevent and control zoonotic disease.
- A zoonoses surveillance system should be capable of measuring the public health impact of veterinary interventions.
- Countries should develop an action plan to implement these recommendations.

A4.3 Domestic and wildlife reservoir studies, early warning and control strategies

A4.3.1 Introduction

There are many complexities in studying the epidemiology of zoonotic diseases, particularly in determining the natural reservoir of a pathogen, which may be quite separate from the initial source of infection. Understanding the relationship between the pathogen, its reservoir host, intermediate hosts and humans is crucial to formulating strategies for prevention and control of zoonotic agents. Animal hosts can be domestic (e.g. pets or livestock), peridomestic (e.g. rodents) or wild.

Disease surveillance in domestic animals is feasible due to the controlled environment in which they live. Animals in enclosed farms, pets and captive wild animals in zoos represent controlled populations, since their movement and interactions with humans and other animals can be restricted and closely monitored. Consequently, it is possible to design controlled systematic studies and set up surveillance systems for long-term monitoring of zoonotic pathogens in these animals.

In contrast, wildlife populations exist in a largely uncontrolled environment. This may also apply to domesticated animals in nomadic cultures and to the unregulated translocation of wildlife. In these cases, there is unhindered interaction between humans, domestic animals and wildlife, as well as with disease vectors and pathogens in the environment. Uncontrolled situations may exist on a farm where a domesticated species is endemic to the area and there are unregulated introductions or interactions between wild and captive populations (e.g. to genetically bolster captive stock). This has occurred with farmed masked palm civets, a species implicated as the source of human infection in the SARS epidemic. Surveying wildlife for zoonotic pathogens involves many challenges (e.g. small or inaccessible populations, nomadic or migratory movement, and endangered species status) to conducting scientific disease studies.

A4.3.2 Studying zoonotic diseases

Despite the inherent challenges, it is often necessary to understand the natural ecology of a zoonotic pathogen and its host in order to control disease transmission and prevent future outbreaks. There are a number of general guiding principles for studying zoonotic diseases:

- identify the source of infection, to determine whether it is from wildlife, domestic or peridomestic animals, or from multiple sources.
- establish the mode of transmission, to determine whether it is by direct contact, vector-borne, environmental contamination, or a combination of modes.
- identify potential host species and the natural reservoirs of the zoonotic pathogen. Current molecular and epidemiological knowledge can be used to identify target species for surveys.
- conduct preliminary surveys of target species and follow-up, when indicated, with long-term ecological and epidemiological studies of identified reservoir species in the wild and/or in an experimental setting where appropriate.

A4.3.3 Handling emerging zoonotic diseases

A biphasic approach should be considered for handling emerging zoonoses: a short- to intermediate-term response to an outbreak or emergence event, indicated by an increasing number of cases (either veterinary or human), and a long-term comprehensive study of the ecology of the zoonotic pathogen. The short-term response should include setting up two emergency teams to respond quickly to the disease outbreak or emergence event. The first team should primarily be responsible for infection control by creating a case definition, identifying the mechanism of disease transmission and breaking the chain of transmission, thus preventing new cases. The second team should concurrently undertake studies on the disease ecology by compiling current knowledge about the disease and using this to develop and conduct preliminary animal surveys to identify the etiological agent. The short- to intermediate-term phase of disease response may include collaboration with a pre-identified reference laboratory to begin development of diagnostic assays to be used in the field and should include a plan for transfer of the technology to a local laboratory where possible.

The two teams would be responsible for implementing short-term control measures and should determine whether or not there is need for long-term follow-up studies by assessing the likelihood of recurrence or emergence in new areas.

Long-term studies should include the establishment of large-scale, multidisciplinary and multinational surveillance, molecular epidemiology and diagnostic technology development, coordinated with reference laboratories, and ecological studies designed to identify natural reservoirs for the pathogen of interest. A follow-up of initial animal surveys with more in-depth disease distribution and prevalence studies should be conducted. Centres of excellence (e.g. reference laboratories) should be identified in the region that can conduct experimental infections to confirm the etiological agent and identify mechanisms of transmission. These centres should also be able to develop more sophisticated diagnostic tests and, when necessary, therapeutics, under appropriate biosafety conditions.

A4.3.4 Prevention and control of emerging zoonotic diseases

There are a number of control methods and tools currently available at the animal reservoir, vector and human levels that are appropriate for the prevention and control of emerging zoonotic diseases.

- **Domestic animals**

  For domestic animals, the common methods and tools used in disease control are:
  - vaccination of pets or livestock (e.g. as for rabies control),
  - prophylactic use of antiparasitics (e.g. antitrypanosomals or coccidiostats),
  - proper biosecurity and quarantine (e.g. excluding wildlife from domestic stock, hygienic practices in husbandry and among farm workers),
  - eradication programmes (depopulation),
  - appropriate veterinary care,
  - proper herd health programmes.

  Other such methods include:
  - breeding for disease resistance,
  - feed and water control,
  - using best animal husbandry practices,
  - routine disease surveillance,
  - testing animals before entering or leaving a farm.

- **Wild animals**

  There is currently no international organization dedicated to monitoring, reporting and studying wild animal health on a global scale. International conservation organizations such as the World Conservation Union and other international wildlife organizations should be more involved in the coordinated research referred to in A4.3.3, as well as the current monitoring, and reporting of wildlife-related health issues to public health authorities.
  Disease surveillance and control in wild animals should take into consideration a number of conservation issues, particularly the conservation status of the species under investigation.

The following methods and tools may be undertaken after careful evaluation of the species involved and its ecology:

- isolating and creating of physical barriers to exclude wild animals from farms or human residences,
- population control by culling,
- treating and vaccinating defined populations (e.g. oral rabies vaccination of foxes),
- limiting wildlife movement,
- conducting preliminary testing of all live import and exports,
- exercising care in adopting and translocating wild animals.

- **Vector control**
  Vector control is an effective tool in the prevention and control of vector-borne zoonotic diseases, for example by, spraying against fleas and mosquitoes during plague and Rift Valley fever outbreaks, respectively; and using tick control in outbreaks of Crimean Congo haemorrhagic fever and Lyme disease. Other effective methods involve environmental management through elimination of vector breeding habitats as well as limiting anthropogenic activities that promote vector breeding, such as land-clearing, unplanned development and the destruction of habitats that support vector predators.

A4.3.5 Public health issues

Effective communication between pubic health officials and the general public is vital to controlling zoonotic disease, particularly when human-to-human transmission is involved (e.g. SARS or Nipah virus infection). Important areas of public education include health education, promotion of personal hygiene and sanitary practices, use of physical barriers such as mosquito bednets and insecticide-treated screens, and hygienic food handling.

Other available tools include improved case management and therapy, in addition to pre- and post-exposure prophylaxis against diseases such as rabies. Isolation and use of protective clothing as well as global information sharing are some of the disease control methods routinely applied in outbreaks of diseases such as Ebola, SARS and avian influenza.

A4.3.6 Summary

In-depth ecological studies of emerging zoonotic diseases require interdisciplinary and multi-institutional collaboration. However, whether or not such studies are necessary is situation dependent. For example, the identification of pteropid bats as reservoir for Hendra virus enabled rapid identification of the reservoir for Nipah virus in Malaysia and even faster identification in Bangladesh. Similarly, avian influenza is a seasonally recurring disease and understanding its ecology will allow us to better appreciate the extent of the risk to domestic livestock and people.

Understanding the source of infection and mechanisms of transmission of zoonotic diseases will help to prevent the spread of disease even before the pathogen’s ecology is fully understood. However, understanding the underlying causes for disease emergence and the ecology of pathogens and their hosts will ultimately help to deal more effectively with future emergence events of either familiar or novel pathogens.

A4.4 Improving international responses to emerging zoonoses

In order to propose ways and means to strengthen global capacity for responding to emerging zoonoses, the criteria for mounting an international response for emerging zoonotic diseases must first be defined. It is clear from recent epidemics and epizootics that emerging zoonotic diseases are increasingly a global and regional issue. Therefore, coordinated responses are essential across sectors, regions and countries. Outbreaks of emerging zoonoses are mainly characterized as being very dynamic and often unpredictable. Consequently, it is not possible to know in advance the best responses to such events, and immediate action is often required to prevent major mortality and economic impacts.
Because of the very specific characteristics of such outbreaks (e.g. occurrence in wildlife and emergence in both domestic animal and human populations), new mechanisms of response are required, using new tools (e.g. information technology, molecular biology and analytical epidemiology) and bringing together different disciplines (e.g. medical, veterinary, biologists, entomologists, population biology, information technology and diagnosis).

Building capacities in these complex disciplines and in the use of sophisticated tools is usually expensive and often beyond the reach of many countries.

In order to meet these challenges, four key capacities for international responses are needed:
– outbreak response,
– surveillance, reporting, communication, information sharing,
– technical support,
– an analytical decision-making framework.

Recent outbreaks of emerging zoonoses or diseases considered as possible zoonoses (e.g. SARS) have led to the identification of strengths and weaknesses in the international response. Three examples of recent epidemics are presented which illustrate aspects of the successes and challenges of mounting an international response to emerging zoonoses.

- **Severe acute respiratory syndrome**

The SARS epidemic in 2003 exemplified the role the international response can play in managing a global problem. Information sharing and management were coordinated by WHO; information was posted in a timely fashion on the WHO web site. Different international teams from various disciplines shared information and worked together to rapidly provide tools and results to enhance diagnosis and epidemiological analysis of the new pathogen, the SARS coronavirus.

Another improvement over past efforts was better risk communication. Potential risks were not hidden and timely information was provided to the media. The large international response was needed because SARS appeared to be and was proven to be caused by a new agent, which caused a serious disease, and the agent could be readily transmitted under certain circumstances. It was already an international problem before it was first reported to WHO. Delays in engaging international assistance and in notifying this outbreak to the international community had a major impact in allowing the problem to become a global threat. The involvement of veterinarians in identifying the initial source of the epidemic was minimal, illustrating the need for better participation and communication between and within disciplines. Communication difficulties were also identified at the local and national levels between hospitals and public health staff, which may have slowed down the control of the outbreak in a number of countries.

- **Bovine spongiform encephalopathy**
  While the international response to SARS was considered to be success, the response to the BSE outbreak, first identified in the late 1980s, was clearly identified as an example of poor risk management and communication at the national and international levels. One of the important lessons learnt from the BSE epidemic was that no emerging animal disease should be neglected and such diseases should always be assessed for their public health impact. Insufficient attention was paid at the beginning of the epidemic to warning signals of the disease agent jumping the species barrier and this certainly delayed the evidence versus risk-based decisions. In addition, such decisions were hampered by economic interests that conflicted with the precautionary principle. In addition, the long incubation period, difficulty in ante-mortem diagnosis and absence of a reliable early screening test for use at slaughterhouse level were major limiting factors in understanding and controlling the epidemic.

- **Avian influenza**
  A number of avian influenza epidemics have occurred in various parts of the world in 2003 and 2004, particularly in South-East Asia. The most recent epidemic re-emphasized the need for integrating veterinary and medical surveillance and decision-making: such integration is limited or nonexistent in many countries. Similarly, integration of wildlife surveillance (e.g. regular testing of waterfowl and migrating birds) was considered important, particularly the use of birds as sentinels, as a tool for tracking infections and predicting emerging epidemics. Finally, major strategies to control the epidemic (e.g. vaccination of birds) should be agreed upon in advance as part of preparedness and response planning.

General areas for strengthening international responses to emerging zoonoses include:
– better communication between countries and various international organizations, and between the public health and agricultural sectors;
– general support for public health and veterinary core capacities in most countries, including education, database templates and standards, risk management and assessment, and communication skills;
– at the international level, capacities for outbreak responses, forward planning and strategic research based on potential scenarios.

Mechanisms for responding to emerging zoonotic diseases could be improved through:
– better international coordination and formalizing a means of providing advice and training;
– providing advice and support for better networking and sharing of resources between public health, medical and veterinary laboratories;
– requiring all suspected zoonoses to be reported from medical or veterinary sources within 24 hours after detection to all relevant agencies (e.g. ministry of agriculture, ministry of health, WHO, OIE and FAO);
– providing incentives for timely reporting;
– improving validation of and responses to reports from different sources;
– more sustained financial support for scientific studies to answer public health questions and build expertise;
– ensuring availability of special funds for emergency responses;

– conducting rapid scientific studies to occur to answer scientific questions related to the emergence of a new disease;
– providing specific funds for strengthening the public and animal health infrastructure;
– international organizations (WHO, FAO and OIE) jointly raising political awareness and support for public and animal health infrastructure (human resources, facilities, implementation);
– improving coordination of activities among animal health, human health and food safety authorities;
– more integration (meetings, joint planning, networks) of medical and veterinary responses to emerging diseases (e.g. scenario development and monitoring of avian influenza vaccination);
– establishing guidelines by international organizations concerning core capacities for emerging zoonoses and how these are integrated between laboratories and the field and across sectors;
– establishing an international network to support countries when analysing their emerging disease situation;
– establishing regional networks to consider medium-term needs after an outbreak has occurred.

Collaboration between sectors and among relevant stakeholders is necessary for effective implementation and support of zoonoses control efforts. Better collaboration is required at both horizontal (laboratories: medical, veterinary, public, private; clinics; hospitals; public health and veterinary services; and wildlife agencies) and vertical (local, national, regional and global) levels. To ensure such collaboration, it is necessary to foster fundamental preconditions through:
– political support,
– planning for joint infrastructure and training,
– development of broad health fora (networks).

At the global level, the international organizations (WHO, FAO and OIE) need to develop a common communication and information-sharing platform, including a common surveillance and reporting system for emerging zoonotic diseases, as well as joint strategies and resource mobilization for scenario development, planning and research.

Annex 5 – Future concerns on emergence of zoonotic diseases at the regional level

A5.1 WHO European Region

A5.1.1 Key zoonotic diseases

Several "old" and well-known zoonotic diseases appear to be re-emerging in the WHO European Region, mostly as a result of civil war, disruption of the traditional centralized economies, and decreases in incomes in general. During the last three years, the WHO Regional Office for Europe has been involved in an outbreaks of Crimean Congo haemorrhagic fever in south-eastern Europe, tularaemia in Albania and Kosovo, anthrax in Romania and leishmaniasis in the countries bordering the Mediterranean Sea. The Regional Office has been particularly involved in dealing with leishmaniasis in HIV-immunodepressed people in Albania, Italy and Spain, and in Tajikistan as a result of imported cases from Afghanistan.

Recently, an outbreak of Q Fever was reported in Bosnia with over 100 people affected near the town of Banja Luca. The increasing spread of tick-borne encephalitis into central and western Europe from the Baltic States and eastern Europe is also of concern. New and as yet unknown emerging threats with multiple risk factors are expected to arise, but predicting their emergence is difficult. Monitoring changes in these risk factors may increase alertness, resulting in improved surveillance. The following diseases are considered key zoonoses of concern for the Region.

Zoonotic agents for which emergence will have a major impact on public health:
– avian influenza virus
– drug-resistant and more virulent strains of foodborne bacteria.

Zoonoses and zoonotic agents with current and potentially increasing impact:
– transmissible spongiform encephalopathies (TSEs)
– Hanta virus[1]
– rabies (eastern Europe): EBL/classic
– orthopox virus[1]
– tick-borne encephalitis
– hepatitis E (porcine)
– Lyme disease[1]
– *Rickettsia* spp.
– tuberculosis (bovine/avian)
– tularaemia
– *Brucella melitensis*
– marine brucellosis
– *Echinococcus multilocularis*[1]

[1] Currently increasing in prevalence in Europe.

– *Echinococcus granulosus*
– *Leishmania* spp.
– *Taenia solium*
– trichinellosis
– *Baylisascaris ascaris*[1] (larval migrans)
– toxoplasmosis
– cryptosporidiosis/giardiasis

Zoonoses and zoonotic agents from outside the WHO European Region:
– Rift Valley fever
– dengue virus
– West Nile virus
– alpha viruses
– TSEs
– pandemic influenza
– SARS coronavirus
– monkeypox
– paratuberculosis
– Borna virus
– pathogens transmitted via blood and blood products
– pathogens from marine environments (*Vibrio* spp., influenza A/B, Calici virus, *Brucella* spp., nematodes)
– *Burkholderia pseudomallei* (potentially)

A5.1.2 Main risk factors

The risk factors involved in the emergence of zoonoses are complex and often multifactorial. The main factors are listed, along with specific risk factors for avian influenza, showing that some risk factors are primarily involved followed by amplifying risk factors.

Socioeconomic:
– human behaviour (e.g. travel, eating habits, outdoor life)
– increasing number of immunocompromised people (e.g. elderly)
– increasing movement of people and animals/products

Ecological:
– wildlife and game farming
– free-range animal farming
– factory farming

Medical technology:
– xenotransplantation
– blood transfusion

Agricultural practices:
– trade
– potential shift of factory farming from western to eastern Europe

[1] idem

Global warming:
– providing an enabling environment for vectors of disease

Other general risk factors:
– differences in the quality of public health and veterinary public health infrastructure, and lack of coordination at the regional level
– insufficient investment in public health-related scientific research
– complacency (professionals, politicians)

Risk factors for avian influenza:

Primary risk factors
– mixed farming
– insufficient biosecurity on farms, leading to indirect contact with wildlife

Amplifying risk factors
– flock density (many intensive contacts)
– animal-to-human transmission
– human-to-human contacts (including containment strategy)

A5.1.3 Surveillance and early warning systems needs

Several actions are currently being undertaken in the European Union (EU) to coordinate the response to future emerging zoonoses. These include the establishment of the European Centre for Disease Prevention and Control (ECDC) and the European Food Safety Authority (EFSA), and the funding of research related to, for example, the establishment of pandemic influenza preparedness plans. In addition, an EU network of excellence, MED-VET-NET, was established to promote veterinary–medical coordination and collaboration among national reference laboratories in relation to zoonoses surveillance and research. This is only one example of EU funding in the field of zoonotic research, but it is unclear if sustained financial support will be provided for such initiatives.

Systems that allow for syndromic surveillance and verification of signals by laboratory research are in their infancy, and are limited to a few national or regional pilots without European oversight or long-term investment. Data on zoonoses and zoonotic agents in animals, food, feed and humans listed in the EU's Zoonoses Directive (2003/99/EC) need to be collected at the national level and communicated to the ECDC and EFSA. Currently, a report is only made available 12 months after the end of the year in which it is reported. Furthermore, there are no established links between the human surveillance networks (2119/98/EC) and the reporting done on the veterinary and food side. In addition, it is not clear if and how the analysis of data collected from animals and humans will be coordinated. In the new zoonoses legislation, there is no obvious legal basis for the collaboration between ECDC and EFSA. Neither is it yet clear how the containment of outbreaks of newly emerging zoonotic diseases with the potential to become regional concerns will be coordinated.

A5.1.4 Actions to be undertaken to improve prevention and control of zoonotic diseases

The current organization of the public health system in Europe is fragmented and lacks the authority needed to deal with severe supranational health threats. The first step in changing this situation is the formation of the ECDC as a centralized monitoring, analysis and response resource. However, there is concern about how the ECDC can serve as a rapid response system, since funding for laboratories that would carry out targeted investigations is not incorporated in the EU budget. Currently, the responsibility for detecting and responding to emerging infections lies with the national authorities, each with their own decision-making structure to respond to a crisis. There is also concern about how emerging infectious disease outbreaks of regional significance will be coordinated. One possibility for improving the situation is to develop the ECDC as a supranational body that would coordinate efforts to build a response structure for such emergencies. This centre would have access to and funding for sufficient and sustained epidemiological and microbiological expertise, and would have the political mandate to override national and economic interests during infectious disease emergencies. An alternative possibility would be for the ECDC to coordinate and facilitate responses to serious public health events of international significance, but its mandate would not override national laws. In both scenarios a rapid response to emerging zoonoses is crucial.

More than 40% of Europe's territory (over 4 000 000 km^2) is covered by non-EU Member States in east and south-east Europe. Many health problems and emerging zoonoses occur in these states including Belarus, the Russian Federation, Ukraine, and the smaller countries of the former Yugoslavia. Therefore, close collaboration of WHO, not only with the EU but also with other European countries which are not part of the EU, is strongly recommended. Since zoonoses that emerge today in developing countries, such as those in Eastern Europe, may cause problems in developed countries tomorrow, the resource-rich countries need to take responsibility for effective and efficient zoonoses prevention and control programmes in developing countries.

A5.2 WHO Western Pacific Region and South-East Asia Region

A5.2.1 Key zoonotic diseases and zoonotic agents

- avian influenza
- SARS
- rabies
- Japanese encephalitis
- Hanta virus
- echinococcosis
- cysticercosis
- leptospiroisis
- Nipah virus (henipaviruses)
- schistosomiasis

A5.2.2 Main risk factors

Avian influenza:
- increased demand for animal protein resulting in expansion and intensification of farming
- increase in mixed farming practices
- acceleration of international trade
- "wet" markets (live animals and slaughter in public)

SARS:
- human consumption of wildlife/exotic species as delicacies

Rabies:
- lack of population control and vaccination of stray dogs
- inadequate vaccine coverage of pet dogs

Japanese encephalitis:
- increased free-range pig farming in rice fields (high mosquito prevalence)
- inadequate or lack of vaccine coverage in humans

Hanta virus:
- close contact between humans and rodents

Echinococcosis:
- no proper slaughtering practices and poor hygiene
- no meat inspection
- lack of personal hygiene (e.g. hand-washing)

Cysticercosis:
- environmental contamination with human faeces (poor sanitation)
- pig management practices (free-range farming)
- pork consumption habits (undercooked or raw pork)
- lack or absence of pork inspection and control

Leptospirosis:
- increased exposure to rodent excreta and contaminated water

Nipah virus (henipaviruses):
- anthropogenic introduction of large-scale pig farms into pteropid bat habitats
- fruit orchards or other food sources for megachiropteran bats in close proximity of farmed pigs
- increased interface between humans and pteropid bats and inadequate personal hygiene

Schistosomiasis:
- uncontrolled irrigation
- livestock management practices

A5.2.3 Problems and challenges

Avian influenza:
- biocontainment of large-scale poultry farms
- monitoring the health status of animals
- early detection and notification

SARS:
- legislation to regularly control wildlife trade and food market practices

Rabies:
- domestic dog population control
- compulsory vaccination of all dogs
- public awareness and education

Japanese encephalitis:
- integrated vector control
- vaccination of high-risk human populations.

Hanta virus
- control of rodent populations in endemic areas

Echinococcosis:
- proper management of slaughterhouses and meat markets
- treatment of dogs with antiparasitics
- public awareness of personal hygiene practices

Cysticercosis:
- strict inspection of pork
- proper management of slaughterhouses and meat markets
- public awareness of food safety (need for thorough cooking of pork) and personal hygiene practices (toilet use, hand-washing)

Leptospirosis:
- rodent control
- proper agriculture practices (e.g. wearing boots)
- appropriateness of vaccination for high-risk groups

Nipah virus (henipaviruses):
- education and awareness of flying foxes as a reservoir and potential source of infection,
- improve sanitary and hygienic practices (e.g. wash fruit and hands before eating)
- separation of pig farms from orchards and rainforest habitats
- biosecurity measures and improve herd health practices on large-scale farms

Schistosomiasis:
- proper management of irrigation systems
- community case detection and mass treatment
- understanding the role of domesticated animals and wildlife as reservoir hosts

A5.2.4 Surveillance and early warning system needs

Infrastructural adjustments conducive to surveillance and monitoring for the emergence of zoonoses can be facilitated by:
- strengthening of the existing national veterinary and public health surveillance systems;
- strengthening cooperation between veterinary and public health authorities for information sharing;
- building animal health services infrastructure where needed, at all levels;
- capacity building of laboratory facilities, including technology transfer;
- developing and encouraging the use of regional and global reference laboratories;
- promoting a culture of collaboration and information sharing among scientists.

A5.2.5 Actions to be undertaken to improve prevention and control of zoonotic diseases

Several actions can be taken at the regional level aimed at improving surveillance, prevention and control of zoonoses including:
- establishing a "national zoonoses control committee", including veterinary and medical public health experts (together with wildlife veterinarians) and other concerned agencies in each country;
- discouraging the practice of "wet" markets with butchering practices held in public, instead creating separate butchering areas away from the public;
- investigating the health and environmental impacts of mixed-animal farming;
- compulsory notification of abnormal mortality of livestock and wildlife by farmers and wildlife agencies, respectively, as part of a surveillance programme;
- establishing federally subsidized veterinary assistance to farmers specifically for setting up herd health protocols, good record-keeping and reporting of livestock (zoonotic) disease to improve surveillance and facilitate the response of public health officials. Initial setting up of herd health protocols will be of little or no cost to farm owners and compensation will be provided to farmers who report loss of livestock due to a zoonotic disease.

A5.3 WHO Eastern Mediterranean Region and WHO African Region

A5.3.1 Key zoonotic diseases

Quantification and prioritization of key zoonotic diseases is difficult in the two regions because of a lack of data on disease burdens, especially for human populations. Endemic zoonotic and emerging zoonotic diseases are a major concern in both regions because of their impact on the agricultural and public health sectors. Initial priorities can be set using existing information and then refined, based on the results of specific studies.

Endemic zoonotic diseases:
- plague
- yellow fever
- leptospirosis
- relapsing fever
- leishmaniasis
- rabies
- anthrax
- brucellosis
- fasciolosis
- cysticercosis
- echinococcosis
- tuberculosis
- trypanosomiasis
- screw-worm myasis (potentially)

Emerging zoonotic diseases :
- Rift Valley fever
- Lassa fever
- monkeypox
- Crimean Congo haemorrhagic fever
- Ebola
- other emerging diseases of global importance (e.g. SARS and avian influenza)

A5.3.2 Main risk factors

Although many of the traditional zoonotic diseases have been controlled, they are re-emerging, because of the lack of public investment. The main risk factors for emergence and re-emergence of zoonotic diseases in the regions are listed.

Socioeconomic:
- intensive farming (without biosecurity measures)
- water-supply projects
- urbanization
- human population movement
- animal movement
- famine

Environmental:
- climate change (e.g. global warming)
- presence of vectors and/or reservoirs

Health-related:
- coinfection with other diseases agents (HIV, *Mycobacterium tuberculosis*)

Cultural and behavioural risk factors:
- lack of knowledge
- food habits
- changes in lifestyle

A5.3.3 Problems and challenges

Factors which constrain the prevention and control of zoonotic diseases, thus helping to provide an enabling environment for the emergence and re-emergence of these diseases include:
- breakdown or weakness of health infrastructure;
- weak disease surveillance systems;
- absence of integration of animal and public health systems;
- insufficient information on the burden of zoonotic diseases;
- insufficient human and financial resources;
- weakness or absence of collaboration and coordination between public health, veterinary, agriculture and wildlife sectors.

A5.3.4 Surveillance and early warning systems needs

Surveillance is critical but weak in both regions. There is a need to strengthen existing initiatives and systems and establish linkages between animal and public health by:
- conducting studies to provide evidence for priority setting and guiding action;
- building on existing data;
- strengthening the capacity of diagnostic and research laboratories;
- sharing information;
- strengthening interagency collaboration (between, for example, FAO, WHO, OIE and the African Union) through coordination mechanisms, which may include tripartite meetings; joint planning, studies, statements, consultations, working groups and guidelines; and GLEWS, etc.;
- setting priorities based on both health impact and the agricultural market.

A5.3.5 Actions to be undertaken to improve prevention and control of zoonotic diseases

There is a need to improve the basic infrastructure of human and veterinary health systems in order to control endemic zoonotic diseases. There is also a need to increase political awareness of the importance of zoonotic diseases: this requires demonstrating their impact on the agricultural sector (e.g. their effect on markets) as well as on human health. Specific actions include:
- preparing educational materials based on research findings, and training public health and agricultural extension workers as well as school teachers;
- social mobilization involving medical anthropologists, ethno scientists and traditional healers;

– strengthening preparedness through identification of an appropriate structure for the prevention and control of zoonotic diseases, strengthening of laboratory capacity, improving case management and developing tools for risk assessment and prediction;
– linking zoonotic disease prevention and control programmes with existing initiatives (e.g. Southern African Development Community).

A5.3.6 Recommendation

A framework and appropriate tools should be developed to help to gather evidence on the burden of zoonotic diseases. The information obtained should serve for advocacy.

A5.4 WHO Region of the Americas

A5.4.1 Key zoonotic diseases

Several important zoonoses which have emerged in the Americas during recent years are now spreading into new geographical areas.

Zoonotic diseases and agents of current concern:
– West Nile virus
– rabies (vampire bats, raccoons, monkeys)
– equine encephalitides (Venezuelan-equine encephalomyelitis, eastern equine encephalomyelitis)
– Hanta virus
– arenaviruses
– avian influenza
– pox viruses (e.g. monkeypox)
– yellow fever
– HIV/AIDS
– plague
– tularaemia
– anthrax
– Lyme disease
– *Leptospira*
– brucellosis
– bovine tuberculosis
– *Bordetella bronchispectica*
– *Bartonella*
– pet-associated salmonellosis
– chlamydia
– Q fever
– typhus
– *Ehrlichia*/anaplasmosis

- Rocky Mountain spotted fever
- Febre maculosa - spotted fever
- *Leishmania* (cutaneous and visceral)
- *Echinococcus multilocularis*
- American trypanosomiasis (Chagas disease)
- cysticercosis
- *Trichinella*
- *Cryptosporidium*
- *Giardia*
- *Toxoplasma*
- *Baylisascaris*
- BSE
- variant Creutzfeldt-Jakob disease (vCJD)
- coccidioidomycosis

Zoonotic diseases and agents of future concern:
- West Nile virus (South America)
- yellow fever
- SARS
- imported arboviruses (e.g. Rift Valley fever virus, Ross River virus)
- arenaviruses
- hepatitis E (porcine)
- Borna viruses
- pox viruses
- Streptobacilliary rat bite fever
- *Bartonella*
- meliodosis (*Burkholderia pseudomallei*)
- plague
- *Echinococcus* spp.
- chronic wasting disease
- vCJD

A5.4.2 Main risk factors

Multiple risk factors are responsible for the emergence of zoonotic diseases in the Americas. Many of these are a result of human actions, activities or changes in demographics, such as:
- ageing population
- immunosuppression
- importation of exotic mosquitoes and other arthropods
- increase in urbanization
- increase in wildlife populations by conservation
- modified environment (e.g. feeding deer in winter)
- human–animal bonds
- climate variability (e.g. change in vector distribution)
- displacement of animals due to forest fires or other natural events (e.g. floods, hurricanes)
- ecotourism (e.g. recreational use of wild lands)
- disruption of habitat (e.g. rainforest) by deforestation and mining for economic interest

- immigration, legal and illegal
- increasing poverty in some countries in Latin America (includes issues of malnutrition, overcrowding, insect pests and vermin populations)
- lack of access to health care
- ethnic food preferences (e.g. eating wild animals)
- occupation-associated risks
- exotic animals being kept as pets
- legal and illegal importation of animals for pets
- intentional introduction of non-indigenous species
- intentional release of an agent
- laboratory biosecurity

A5.4.3 Surveillance and early warning systems needs

Many surveillance systems exist for wildlife, domestic animals and pets, and humans; however, they are not linked. There are several initiatives in the Americas that can play a role in surveillance and early warning of zoonotic disease outbreaks:

- VeTNET, which involves retraining of veterinary practitioners to recognize and report zoonotic agents as part of an outbreak response team;
- zoo practitioners have established a surveillance network;
- the Pan American Health Organization has a core database on zoonoses with 250 variables;
- the Laboratory Response Network of the United States Centers for Disease Control and Prevention involves over 100 laboratories in 50 states and includes personnel from public health and veterinary medicine.

A5.4.4 Actions to be undertaken to improve prevention and control of zoonotic diseases

A variety of actions at the regional, national and local levels in the Americas could assist in prevention and control efforts.

Regulatory:

- continuous review of existing regulations and quarantine procedures and their enforcement;
- identify gaps, areas of responsibility, coordination and communication (e.g. in the importation of exotic animals);
- look for innovative approaches for promoting intersectoral collaboration aimed at improving the interface between human and animal health sectors (e.g. having joint task forces with common goals).

Surveillance:

- incorporate already available data into linked data systems
- increase access to existing data and databases
- develop capacity for surveillance of wildlife disease
- review and integrate data at veterinary schools in the Region

– incorporate veterinary laboratory data into public health surveillance (use pets as an early warning)
– integrate human, domestic animal and wildlife data

Building long-term capacity and emergency preparedness and response:
– establish or strengthen regional reference laboratories
– strengthen regional diagnostic capacity
– strengthen regional epidemiology and outbreak response capacities

Resources:
– identify and access funding

Research:
– develop a research agenda that will optimize our understanding of the relationship between wildlife, animal and human populations and health
– promote vaccine development and uptake
– establish zoonotic disease centres, including expertise from academia and government, which focus on research

Education and training:
– enhance and continue the education of animal health and medical field workers
– promote an interest in pubic health activities and careers among students recruited into veterinary schools
– add a focus on zoonoses for veterinary and medical students and other students in health-associated areas
– ensure training in public health in human and veterinary medical programmes is complementary (e.g. teach students about the roles of all partners)
– develop post-veterinary study and practicum programmes
– educate specialists in veterinary and medical fields (e.g. in pathology, wildlife disease, epidemiology)

Communication and public education:
– enhance communication between partners in health
– further develop public education programmes

A5.4.5 Recommendations

There are several activities that could facilitate planning and implementation of actions in the Americas aimed at surveillance, prevention and control of zoonotic diseases including:
– holding a meeting of the relevant people from the Americas to discuss the next steps, strategies and priorities
– holding a meeting of relevant people from Pacific Rim countries to discuss related issues
– developing/enhancing links with a multitude of health-associated groups and stakeholders
– developing centres for zoonotic disease surveillance, prevention, control and research
– establishing multidisciplinary partnerships between international organizations, governments, nongovernmental organizations and academia

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