Zoonoses in Europe

Zoonoses in Europe:

a risk to public health

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PREFACE

Recent outbreaks of avian influenza and SARS have made us more alert to the emergence of zoonoses and have re-emphasised their potential threat to human health and economy. The Dutch Ministry of Health, Welfare and Sports has commissioned the Health Council of the Netherlands to prepare an advice to deal with the risks of (re-)emerging animal infections to human public health in Europe and the problems that may arise in the communication among the different disciplines and institutions involved. The Health Council has asked the National Institute for Public Health and the Environment (RIVM) to summarise the current knowledge on zoonoses in a reference document for the Council's advice. This scientific knowledge has been assembled in an abridged form in this RIVM report, which does not give answers to all possible questions on the matter, but rather summarises the important issues. The Health Council's advice will be presented at the conference *'European Response to Public Health Risks from Emerging Zoonotic Diseases'* organised during the Dutch presidency of the European Union in September 2004.

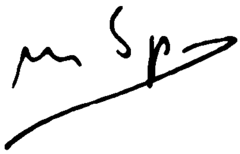
This report summarises insights from the scientific literature and the opinions of experts in the scientific community. It discusses two aspects: first, the potential risks of infectious diseases from the animal reservoir for public health in Europe and second, the current European legislative situation of the surveillance and control of zoonoses with special attention to cooperation among professionals in the fields of human and veterinary public health. The report should be read as a document providing scientific background for the Health Council's advice. It is beyond the scope of this reference document to describe the different surveillance and control systems in every European country. Instead, due to the nature of the assignment and the background of the authors, they take the situation in the Netherlands as an example to explain the organisation of surveillance and control of zoonoses.

We are grateful to the many experts who kindly cooperated by giving their views on the topic and by proofreading the various chapters.

As you will see while reading the report, animal diseases are a continuing threat to human public health in Europe. Complex and yet unknown sets of risk factors will lead to the introduction of new infections into the human population. Although we do not know which disease will emerge next, establishing early warning systems, syndrome surveillance and better cooperation among different disciplines, institutions, and authorities will make us better prepared and will surely improve our alertness and our abilities for early control of emerging diseases.

I am convinced that this report will be useful to those who are involved in the prevention and control of zoonoses in Europe.

Bilthoven, 16 July 2004



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ABSTRACT

Infectious diseases originating from animal reservoirs (zoonoses) are a constant threat to public health. Recent examples are the outbreaks of avian influenza and SARS.

Although it is impossible to predict which zoonoses will emerge in the coming years in Europe, this report aims to summarize current scientific knowledge on the risks of (emerging) zoonoses for human public health in Europe. For this purpose, currently known zoonoses that are more or less likely to cause problems in Europe in the future and risk factors that may be involved in the emergence of zoonoses are listed. Also, European legislation concerning zoonoses and the strengths and weaknesses of the prevention and control of zoonotic diseases are discussed.

The emergence of a zoonosis will often be the result of a complex mix of risk factors, in which the intensity of contact between the original reservoir (the intermediate reservoir and vectors) and human beings seems to be crucial. Prevention and control of the emergence of zoonoses is therefore very difficult and may require a double-edged strategy. On the one hand, preparedness needs to be improved as much as possible if it concerns zoonoses that are considered as a potential risk for public health in Europe (preparing for the known and/or imaginable). On the other hand, public and veterinary health systems, and the interaction of the two in Europe, need to be strengthened to generate basic scientific knowledge on missing links, to integrate current knowledge and to develop new ways for early warning and outbreak control to prepare as much as possible for new and currently unknown zoonoses. Concerted action at European level will be required to respond timely and effectively to zoonoses threatening public health in Europe.

HET RAPPORT IN HET KORT

Zoönosen in Europa: risico's voor de volksgezondheid

Infectieziekten die afkomstig zijn van dieren (zoönosen) vormen een constant gevaar voor de volksgezondheid. Recente voorbeelden van zoönosen zijn de vogelpest en SARS.

Het is niet te voorspellen welke zoönosen in de komende jaren voor problemen gaan zorgen in Europa. Toch wordt in dit rapport de wetenschappelijke kennis over de risico's van opkomende zoönosen voor de Europese volksgezondheid samengevat en wordt een overzicht gegeven van bekende zoönosen waarvan in meer of mindere mate gevreesd wordt dat ze in de toekomst voor problemen kunnen zorgen in Europa. Hierbij is gebruik gemaakt van zowel literatuurgegevens als ook van de meningen van experts. Ook wordt een overzicht gegeven van de factoren die in het verleden bij het opkomen van zoönosen een rol hebben gespeeld. Verder wordt de Europese wetgeving op het gebied van zoönosen samengevat en worden de sterke en de zwakke punten die naar voren kwamen in interviews met Nederlandse en Europese deskundigen genoemd.

Het opkomen van een zoönose is vrijwel altijd het gevolg van een complexe mix van factoren, waarbij de intensiteit van contact tussen dieren die de ziekte verspreiden, - eventueel via andere dieren (bijvoorbeeld via vectoren, zoals muggen) en de mens van cruciaal belang is. Om het opkomen van zoönosen te voorkómen en te bestrijden is een tweezijdige strategie nodig. Aan de ene kant moeten we ons beter voorbereiden op de zoönosen waarvan al gevreesd wordt dat zij in de toekomst voor problemen gaan zorgen, door humane en veterinaire systemen beter op elkaar af te stemmen (voorbereiden op het bekende/voorstelbare). Aan de andere kant moet meer fundamenteel onderzoek gedaan worden naar allerlei onbekende variabelen (zoals het vóórkomen van bepaalde ziekten bij wild en de invloed van het klimaat op bepaalde vectoren) en moeten systemen ontwikkeld worden om nieuwe ziekten tijdig op te merken (zoals zogenaamde early warning systemen en mogelijk syndroomsurveillance).
De Europese landen moeten gezamenlijk optreden om tijdig en effectief op het opkomen van (nieuwe) zoonosen ter reageren.

CONTENTS

KEY ELEMENTS OF THIS REPORT

This report aims to summarise scientific knowledge and opinions existing within the scientific community to achieve more insight into the risks of infectious diseases among animals for human public health in Europe and to sum up important European legislation concerning zoonoses and existing and nonexisting cross links between the veterinary and human public health sectors.

Emerging zoonoses can be divided into two categories: zoonoses that already exist in Europe or on other continents and that may emerge in Europe in the future; and new zoonoses that have never appeared or been recognised before (e.g. severe acute respiratory syndrome [SARS]), but that can emerge suddenly and globally in the future.

Chapter 2 summarises current scientific knowledge on risk factors for the emergence of currently known zoonoses. Zoonoses that are more or less likely to emerge in Europe are listed, described, and classified according to their mode of transmission, since this is a common identifier that can serve as a starting point for prevention. The list of zoonoses in Appendix IV gives no clues to the emerging zoonoses most relevant to Europe because this would need prioritisation. We mention some criteria that could be used to prioritise; however, prioritisation requires in-depth study, which is beyond the scope of this report.

At several levels, current knowledge needs to be improved (e.g. by means of more integrated knowledge on vector-borne diseases that are endemic to Europe, the effects of climate on vector populations, and subsequent effects on the occurrence of infectious diseases). Fundamental knowledge (e.g. on mechanisms of crossing the species barrier; pathogen discovery; interactions among climate, ecology, and infectious disease emergence; designing generic detection systems for early warning; etc.) should be acquired as well. Research may help find missing links with respect to reservoirs (especially with respect to wildlife), and identify vectors and pathogens to prevent or control the emergence of zoonoses that are already present in European animals, but are still unnoticed.

Chapter 3 discusses new and yet unknown zoonoses. Although it is impossible to predict the next new disease coming from animal reservoirs, factors that may affect emergence are listed, i.e. pathogen, reservoir and vector characteristics, transmission routes, geographical distribution, anthropogenic factors, and characteristics of the disease. The intensity of contacts between the original reservoir, (the intermediate reservoir and vectors) and human beings is crucial in the emergence of a zoonosis.

Prevention and control of the emergence of zoonoses, new or not, may require a double-edged strategy. On one hand, preparedness needs to be improved as much as possible (preparing for the known and/or imaginable). On the other hand, an analysis of the weaknesses that may hinder or delay the prevention and control of emerging zoonoses within the EU may reveal points for improvement.

Preparing for the known and/or imaginable may involve prioritisation of action. This might be helpful to get some idea of the most important threats. However, this subject is beyond the scope of this report.

Preparing for yet unknown zoonoses is difficult and basically means that changes in one of many risk factors – or even just chance – may be followed by the emergence of a new zoonosis. Since predictions of the occurrence new zoonoses are virtually impossible, the EU should strengthen itself as much as possible. For example, syndrome surveillance of early indicators (e.g. certain risk factors such as ecotourism and animal mortality) may facilitate early detection of new or existing zoonoses. At present, very few countries have developed systems for early detection of new diseases or syndromes, and the effectiveness of syndrome surveillance is still being debated.

For an efficient and quick response to zoonoses that threaten public health in Europe, concerted action should be taken, preferably coordinated at the European level (Chapter 4). At the WHO Geneva conference, concerns were raised about the current organisation of public health systems in Europe since they are fragmented and no supranational legal authorities exist. The responsibility for signalling and responding to emerging infections lies with the national authorities, each with their own decision-making structure for responding to a crisis, which will delay a European response towards emerging zoonoses. European legislation in the field of zoonoses surveillance and control has been developed. Other new developments are the installation of the European Centre for Disease Prevention and Control (ECDC) and the European Food Safety Authority (EFSA). At present, no formal cooperation is foreseen for these institutions, and it is not clear how they will interact with other (existing) networks.

In conclusion, infectious diseases originating from the animal reservoir are now increasingly recognised as a threat to human public health. Better preparedness to protect and respond is dependent on efforts to develop all levels of the public health infrastructure and to support research that leads to new diagnostics and surveillance systems, new vaccines, and new treatment regimens. Basic knowledge about several zoonoses needs also to be improved. If awareness, surveillance, and co-ordination are improved, we might be better prepared to recognise and combat the next emerging zoonosis more quickly and more efficiently than we would have in the past.

CHAPTER 1. AIMS AND DELINEATION OF THIS REPORT

1.1 Introduction

Recent outbreaks of SARS and avian influenza have again shown the large potential of microorganisms of animal reservoirs to adapt to human hosts. Newly emerged zoonoses such as bovine spongiform encephalopathy (BSE), other food-borne diseases, and some viral infectious agents (Nipah, Ebola, avian influenza, and monkeypox viruses) have had serious direct and indirect implications for public health. A wide variety of animal species, both domesticated and wild, have acted as reservoirs for these pathogens. Considering the wide span of animal species involved and the usually complex natural history of the pathogens concerned, effective surveillance, prevention, and control of zoonotic diseases have posed a real challenge to public health.

Undoubtedly, new zoonoses will occur and some existing zoonoses will invade new geographical areas or re-emerge in certain areas with the continuation of environmental changes and human settlement in formerly uninhabited areas. The question is not if, but how and when they will emerge and if existing public health monitoring systems will be successful in the timely detection and control of new or re-emerging zoonoses.

1.2 Aims

This report, which was written at the request of the Health Council (HC) of the Netherlands, aims to summarise scientific knowledge as well as expert opinions to answer the following questions:

1. *What are the risks of infectious diseases of animals (wildlife, livestock, and domestic animals) for human public health in Europe?*

2. *In what situations is good cooperation between the human public health sector and animal health sectors essential to prevent and/or control zoonotic diseases, and how can this cooperation be improved?*
   This question is only briefly addressed, as a detailed discussion of administrative liabilities and legislation issues is beyond the scope of this report.

The HC will use this report as a reference document in advising the Dutch Government on zoonotic risks.

1.3 Delineation of this report

The report primarily aims to list zoonoses that are relevant to public health, and that are considered to have a relatively high probability of emergence or re-emergence in Europe. Existing, well-described, and well-monitored food-borne zoonoses such as *Campylobacter* spp. and *Salmonella* spp. are not primary subjects of this report, although strains of increasing importance are discussed. Zoonoses that are deliberately introduced into human populations [1,2] and diseases that are primarily the result of toxins produced by animal-borne pathogens are not covered.

Potential risks of antibiotic resistance [3] are beyond the scope of this report. However, these risks are mentioned in some sections because the issue was considered a major concern during the WHO Geneva conference*.

In this report, the following definitions are used:

Infectious diseases originating from animal reservoirs (zoonoses). Diseases transmitted between vertebrate animals and man under natural conditions [4]. This includes diseases that are transmitted through a vector.

Emerging disease. In 1959, the World Health Organisation (WHO) defined an emerging disease as 'a disease that has appeared in a human population for the first time, or has occurred previously but is increasing in incidence or expanding into areas where it has not previously been reported' [4]. At the WHO Geneva conference in 2004, a new definition for emerging zoonoses was formulated: 'An emerging zoonosis is a zoonosis that is newly recognised or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographic, host, or vector range. It is noted that some of these diseases may further evolve and become effectively and essentially transmissible from human to human (e.g. HIV).' The 2004 definition is used in this report.

Reservoir. One or more epidemiologically connected animal and/or human populations in which the pathogen can be permanently maintained and from which infection can be transmitted to human beings (definition from Haydon *et al.* [5], with slight modifications).

European Union (EU). All countries affiliated with the EU, including candidate countries.

* The term 'WHO Geneva conference' is used in this report to refer to the WHO/Food and Agricultural Organization of the United Nations (FAO)/World Organization for Animal Health (OIE) Joint Consultation on Emerging Zoonotic Diseases in Collaboration with the Health Council of the Netherlands; 3-5 May 2004, Geneva, Switzerland; report in preparation (Appendix VII).

1.4 Outline

Chapter 2 lists known zoonoses that have a high probability of emerging and/or of acquiring significant public health relevance in Europe. This list was compiled on the basis of lists in the literature, notifiable zoonoses according to Directive 2003/99/EC, the World Organization for Animal Health (OIE) and affiliated countries (the Netherlands), and expert opinions. The focus is on zoonoses that are currently emerging in Europe or that have a high potential for emergence in Europe.

Chapter 3 describes the events that may lead to the emergence of currently unknown zoonoses from animals in the future. As literature on this topic is scarce, Chapter 3 is based mainly on the opinion of Dutch experts.

Chapter 4 focuses on EU legislation concerning prevention, surveillance, and control of existing emerging zoonoses and on the early detection of new zoonoses (early warning), and discusses possibilities for improving current systems by more efficient use of the existing organisations and monitoring systems. Chapter 4 also provides scientific arguments as to where improvements are advisable.

The *Appendices* provide details of the risk factors, lists of zoonoses, and an analysis of expert opinions from a self-administered questionnaire and face-to-face interviews.

CHAPTER 2. LISTING ZOONOSES BY THREAT TO PUBLIC HEALTH IN EUROPE

What are the risks of infectious diseases of animals (wildlife, livestock, and domestic animals) to public health in Europe? Existing threats.

2.1 Introduction

Emerging infectious diseases have increased our concern about human health. Key questions are: Are we able to predict emerging and re-emerging diseases? What are the main reservoirs? What are the main risk factors? Are we able to recognise new infections from these reservoirs in time?

The aim of this chapter is to compile a list of the most relevant zoonoses that might emerge in Europe. Therefore, the literature was searched for relevant information, analysing several Internet sources, such as the WHO, OIE, and Centers for Disease Control (CDC) Websites, and experts within the scientific community were consulted (by means of self-administered questionnaires, in-depth interviews, and information exchange at the WHO Geneva conference). In addition, risk factors for the emergence of zoonoses were discussed. Emerging zoonoses were clustered from the list of relevant zoonoses by transmission route and/or reservoir host to pinpoint the combined risk factors for emergence and the combined surveillance and control measures that can be taken. However, it should be noted that the fact that certain zoonoses are mentioned and clustered does not mean that these zoonoses will cause severe public health problems in the future. Therefore, the list should be prioritised by several criteria, preferably in a quantitative way. Several of these criteria are discussed here, and they could be used to weight the various zoonoses listed in this report.

2.2 From infectious diseases to emerging zoonoses

During the last decades, unknown human diseases such as AIDS, Ebola Dengue haemorrhagic fever and Hanta virus pulmonary syndrome emerged from enzootic foci. The emergence of these diseases has been linked to changes in ecosystems with high levels of biodiversity, and to increasing contact of these changing systems with livestock populations that are in close contact with dense human populations with changing behaviour. The interfaces pose a risk of the emergence of novel diseases [6]. In this section, the current knowledge of emerging diseases originating from animal reservoirs (zoonoses) is summarised from databases and the literature.

2.2.1 Human pathogen database

Taylor *et al.* constructed a database including 1415 identified species of infectious organisms known to be pathogenic to humans. They derived the data from several sources and included very recently described human pathogens, with 217 viruses and prions, 538 bacteria and rickettsia, 307 fungi, 66 protozoa, and 287 helminths in total. Of these 1415 human pathogens, 868 (61%) were considered zoonotic and 175 pathogenic species were associated with emerging diseases. This analysis showed that zoonotic pathogens are more likely to be associated with emerging than non-emerging diseases [7,8]. Ectoparasites were excluded from this database. No association between transmission route and emergence was found. The conclusion was that, of the 175 emerging organisms, 132 (75%) were zoonotic, and overall, zoonotic pathogens were twice as likely to be associated with emerging diseases as nonzoonotic pathogens. Even though this analysis is based on a list of microorganisms that is unlikely to be complete, and the disease emergence is to some extent subjectively defined, some broad conclusions could be drawn. It was shown that, among taxa, protozoa and viruses are particularly likely to emerge, and helminths are particularly unlikely to do so.

2.2.2 Outbreaks of emerging zoonoses

In this section, we elaborate on the emergence of zoonoses that have caused outbreaks the last 5 years and were mentioned in WHO's Disease Outbreak News on the Internet [9]. However, not only the outbreaks are important in the emergence of zoonoses; there are some zoonoses that are steadily increasing their prevalence without causing outbreaks. Listing these zoonoses is difficult because incidence figures from various countries can differ, are difficult to compare, and are not readily available to describe disease emergence. Appendix II shows the outbreaks from 1999–2004 listed in WHO's Disease Outbreak News on the Internet [9]. Figure 2.1 shows major outbreaks occurring between 1996 and 2004 as listed by WHO. Most emerging zoonoses still occur in Africa and Asia. Although strictly not zoonoses (because humans are now the main amplifying hosts; see definition in Chapter 1), yellow fever and dengue haemorrhagic fever have caused frequent outbreaks with many cases in the tropics (Africa, South and Middle America, and South-east Asia). Other frequently occurring

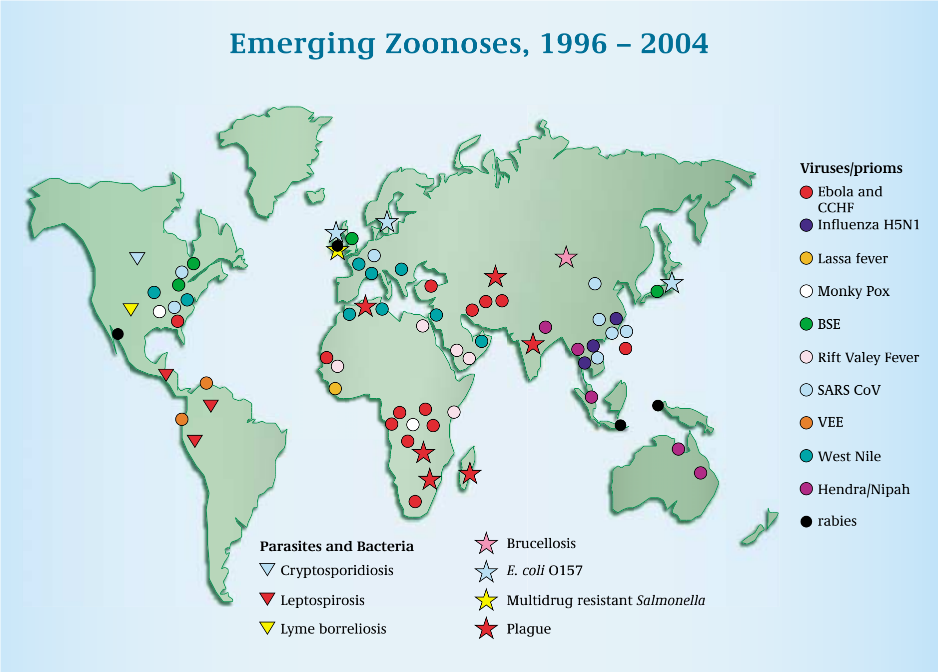

Figure 2.1. Emerging zoonoses, 1996-2004.
Reprinted with permission of WHO Communicable Disease Surveillance & Response (CSR), F. Meslin and P. Formenty
BSE, bovine spongiform encephalopathy; CCHF, Crimean Congo haemorrhagic fever; CoV, Corona virus; VEE, Venezuelan equine encephalitis

haemorrhagic fevers are Ebola and Crimean Congo haemorrhagic fever (CCHF) in African countries. Avian influenza and SARS occurred in numerous countries in 2003 and 2004. Between 1999 and 2004, outbreaks of the following zoonoses were listed for Europe: tularaemia (2002, Kosovo), avian influenza (2003, the Netherlands), and trichinellosis (2003, Germany).

2.2.3 Risk factors for emergence

Several factors have facilitated the emergence of new diseases and the re-emergence of already known diseases that were thought to be under control. The factors include microbiological adaptation, environmental changes, globalisation of agriculture, food production and trade, and human behavioural factors. Other factors have accelerated emergence, such as the disruption of public health systems. For this report, risk factors for the emergence of infectious diseases that are mentioned in official reports and at Websites of various organisations [American Society for Microbiology (ASM), CDC, OIE, WHO, and Food and Agriculture Organization (FAO) [10-13]] were summarised, as well as risk factors mentioned in the literature [14-18] (Table 2.1).

The existence of most risk factors listed is almost entirely the result of human influence, and although they all have their own specific accents, risk factors are often

Table 2.1. List of risk factors for the emergence of zoonoses taken from the literature and the WHO Geneva conference

Category
Risk factors associated with the agent
Microbiological adaptation and selection
Anthropogenic risk factors
Characteristics of the human host population
Human behaviour
Political issues
Economic issues
Climate and ecology
Developments in animal husbandry
Medical developments

intertwined. Many different factors have played an important role in the emergence of most diseases. The set of risk factors and their interaction in the emergence of a disease is complex and varies by pathogen. Appendix III discusses risk factors that may have played an important or even crucial role in the emergence of some illustrative infectious agents [human immunodeficiency virus (HIV), West Nile virus (WNV) and avian influenza viruses].

Risk factors associated with the agent: microbiological adaptation and selection

Microbiological adaptation and selection is a continuous process and occurs through spontaneous mutation (genetic 'drift') and exchange of DNA/RNA between microbes (genetic 'shift'). Influenza viruses are well known for their rapid genetic changes.
The human SARS Coronavirus (SARS-CoV) is closely related to viruses found in masked palm civets *(Paguma larvata)* and raccoon dogs *(Nyctereutes procyonoides)*, the only difference being a 29-base-pare sequence occurring in the animal species, but not in most of the human cases [19]. This suggests that this genetic change was involved in the disease emergence [20]. By adapting to new animal hosts, pathogens may also invade new geographical areas.

Anthropogenic risk factors

All other listed risk factors are directly or indirectly the result of human activity. Among these are demographic changes, behavioural issues, socioeconomic environment, political developments, environmental changes, and developments in the agricultural and medical sectors.

Characteristics of the human host population. Demographic factors involve increasing population densities, which leads to a greater probability of zoonotic outbreaks (urban zoonoses [14]), but also increasing populations of susceptible elderly people in affluent countries. In contrast, poverty, undernutrition, and underlying chronic diseases [such as acquired immunodeficiency syndrome (AIDS)], that frequently occur in developing countries also increase susceptibility.
Vaccination may increase human immunity to specific pathogens, and, consequently, cessation of vaccination may lead to the lack of vaccine-induced or wild-type immu-

nity. The consequence is that populations may become susceptible to closely related microorganisms or viruses (e.g. the eradication of smallpox followed by increased susceptibility to other orthopox viruses).

Human behaviour. This involves individual high-risk behaviour and travel, for instance. Other examples are keeping exotic pets at home when suffering from immunosuppression, consuming exotic meats, not using insect repellents or bed nets in the tropics, unsafe sex, and using drugs. Currently, leishmaniasis is emerging in Spain and is now mainly transmitted from intravenous drug user to another by their sharing needles [21]. Exposure to exotic pets and consumption of exotic meat may increase risk of spreading exotic diseases [22]. For example, prairie dogs that were infected by recently imported ill Gambian giants rats (*Cricetomys* spp.) from Ghana subsequently caused a monkeypox outbreak in humans [23]. Recreational activities may increase exposure to several vectors, such as ticks. The prevalence of Lyme borreliosis is currently growing in many European countries [24]. International travel, particularly air travel, increases the opportunities for the quick and wide spread of diseases. For example, SARS was spread from Hong Kong to Canada and many other countries because of disease transmission caused by travelling of infected people [25].

Political issues. War, political instability, or lack of political interest may cause deterioration of human and veterinary public health systems or may hinder the proper containment of emerging zoonoses. This leads to decreased quality of care, delayed diagnosis and treatment, and the breakdown of prevention, surveillance, and control systems. With the change of political leadership in eastern Europe, public health systems and social structures deteriorated, and several zoonoses that had been occurring at low frequencies during previous years re-emerged [26]. An example of such zoonoses is trichinellosis, the incidence of which increased sharply in Romania shortly after the change of power. Currently, the prevalence is decreasing again [27]. In countries with relatively well-organised public healthcare systems, lack of integration of human and animal disease surveillance may hinder the timely recognition of disease emergence.

Economic issues. Economic development activities can have intended or unintended impacts on the environment. Economic development may have numerous consequences, many of which can be identified in other risk factors. For example, economic development can increase international travel intensity, can increase the prevalence of factory farming, and can change demographics (e.g. increasing population density, which may in turn increase the pressure on arable land, leading to changes in land use and to conflict). The increasing income in low/middle income countries has led to a sharply increasing demand for animal proteins, which has consequences for farming practices and global trade. Indeed, factory farming is currently being practised in the proximity of many cities in southeast Asia [28].
Rapid and wide distribution of animals and animal products can lead to the broad dissemination of pathogens, especially those pathogens that do not cause symptoms immediately. An example is BSE, which originated in the United Kingdom and then was introduced to the mainland of Europe [29]. Lack of economic development may

increase poverty, which leads to various adverse conditions, some of which have already been mentioned. Crowding, reduced hygiene, and lack of clean drinking water may increase the risks of the emergence of infectious diseases. Plague, a disease caused by *Yersinia pestis* and transmitted from small rodents to people by fleas, is an example of a disease that flourishes in poor hygienic conditions (http://www.who.int/mediacentre/factsheets/fs267/en/).

Climate and ecology. Research indicates that the global climate is changing [30]. Global warming may have many different and largely unpredictable consequences, such as an increasing level of sea water, increasing rainfall in several temperate regions, decreasing rainfall in other regions, and an increase of several natural phenomena such as tornados and cloudbursts. These climate changes may have important effects on the distribution patterns of many zoonoses. For example, Lyme borreliosis is emerging, apparently because tick populations transferring *Borrelia burgdorferi* spp. have been growing, probably partly due to the current warm summers and mild winters in northern Europe, which have helped tick populations to thrive [31].
Ecological changes, such as encroachment of forests and destruction of natural areas (frequently occurring in Africa, South America, and Asia) may increase human contacts with animals that they have not met before, and these animals may carry microbes that may adapt to humans, leading to new diseases. For example, Nipah virus originates in the bats of the *Pteropus* genus living in the rainforests of South-east Asia. Due to the large forest fires of recent years, bats moved towards human settlements where they transmitted the virus to pigs that transmitted it to humans. This caused outbreaks of encephalitis [32] [33]. In contrast, in several European countries with nature restoration programmes, opportunities for sylvatic animals (vertebrates and arthropods) increase and so do opportunities for the spreading of zoonotic pathogens.

Developments in animal husbandry have direct effects on the density of domestic animals in a certain areas. Factory farming often leads to crowding of domestic animals, such as poultry, pigs, and cattle. This increases the risk of fast and efficient transmission of infectious agents. The large outbreaks of avian influenza in South-east Asia occurred in areas with high densities of poultry (Appendix III). However, factory farming may also increase the possibilities for disease control by means of mass vaccination and the prevention of contacts between domesticated and wild animals. Nonetheless, extensive farming may increase the probability of the exchange of pathogens between domestic and wild animals, and their ultimate transmission to humans. Examples of the transmission routes are avian influenza and several parasitic infections such as trichinellosis and toxoplasmosis.
Other factors that may increase the risk of emergence or re-emergence of zoonoses include the increased use of monocultures that are prone to certain diseases, efficient dissemination of a disease through widely distributed agricultural products, and the use of antimicrobials and pesticides for growth production that may cause the emergence of resistant strains.

Medical developments. At the start of the AIDS epidemic, blood transfusion played a significant role in the spread of the disease among heterosexuals (especially haemophilia patients) in the affluent countries [34]. Xenotransplantation may also harbour great risks of dissemination of viral diseases.

2.3 List of potential diseases emerging from animal reservoirs relevant to Europe

The literature was searched for the target words 'emerging' and 'zoonoses/zoonosis' so that a list of emerging zoonoses that may be or may become important for Europe could be made. In addition, the OIE-list of notifiable zoonoses was screened, Websites (WHO, OIE) were analysed, and the EU directives on zoonoses were analysed. Dutch experts in the fields of human and veterinary virology, bacteriology, parasitology, and public health were asked if they could suggest additional zoonoses. Moreover, during the workshop at the WHO Geneva conference, experts from several European countries were asked the same question again (Appendix V).
From all these sources of information, a list of potential emerging zoonoses that are relevant to Europe (Appendix IV) was compiled. This list includes the zoonotic diseases, classified as viral, bacterial, and parasitic. The list gives the etiological agent, primary or most likely reservoir, mode of transmission, and, briefly, the geographical distribution.

To contain the risks of known zoonoses for human public health in Europe, ideally, diseases should be prioritised according to their probability of emergence and the severity of their symptoms. Several criteria for the relevance of threats should be considered and, if possible, weighted (Table 2.2). However, it is very difficult to anticipate the dissemination of zoonoses because the spread in time and space is very unpredictable for almost all of them. Moreover, many factors are involved in the emergence of zoonoses, and their interaction is often complex (Section 2.2.2). Accurate data are needed for quantitative risk analyses, which are not readily available for emerging zoonoses.

Table 2.2. Criteria that can be used for prioritisation.

Criteria
One or more risk factors present currently or in the future
Transmission speed (basic reproductive rates, R0)
Human-to-human transmission
Incidence, prevalence, presence
Trends (in incidence)
Attack rate
Case fatality rate
Availability of (preventive) treatment or vaccination
Cost
Risk perception

Scenario analyses ('what if') may be useful to estimate risks and to develop priority ratings. Priority ratings have been developed to categorise infectious diseases according to the priority level they should be assigned for surveillance and control [35-37]. For the reasons already stated, quantitative risk analyses and prioritisation were not applied for this paper.

However, zoonoses were clustered according to their primary reservoir and/or mode of transmission because diseases with a common reservoir and/or transmission route may be clustered in early warning systems, and monitored, prevented, and controlled in similar ways. The following clusters were defined:

- Vector-borne zoonoses
- Zoonoses transmitted by direct or indirect contact with wildlife
- Zoonoses transmitted by direct or indirect contact with production animals and food
- Zoonoses transmitted by pets.

2.3.1 Vector-borne zoonoses

Vector-borne diseases result from infections transmitted to humans and other animals by blood arthropods such as mosquitoes, sandflies, ticks, and fleas. Vector-borne pathogens, including arboviruses, rickettsiae, bacteria, protozoa, and worm parasites, spend part of their life cycles in cold-blooded arthropod vectors. Their distributions are thus influenced by environmental change. To understand the environmental changes in disease emergence, integration of climatic changes and diverse branches of biology (such as ecology, wildlife biology, conservation biology, invasion biology, wildlife veterinary medicine, and microbiology) are required [15 38]. There are numerous factors that are changing the physical and social environment on Earth to such an extent that they will be able to influence the status of many vector-borne diseases in the future. However, it is important to emphasise that there is considerable uncertainty about the extent to which each of the changes will occur in the future [38]. For some vector-borne zoonoses, more in-depth studies in relation to climate change and vector populations have been carried out [31 38-43].

Endemic vector-borne zoonoses that can emerge. Vector-borne zoonoses already present or endemic in Europe and with potential for emergence include West Nile virus (WNV), sandfly-borne diseases, CCHF, tick-borne encephalitis (TBE), ehrlichiosis, bartonellosis, rickettsiosis, Lyme borreliosis, babesiosis, and leishmaniasis. Factors enhancing the possible spread of these zoonoses are climatic changes, increased animal reservoir densities, and more interplay between humans and nature (recreational activities). Different management of growing wildlife populations may lead to larger and possibly new tick populations. Here the relevance of these endemic and potentially emerging zoonoses for Europe is discussed, categorised by vector type.

Mosquito-borne diseases. WNV is a mosquito-borne flavivirus and a human, equine, and avian neuropathogen. The virus is indigenous to Africa, Asia, Europe, and Australia, and it has recently caused large epidemics in Romania, Russia, and Israel. Birds are the natural reservoir (amplifying hosts), and WNV is maintained in nature in a mosquito-bird-mosquito transmission cycle primarily involving *Culex* spp. mosquitoes. WNV was recently introduced to North America, where it was first detected in 1999 during an epidemic of meningoencephalitis in New York City (Appendix III). From 1999 to 2002, the virus extended its range throughout much of the eastern parts of the USA, and its range within the western hemisphere is expected to continue to expand [44]. Introduction of WNV in Europe is supposed to be merely a matter of time [45]. According to a WHO report reviewing European vector borne diseases [46], other mosquito-borne viruses relevant to Europe include Bunya viruses: the Batai, Ockelbo, Inkoo, and Tahyna viruses.

Dengue was once endemic to Southern Europe (outbreak in Greece in 1928), but although the disease disappeared from Europe, mainly because of piped water supplies, it is still one of the most important global arboviral diseases. Four closely related, but antigenically distinct, virus serotypes exist. It is primarily a disease of the tropics. The spread of dengue is limited because of the cold intolerance of its natural vector *Aedes aegypti,* a domestic, day-biting mosquito that prefers to feed on humans. Dengue virus can also become transmissible by a possible other vector, *Aedes albopictus,* which also occurs in Europe. Important risk factors include the strain and serotype of the infecting virus, as well as age, immune status, and genetic predisposition of the patient.

Tick-borne diseases. Ixodus ricinus, the European sheep tick, is the most common tick in Western Europe with a distribution towards Central Asia and North Africa. It serves as a reservoir for *Borrelia* spp., *Ehrlichia* spp., *Francisella tularensis, Rickettsia helvetica* [47 48] and the TBE virus in Europe. A marked northward spread of *I. ricinus* in Sweden during the last two decades was closely related to summers and winters in the 1990s that were warmer than those of the preceding three decades [31]. Tick-borne encephalitis and Lyme borreliosis are considered the two major vector-borne diseases of the northern temperate regions due to significant increases in incidence since the 1980s, eventhough these diseases show very different epidemiological patterns [24]. Increased incidences of TBE in the Baltic States and Central Europe may have arisen largely from climatic changes and changes in human behaviour (contact with infected ticks). New foci are predicted in Scandinavia, whereas the disease will decrease around the southern edge of its present range [24]. In Europe, CCHF caused by Nairo virus was first isolated in 1944–1945 in the Crimea, but is now reported from Balkan countries, Portugal, and the Russian Federation. The most recent outbreaks were reported from Albania and Kosovo in 2002. The virus can be transmitted by a wide range of ticks including *I. ricinus,* but is perhaps most efficiently transmitted by members of the *Hyalomma* genus. It causes severe disease in humans, and human-to-human spread may occur [9]. In Europe, the emergence of Lyme borreliosis is favoured by increasing populations of ticks, rodents, and other wildlife reservoir hosts. It is one of the most important vector-borne diseases in Europe. Rickettsial diseases are a model of emerging diseases, as before 1974 there were only four known tick-borne *Rickettsiae,* but to date, another nine pathogenic tick-borne rickettsial species have been described [47 48]. An expanding distribution of *I. ricinus* may be responsible for the emergence of other yet unknown tick-borne diseases too.

Sandfly-borne diseases. Sandfly-borne viruses are all within the Bunya virus group, and in Europe these include the Arbia, Corfou, Naples, Radi, Sicilian, and Toscana viruses. Most are common throughout Southern Europe and can be imported by tourists returning from endemic areas. Neurological disorders are most obvious from Toscana and Sicilian virus infections, although clinical illness is thought to be only the tip of the iceberg [9].

Leishmaniasis occurs in more than 100 countries, from warm temperate countries through subtropical to tropical countries, but not in South-east Asia and Australia. Human infection is dependent on the ecological relationship between human activity and reservoir systems. Changes in the environment may lead to changes in the distribution of the parasite. Emergence of leishmaniasis has been facilitated by new reservoir hosts, new vector species, transport of infection by human and animal hosts, introduction of humans in zoonotic foci, and extension of reservoir hosts beyond their normal range [49]. Potential changes in the geographical distribution have been described in South-west Asia, with the expansion of the vector *Phlebotomus papatasii* due to global warming [38]. Visceral leishmaniasis and cutaneous leishmaniasis in Europe are caused by *Leishmania infantum* (*L. donovani infantum*) transmitted by sandflies, mainly *Phlebotomus* spp.. Its geographical distribution area includes southern France and the Mediterranean countries. The main reservoirs are dogs, foxes, and rodents. The disease is mainly associated with rural environments, where the flies breed and shelter in rodent burrows. Specific attention should be given to visceral leishmaniasis associated with HIV infection in Spain that is transmitted by sharing contaminated needles and syringes for drug use [50]. In Italy, visceral leishmaniasis caused by *L. infantum* is transmitted by *Phlebotomus perniciosus.* Low temperature appears to be one of the main factors that has prevented the vectors from spreading to Northern Europe so far [38].

Flea-borne diseases. The best-known flea-borne disease is plague, transmitted by fleas of the main reservoir *Rattus rattus* and caused by *Yersinia pestis*. Although plague remains endemic in many parts of Africa, Asia, and the Americas, no known endemic foci occur in Europe. The risk factors for emergence are poverty, social instability, animal trade, and war situations. In Europe, plague has been reported from the Balkan States, France, Spain, Greece, the Russian Federation, and Portugal. Outbreaks are likely to occur in other countries as well. Other examples of flea-borne diseases endemic in Europe are rickettsial diseases like murine typhus caused by *Rickettsia typhi*, and cat scratch disease caused by *Bartonella henselae*. Cats are healthy carriers, and fleas transmit the disease among cats. Human transmission occurs via cat scratches. Human infection may give rise to bacillary angiomatosis in immunocompromised patients, or chronic lymphadenopathy and endocarditis in healthy people [14]. *B. henselae* is widespread in Europe [9 46].

Newly introduced, vector-borne zoonoses. Zoonoses, newly introduced to a continent by infected animals (via international trade) or humans (via international travel), but not yet present in Europe, may depend on the presence of suitable vectors and climatic conditions to survive and spread in completely new environments [24 38 51 52]. Examples of these zoonoses are dengue, yellow fever, Rift Valley fever, and trypanosomiasis. Dengue is considered second after malaria in the number of humans affected worldwide [53]. However, the zoonotic character of dengue and yellow fever is not common because the main animal reservoir is human. Higher temperatures can accelerate the transmission of yellow fever and dengue, even in dry areas where there are artificial water containers. In addition, survival of vectors may be favoured in certain circumstances in metropolitan areas, for example [38]. Rift Valley fever is an important veterinary pathogen with great potential to cause lethal disease in sheep and cattle. It can also cause severe diseases in humans during epidemics among animals. The virus is amplified and transmitted via a wide variety of *Culex* and *Aedes* spp. mosquitoes, and can also transmit without a vector. Experimentally, the virus can infect a wide variety of animals and has a broad geographical range. Therefore, it can emerge rapidly in areas with extensive livestock husbandry. Although the virus has never appeared outside Africa, transmission to nonendemic areas via contaminated animal products, viraemic humans, or nonlivestock animal species is possible and it is a matter of concern. Trypanosomiasis caused by protozoan flagellates *Trypanosoma brucei rhodesiense* limited to East and South-east Africa and *Trypanosoma brucei gambiense* found in large areas of West and Central Africa can create problems for humans and livestock.

Current status regarding vector-borne zoonoses
Risk assessment to predict the possible emergence of vector-borne pathogens includes knowledge of the climate, ecology of arthropods, migration patterns of wild birds, microbiological expertise, influence of human behaviour, and most important, the interaction among these factors. Many of these factors are relevant to Europe and may become active in the emergence of these zoonoses. So far, experts have all stressed the importance of these zoonoses and the lack of expertise in the field of European arthropods, wildlife ecology, climatic changes, and ecological factors in relation to infectious disease emergence in Europe.

2.3.2 Zoonoses transmitted by direct contact with wildlife

Zoonoses that are transmitted by direct contact with wildlife, are endemic to Europe, and are occurring more often or that can emerge are: avian influenza spread by wild birds, Hanta virus infection, rabies (classical and European bat lyssa viruses), pox viral infections, tularaemia, leptospirosis, larva migrans syndrome caused by *Baylisascaris* spp. and echinococcosis.

The avian influenza outbreak in Hong Kong (H5N1) and the outbreak in the Netherlands (H7N7) affected a limited number of people and caused unfortunate deaths [54]. These outbreaks were followed by an H5N1 outbreak in several South-east Asian countries in 2003 and 2004. The main reservoirs of avian influenza viruses are wild birds.

Avian influenza viruses have not easily been transmitted from human to human. However, these are three consecutive occasions that show evidence of an avian influenza virus crossing the human species barrier, which caused infection and death of humans and human-to-human transmission (Appendix III).

Hanta viruses are prevalent worldwide. The virus is endemic in Central and Western Europe, where the predominant serotype is Puumala, transmitted by rodents. It causes renal failure and possibly neurological disorders [55]. A few hundred cases are reported in Europe annually. Exposure to rodent excreta containing the virus may lead to infection and disease. Growing or spreading rodent populations and close contact with humans may lead to greater infection risks of humans. Epidemics occurred in Belgium [56] and North-west France in 1995 and 1996 [57].

Rabies, caused by *Rhabdoviridae,* is emerging in many parts of the world due to growing stray dog populations. However, in Europe, rabies is successfully combatted by oral vaccination programmes for foxes, the primary wildlife reservoir in Europe [58-60]. However, small foci of rabies still occur in foxes in some parts of Europe, which may be a matter of concern in future. Moreover, the increasing prevalence of the racoon dog, a potential carrier of rabies, is another concern in Europe. The effectiveness of the fox oral vaccination programmes in controlling rabies in racoon dogs is not clear [61]. *Rhabdoviridae* that infect bats in Europe are referred to as European bat lyssa viruses (EBLVs) types 1 and 2 (genotypes 5 and 6, respectively). These rhabdoviruses are closely related to the classical rabies virus and are associated with human disease [62]. More than 700 cases of EBLV in bats have been reported between 1977 and 2003. More than 95% of the viral isolates diagnosed have been confirmed as EBLV type 1, and they occurred mostly in serotine bats, whereas EBLV type 2 has been associated with the *Myotis* species of bats. Transmission from bats to livestock, wildlife, and man is possible. Since 1977, four human deaths from EBLV infections have been reported. Due to the protected status of bats in Europe, knowledge of EBLV prevalence and epidemiology in bats is limited [62,63].

Poxvirus infections affect humans and many species of animals. Smallpox, caused by the only human-specific orthopoxvirus, variola, was successfully eradicated in the twentieth century by the induction of cross-protection through vaccination with vaccinia virus. Since the eradication of smallpox and the cessation of vaccination against smallpox, human infections with other animal poxviruses, mainly causing self-limiting infections, may become more prevalent due to the lack of cross- protective immunity. The main reservoirs for animal orthopoxviruses may be rodents [64]. In 2003, a first outbreak of monkeypox in the western hemisphere initially affected 11 people in Wisconsin after a bite or direct contact with infected prairie dogs. These animals were in close contact with recently imported ill Gambian giant rats (*Cricetomys* spp.) from Ghana [23]. Although the natural history of monkeypox is not clear, naturally infected species in Africa include various rodents (squirrels, rats, mice, and porcupines) and primates [65]. After the initial outbreak, a total of 72 confirmed or suspected cases occurred in the USA. In addition, during the early phase of the epidemic, prairie dogs were exported to Western European countries including the Netherlands and Germany. No cases were reported, but it was clear that international trade in the area of exotic pets is an important risk factor for emerging zoonoses worldwide. This incident thus showed the need for an international early warning system and a system for the trace-back investigations of commercially sold exotic pets. The introduction of new poxviruses to new animal species in new habitats in the world may lead to new animal reservoirs. Whether monkeypox escaped into the North American rodent vector during the outbreak remains unclear [64].

Tularaemia is a plague-like disease observed in ground squirrels in California in 1911, which was caused by a Gram-negative bacterium *Fransiscella tularensis*. It occurs worldwide in more than 100 species, mostly wild animals, birds, insects, and ticks (*I. ricinus, Dermocentor* spp.). Two main biovars, types A and B, are found in North America. Biovar A produces the more serious disease in humans, acute febrile illness with an untreated case fatality rate of 5%. Biovar B is widespread in the temperate regions including Europe, and causes a milder, often subclinical, disease. It can be transmitted by different routes: bites by infected arthropods; direct contact with infected animals or tissues; contaminated food, water, or soil; and inhalation of infective aerosols. In Europe, large outbreaks occurred in Kosovo in 2000 and 2002 [9] and also in Finland and Sweden. Although it might be not of broad public health importance at this time, tularaemia might be important focally because of its facile transmission, high mortality (depending on the subtype), and virulence of the infection [46].

The *Baylisascaris procyonis* infection of racoons is recognised as a cause of severe human disease and is an emerging helminthic zoonosis. It may become a more serious public health problem than is currently recognised [66]. Adult worms are found in the small bowel of racoons, but natural infections have also been reported in dogs and foxes. Humans and other parathenic hosts (rodents and small mammals) may be infected by environmental uptake of infectious eggs that causes a larva migrans syndrome. An estimated 5–7% of larvae invade the brain, which leads to neurological disorders. The parasite is known to exist in Eastern Europe, and human cases in Germany have been described.

The adult stage of the cestode parasite *Echinococcus granulosus* inhabits the intestines of carnivores. Eggs shed via faeces are taken up by intermediate hosts including humans, leading to the larval stage of the parasite and pathological conditions in the liver and lungs. In humans, the disease is called hydatid disease, a serious parasitic zoonosis. Mediterranean countries are reporting alarmingly high prevalences of *E. granulosus* in humans and animals, and the rates of incidence in some Eastern European countries and Central Asia are rising. These data provide strong evidence of a real increase or re-emergence of the incidence and prevalence of hydatid disease [67]. *Echinococcus multilocularis* is of serious importance in Europe. The disease is transmitted by oral uptake of eggs from the environment, and the main reservoir in Europe is the fox. In humans, infection may lead to a very serious life-threatening disease, alveolar echinococcosis. Increased prevalences in Central Europe (the well-known endemic region of the parasite) and the spread of the parasite to new areas in Europe in the last 15 years have been described. More than 550 human cases have been described in Europe since 1980 [68]. Control of *E. multilocularis* in the primary reservoir is difficult because of the absence of a vaccine and growing fox populations.

Newly introduced zoonoses originating from wildlife

Zoonoses from wildlife may be introduced to Europe by an infected animal or human patient via travel or trade. Examples of these infections are Ebola, Marburg or Lassa virus infections, and retroviral infections, and to a lesser extent, possibly Nipah, Menangle, and Hendra virus infections.

Human Ebola virus infections cause haemorrhagic fever and death within a few days. Each epidemic resulted from the handling of an infected monkey carcass (chimpanzee/gorilla). Increased animal mortality always preceded the first human cases. The most lethal strains cause up to 88% mortality in central Africa [69]. The high case-fatality rates of these viruses may hamper their spread towards other regions [70].

Nipah, Hendra, and Menangle virus infections emerged in South-east Asia and Australia because of close contact between wildlife reservoirs (flying foxes and bats) and domestic animals. Hendra virus, initially named equine morbillivirus, was the cause of outbreaks in horses in Australia, but does not appear to be very contagious [71]. Nipah virus was responsible for major outbreaks in pigs and humans in Malaysia and Singapore with more than hundred of cases of disease and death [72], and there have been several recent outbreaks in Bangladesh [9].

Retroviral zoonoses have received public health attention due to the origin of HIV_1 and 2 linked to cross-species transmission of simian immunodeficiency viruses (SIVs) from naturally infected primates, where prevalences can range up to 36%. Human exposure due to hunting, butchering, or keeping infected primates have been suggested as possible routes of infection [73] (Appendix III). A recent study identified simian foamy viruses among people exposed to nonhuman primates. This highlights the relatively frequent cross-species transmission of simian retroviruses to humans and draws attention to the risk of human infection with these viruses [74].

2.3.3 Infections via direct contact with production animals and food

Zoonoses of production animals transmitted to humans via their meat or milk are known as food-borne zoonoses, but most of these zoonoses can also be transmitted via direct contact. In Europe, tuberculosis, brucellosis, salmonellosis, campylobacteriosis, verocytotoxin-producing *Escherichia coli* (VTEC), trichinellosis, toxoplasmosis, hepatitis E, cryptosporidiosis, and cysticercosis are potential emerging diseases. Another serious threat is the trade and consumption of meat from exotic animals and the emergence of new strains that are more virulent or resistant to antibiotics.

Tuberculosis is still one of the most important bacterial infectious diseases worldwide. Although tuberculosis caused by *Mycobacterium bovis* is a well-known zoonosis, new multiresistant strains may become important in the future, especially when travel and trade with Eastern European countries becomes more frequent. In this respect, we should also turn our attention to brucellosis spread by the trade of infected goats from Southern European countries to Northern Europe.

The overall human disease burden of salmonellosis and campylobacteriosis probably makes these infections the most important ones in Europe. The incidence of campylobacteriosis increased in the 1990s in countries all over the world except the United States and the Netherlands. Furthermore, new and emerging strains like VTEC, *Salmonella enteritica* DT 104 and the multiresistant Newport strain have been described.

Hepatitis E virus (HEV) is endemic in much of the developing world. Infections in humans can result in acute hepatitis, and the infection may cause serious complications, especially for pregnant women. In Europe, the prevalence is rather low (1-3%), but in recent years more and more people who have not been abroad have been diagnosed with this infection. HEV is prevalent in some animal species and it has been stated that HEV sequences, closely related to human HEV sequences, can be detected in pigs in developing as well as industrialised countries [75]. Recently, zoonotic food-borne HEV infections have been reported from Japan. Several HEV outbreaks occurred after people had eaten the raw meat of wild boar and deer [76].

Cryptosporidium parvum is a protozoa that causes gastroenteritis in humans and animals. It can be transmitted via livestock and water supplies [77] [78]. Food-borne transmission, including transmission in meat, has been described [79].

Strictly meat-transmitted zoonoses include trichinellosis, which is transmitted via infected, raw or insufficiently cooked pork, horsemeat, and game. Attention should be paid to this zoonosis because of changing behaviour in human food consumption, changing EU regulations, and the appearance of new *Trichinella* strains in new hosts [80].

Neurocysticercosis due to *Taenia solium* remains an important health issue in many countries in Africa, Asia, and Latin America. Approximately 50 million people are infected and some 50,000 die of cysticercosis annually. Poor hygiene, poor pig management, and lack of proper meat inspection and control favour the spread of the parasite. Control can be achieved with the current technology, therefore control is presumed to be a political decision [81]. *Taenia solium* is still endemic to Eastern Europe so that increased international trade and especially travel of human *T. solium* carriers may introduce the parasite to new geographic regions in Western Europe.

Finally, the appearance of new species or strains in unexpected hosts, possibly more pathogenic or more resistant to antibiotics, as well as the importance of direct transmission, warn us not to ignore well-known food-borne zoonoses. The market for the meat of exotic game animals or new domesticated animals imported from outside the EU is rapidly growing [82]. This may result in the introduction of new zoonotic agents.

2.3.4 Zoonoses transmitted by pets (dogs, cats, rodents)

Pets living in close contact with humans may be important because of direct or indirect transmission of zoonoses such as toxoplasmosis, campylobacteriosis, salmonellosis, and echinococcosis. Bite incidents are a substantial public health problem, with 4.7 million cases and 800,000 hospitalised patients in the USA annually [83], and transmission of zoonotic pathogens via this route might cause many deaths if the patients are left untreated. *Capnocytophagia carnimorsus* is an example of such a pathogen. Although we have no precise data on bite incidents in Europe, some local studies and one national study have estimated the incidence of bite incidents. The Swiss Sentinel Surveillance Network estimated an annual rate of medical consultations for bites and scratches from pets of 325 per 100,000 persons/year. Over 60% of the consultations were for dog bites (most frequently among children), and cat scratches accounted for about 25% of the consultations [84]. In some economically deprived coastal cities in England, an estimated 300 per 100,000 persons/year received treatment for dog bites [85]. In Lyon, estimates were remarkably lower, ranging from 10 post-rabies-exposure treatments per 100,000 persons/year to 38 self-reported bites per 100,000 persons/year [86].

2.4 Discussion

This chapter describes relevant risk factors for the emergence of zoonoses and zoonoses that are currently emerging, or that may emerge in Europe in the future. From the list of risk factors and the list of potential emerging zoonoses (Appendix IV), it is clear that predicting the next major outbreak is impossible. However, some of the zoonoses already endemic in Europe are becoming or can become more important. Climatic factors and human behaviour, but also trade and travel, can lead to the re-emergence of well-known diseases.

As already mentioned, priority ratings have been developed to categorise infectious diseases [35-37]. In this report, the listed potential emerging pathogens were not further prioritised. However, these zoonoses were clustered according to their primary reservoirs and/or modes of transmission because the clusters may be relevant in early warning systems, and their spreading could be prevented or monitored and controlled in similar ways.

Of the zoonoses mentioned, endemic vector-borne zoonoses may already be more important because of climatic changes and human behaviour. The introduction of infected animals and humans may be relevant if these zoonoses can be maintained in similar vectors. In many areas, changes in land use, reforestation, and new human settlements have led to more abundant tick populations. Warmer winters in temperate regions may extend the transmission season for some ticks and pathogens [51]. Consequently, the incidence may increase, or new diseases may be introduced in certain regions. For example, the incidence of Lyme borreliosis is increasing in some parts of Europe [47]. As many experts have mentioned, the occurrence of WNV in new areas in Europe seems only a matter of time. In addition, the recognition of new rickettsial pathogens in ticks may lead to the diagnosis of yet unknown human diseases [87].

Zoonoses transmitted by wildlife are of special interest because of the complicated or even impossible prevention and control measures to be taken. An example of a zoonosis relevant to public health that is transmitted by foxes in Europe is *Echinococcus multilocularis*. Although more and more epidemiological studies of wildlife in Europe show an increasing prevalence and infection rate in foxes [88], little knowledge is yet available about the population dynamics of the parasite in wildlife, its transmission route, human infection risk, and control measures that can be taken. Long incubation periods are unfavourable for getting attention for such diseases in public health.

Food-borne zoonoses are not within the primary scope of this report because they are covered by various European directives (Chapter 4). However, the burden of disease due to campylobacteriosis and salmonellosis makes food-borne zoonoses perhaps the most relevant ones in Europe. New, emerging strains of food-borne zoonoses may be the cause of new, serious disease problems. In addition, meat from exotic game animals or new domesticated animals imported from outside the EU may be responsible for the introduction of new zoonotic agents.

CHAPTER 3. NEW THREATS OF INFECTIOUS DISEASES FROM ANIMAL RESERVOIRS

What are the risks of infectious diseases of animals (wildlife, livestock, and domestic animals) to public health in Europe? New and unknown threats.

3.1 Introduction

With the continuation of environmental changes in combination with increasing mobility and globalisation, and increasing contact among humans, domestic animals, and wildlife, new zoonoses will undoubtedly appear, and some existing zoonoses will invade new geographical areas or re-emerge in certain areas.

The emergence of new zoonoses will always be the result of a complex cascade of intertwined events that will be different each time (Chapter 2). Appendix III gives examples of factors involved in the emergence of three communicable diseases. The conclusion from literature studies and expert opinions is that it is impossible to predict from which geographic area or which animal reservoir a new zoonosis will emerge, and from which taxonomic group this pathogen will be. We can not know the risk factors or the events that will lead to emergence.

Therefore, instead of predicting the direction from which new zoonoses can be expected, this chapter summarises some of the characteristics of zoonotic diseases that may influence their probability of emergence.

Much of the information in this chapter comes from the results of the WHO Geneva conference in which several European experts participated and from a questionnaire filled in by Dutch and European experts (Appendices VI and VII) that they completed from the point of view of their individual expertise. Although the experts' answers may be somewhat biased by recent events such as zoonotic epidemics caused by avian influenza and SARS in South-east Asia [20 89], the answers may provide valuable information on factors considered potential risk factors for zoonosis emergence.

3.2 Characteristics of zoonoses and probability of emergence

3.2.1 Characteristics of the pathogen

Some pathogens need time to adapt to a new host after crossing the species barrier. Antia *et al*. show, by stochastic modelling, that an initially low human-to-human transmission rate (given by the basic reproductive rate R_0) leads to long chains of transmission, which favours the evolution of a zoonotic pathogen, so that eventual emergence is more likely [90]. The basic reproductive rate of a zoonosis determines its potential for causing epidemics (if it exceeds unity, i.e. if one case causes more than one secondary case, an epidemic may arise).

However, other pathogens (such as certain viruses) seem to adapt relatively easily to human hosts. Most experts mention viruses, especially RNA viruses, as being most likely to produce newly emerging zoonoses. Taylor and colleagues' analysis of a database with 1415 human pathogens also shows that RNA viruses are most likely to emerge [7,8]. The families mentioned were the *Caliciviridae, Coronaviridae, Orthomyxoviridae* and *Paramyxoviridae.* New poxviruses and new retroviruses were thought to have a high potential for emergence in the human population. Influenza A viruses are very likely to emerge, as the segmented genome of these viruses enables reassortment [91]. Further, new prions may emerge in the future.

Taxonomic groups that are probably less important in giving rise to new zoonotic pathogens are bacteria and helminths [7]. However, some bacteria, like the human pathogen *Bordetella pertussis* that possibly evolved from the animal pathogen *Bordetella bronchiseptica* may efficiently cross the species barrier. New or unknown *Rickettsia* emerging via arthropods from rodent populations and bacteria developing antibiotic resistance were mentioned. An example from the past is a multiresistant strain of *Salmonella typhimurium,* definitive type 104 (mr-DT104), that emerged in the 1980s and 1990s and still frequently causes outbreaks [92]. With the increased and injudicious use of antibiotics, new multiresistant and virulent strains will undoubtedly emerge in the future.

It is also possible that animal pathogens will be identified as one of the key causative agents in some chronic diseases with long incubation periods and a multifactorial and largely unknown aetiology. If human exposure to these pathogens increases in future, the prevalence of these chronic diseases may increase. An example of such a pathogen is *Mycobacterium paratuberculosis,* which causes a progressive disease in cattle and is possibly involved in the aetiology of Crohn's disease [93 94].

3.2.2 Reservoirs

According to Dutch experts, important reservoirs in which new emerging zoonoses may evolve are birds (wild, migrating birds, and poultry) and rodents (Appendix V). Examples of the animals that are the reservoirs of important diseases and that have caused major outbreaks [5] are poultry and wild birds in relation to Influenza A virus, rodents in relation to plague, monkeypox, and Hanta virus disease. At the WHO Geneva meeting, marine animals were also mentioned as potential reservoirs for new diseases [95]. However, reservoirs for many infectious diseases have not yet been identified (e.g. Ebola haemorrhagic fever and SARS) [5].

3.2.3 Transmission routes

The route of transmission of a pathogen may determine its opportunities for emergence. For example, avian influenza may spread around the globe rapidly once its transmission from human to human has started because transmission occurs via aerosols. Conversely, SARS is transmitted primarily by close contact via droplets (although transmission also occurs by direct inoculation via contaminated surfaces and possibly faeces). The SARS epidemic could therefore be contained with the aid of strict isolation measures at the level of hospitals [96].

Transmission may also occur via vectors. With global warming and ecological changes, new habitats may arise for insects and ticks (Chapter 2). However, the spread of vectors is easier to predict (with models for assessing changes in climate and vegetation) than the spread of microbes [97 98]. Many other, poorly predictable factors, including human behaviour, may be involved in the emergence of vector-borne zoonoses. Blood and other biological agents may also serve as vectors of new diseases, as long as the causative pathogen and/or the transmission route(s) are unidentified, and reliable diagnostic tests are unavailable. Food (animal products) is an important vector, although food-borne zoonoses are not within the primary scope of this report. However, newly evolving pathogens (such as SARS) may well originate from food, and the probability of global emergence increases with increasing global exchange of animals, animal products, and contact with faecally contaminated food and water.

3.2.4 Geographical distribution

Both SARS and avian influenza (H5N1) emerged recently from South-east Asia and are considered to have a potential impact worldwide. With its booming economy, poor possibilities for control and prevention and high and still increasing human and animal population densities, the South-east Asia area indeed offers many opportunities for the emergence of new infectious diseases. The experts also mentioned another region, especially because of its relevance to Europe, namely, Eastern Europe. Some transnational introductions of infectious diseases to Western Europe from the east have indeed been reported [26]. This may include the introduction of formerly unknown diseases to the EU from the east. Furthermore, Central Africa and South America were mentioned because of the continuous infiltration of humans into the forest and deforestation.

3.2.5 Anthropogenic factors

The risk factors for emergence of new zoonoses in Europe that were most often mentioned by Dutch experts were the globalisation of agriculture, trade, and travel; ecological changes (such as deforestation), human behaviour, and changing climate (global warming). Many other risk factors may be important (Chapter 2). Some of these may be typical for Europe and other affluent countries (such as preference for exotic food and pets, recreational activities, breeding of wildlife animals, exotic or otherwise, medical technology (blood transfusion and xenotransplantation), and political issues related to Europe (such as disintegrated responsibilities because of the nature of the EU; see Chapter 4).

3.2.6 Characteristics of the disease

In general, zoonoses that have a high case-fatality rate and/or that cause severe morbidity and have limited abilities for human-to-human transmission are less likely to emerge globally than zoonoses that emerge rather unnoticed. For example, the probability that Ebola virus will cause a pandemic is relatively small because of its transmission route and because it kills rapidly, thereby creating terror among relatives of the dead so that they avoid high-risk contacts [70]. In contrast, HIV diseases can spread unnoticed for decades, since it opens the door to aspecific opportunistic diseases by immunosuppression after a long latency period in populations already suffering from decreased immune function due to other infectious diseases and malnutrition (Appendix III).

The relation between latency time and period of infectiousness determines the capacity and effectiveness of control measures. For example, SARS is infectious and symptomatic in the same period, whereas avian influenza and especially HIV are infectious before the onset of disease. Therefore, control measures for SARS can be efficiently directed towards cases with symptoms, whereas this is impossible for HIV and Influenza A virus [6].

3.3 Discussion

New threats from the animal reservoir are likely to occur in the future, but predicting the next new disease coming from animal reservoirs is difficult. This chapter lists the factors that may be involved with emergence, i.e. pathogen, reservoir, and vector characteristics; transmission routes; geographical distribution; anthropogenic factors; and characteristics of the disease. The intensity of contacts between the original reservoir (the intermediate reservoir and vectors) and human beings is crucial to the emergence of a zoonosis.

CHAPTER 4. EFFECTIVELY CONTROLLING INFECTIONS FROM ANIMALS IN EUROPE: HARMONISING VETERINARY AND PUBLIC HEALTH

4.1 Introduction

This chapter summarises the relevant European legislation that currently exists for the monitoring and control of zoonoses. As this legislation on the human side was recently implemented, systems for surveillance and control are currently being set up and are not yet fully functional. However, the animal legislation was implemented in 1992.

Appendix V gives an example of the Dutch legislation on the control of several zoonotic diseases, as well as the communication and cooperation of professionals from the veterinary and human public health sectors.

Box 4.1. *Definitions of regulations, directives, and decisions*

Regulations are directly applicable to and binding for all EU Member States without the need for any national implementation legislation.

Directives bind Member States to the objectives to be achieved within a certain time while leaving the national authorities the choice of form and means to be used. Directives have to be implemented in national legislation in accordance with the procedures of the individual Member States.

Decisions are binding in all their aspects for those to whom they are addressed. Thus, decisions do not require national implementation of legislation. A decision may be addressed to any or all Member States, to enterprises, or to individuals [99].

4.2 European legislation on zoonoses

Both the veterinary and the public health sectors should be involved for the efficient control of zoonoses. Different legislation was developed at the European level for each sector. The instructions were developed to harmonise the surveillance of zoonoses in the Member States and to provide guidelines for the implementation of monitoring zoonoses to harmonise surveillance systems and to improve the comparability of the data. This section discusses all the zoonosis directives, decisions, and regulations (Box 4.1) of the EU.

Table 4.1. Legislation regarding communicable diseases including zoonotic diseases in humans

Number	Title	Year of publication
Directive 92/117/EEC	Directive concerning measures for protection against specified zoonoses and specified zoonotic agents in animals and products of animal origin in order to prevent outbreaks of food-borne infections and intoxication	1992 repealed
Decision 2119/98/EC	Setting up a network for the surveillance and control of communicable diseases in the Community	1998
Decision 2000/96/EC	Commission decision on the communicable diseases to be progressively covered by the Community network under Decision No.2119/98/EC	2000
Decision 2000/57/EC	Commission decision on the early warning and response system for the prevention and control of communicable diseases under Decision No.2119/98/EC	2000
Decision 2002/253/EC	Laying down case definitions for reporting communicable diseases to the Community network under Decision No. 2119/98/EC	2002
Decision 2003/534/EC	Commission decision amending Decision 2119/98/EC as regards communicable diseases listed in those decisions and amending Decision 2002/253/EC as regards the case definitions for communicable diseases	2003
2003/542/EC	Commission decision amending Decision 2000/96/EC as regards the operation of dedicated surveillance networks	2003

Box 4.2. *List of categories of communicable diseases**

- Diseases preventable by vaccination
- Sexually transmitted diseases
- *Viral hepatitis*
- *Food-borne diseases*
- *Water-borne diseases and diseases of environmental origin*
- Nosocomial infections
- *Other diseases transmissible by unconventional agents (including Creutzfeldt-Jakob disease)*
- *Diseases covered by the international health regulations (yellow fever, cholera and plague)*
- *Other diseases (rabies, typhus, viral heamorrhagic fevers, malaria, and any other as yet unclassified serious epidemic disease, etc.)*

*Categories including zoonotic diseases are in italic font

4.2.1 Legislation on communicable diseases including zoonotic infections in humans

Legislation regarding human infectious disease control has only existed since 1998. Before 1998, a zoonoses regulation (Directive 92/117/EEC, Section 4.2.2) for both animal and human infectious disease control existed. The legislation for human infectious diseases primarily focuses on monitoring communicable diseases and facilitates the harmonisation of the Member States with regard to communicable diseases and zoonoses (Table 4.1).

Table 4.2. Zoonotic diseases to be covered by the Community network according to Decision 2000/96/EC

Zoonotic disease
Botulism
Brucellosis
Campylobacteriosis
Cryptosporidiosis
Echinococcosis
Giardiasis
Infection with enterohaemorrhagic *Escherichia coli**
Influenza*
Leptospirosis
Listeriosis
Plague
Q fever**
Rabies
Salmonellosis*
Shigellosis
Toxoplasmosis
Trichinellosis
Tuberculosis *(Mycobacterium bovis)**
Tularaemia**
Viral haemorrhagic fevers*
Yersiniosis

* Dedicated surveillance networks are in place (Directive 2003/542/EC)

** Amended by Decision 2003/534/EC

Decision 2119/98/EC. Following this decision [100], a European network was set up for the epidemiological surveillance and control of communicable diseases in the European Community. The aims of establishing the network are to promote collaboration among the Member States and to strengthen the coordination of infectious diseases. A list indicating categories of communicable diseases, which should be covered, is given. In this list (Box 4.2), there are several categories that include zoonoses, although they are not summarised in a specific category. Five ensuing decisions were added to Decision 2119/98/EC.

Decision 2000/96/EC is an elaboration of Decision 2119/98/EC, specifying the communicable diseases that should be covered by the Community network 101. This decision describes which communicable diseases the Community network should progressively cover. These diseases will be surveilled by standardised collection and analysis of data in a way that will be determined for each disease or health issue when specific Community surveillance networks are put in place. Table 4.2 gives an overview of the zoonotic diseases to be covered by the Community network. Not all zoonoses listed in Table 4.2 are mentioned in Directive 2000/96/EC as zoonotic diseases. Some of them are placed in another category such as food-borne or water-borne diseases.
Article 8 of Decision 2000/96/EC is particularly important. It describes how surveillance networks are put in place for zoonoses for which surveillance of human cases is required under Directive 92/117/EEC (animal directive), but this surveillance needs to be performed in accordance with Decision 2119/98/EC (human directive). The aim of this article is to link the human and animal directives regarding zoonoses to facilitate harmonised surveillance and to develop harmonised case definitions, in such a way that the data collected serve both directives.

Decision 2000/57/EC describes the procedures for the exchange of relevant information between the Member States and the Commission under an early warning and response system (EWRS) [102]. The structures and/or authorities of each Member State need to collect and exchange all necessary information on events, e.g. by using the national surveillance system, the epidemiological surveillance component of the Community network or any other Community collection system. Member States submit an analytic report of the events and the procedures applied within the EWRS to the European Commission annually.

Decision 2002/253/EC lays down the case definitions for reporting communicable diseases to the Community network [103]. A case definition consists of the clinical description of the disease, the criteria for diagnosis, and the case classification. Use of common case definitions is a first step in making valid comparisons among countries with respect to epidemiological trends and the emergence of relevant zoonoses. In addition, common surveillance methodologies should be developed and agreed upon.

Decision 2003/534/EC prescribes that diseases that are caused by agents specifically engineered for the purpose of maximising morbidity and/or mortality upon deliberate release (bioterrorism), also need to be monitored by the Community network. Five diseases, such as Q fever and tularaemia, have been added to the list of communicable diseases that should be covered by the Community network (Table 4.2) and specific case definitions have been formulated [104]. This decision is not crucially important for this report, considering bioterrorism as a delineation, though it should be mentioned because two of the five diseases that are added can be considered zoonotic.

Decision 2003/542/EC, which concerns communicable diseases, and in particular zoonoses, specifies the diseases for which dedicated surveillance networks have been put in place (Table 4.2, diseases marked with one asterisk). The decision also regulates the relationship of contact points in Member States with designated authorities and calls for operating procedures to improve the comparability of the data [105].

4.2.2 Legislation on zoonotic infections in animals and food

Legislation on zoonoses was recently repealed. Directive 92/117/EC ensured compulsory monitoring of salmonellosis, brucellosis, trichinellosis, and tuberculosis due to *Mycobacterium bovis,* and gave rules for voluntary monitoring of other zoonotic agents. Food-borne outbreaks and antimicrobial resistance monitoring were not covered [106]. A new directive (Directive 2003/99/EC) will enable the harmonisation of such systems. It introduces control measures for animal populations (Table 4.3).

Directive 2003/99/EC was published in December 2003, and Member States were to apply the measures by June 2004. This directive focuses exclusively on zoonotic diseases [107]. It describes how data on the occurrence of zoonoses and zoonotic agents in animals and feed should be collected to determine trends and sources of zoonoses in the European Member States on an annual basis. Data on humans should mostly be collected on the basis of the Communicable Diseases Network legislation. This directive repeals Directive 92/117/EEC. Every Member State needs to develop monitoring programmes for specific zoonoses that form the greatest risk to human health. Moreover, the monitoring systems should facilitate the detection of emerging or newly emerging zoonotic diseases and new strains of zoonotic organisms, not only from domestic animals but also from other sources such as wildlife and pets. Food-borne outbreaks should also be given attention. The national surveillance programmes need

Table 4.3. Legislation on zoonotic diseases in animals

Number	Title	Year of publication
Directive 92/117/EEC	Directive concerning measures for protection against specified zoonoses and specified zoonotic agents in animals and products of animal origin in order to prevent outbreaks of food-borne infections and intoxication	1992 repealed 2003
Directive 2003/99/EC	Directive on the monitoring of zoonoses and zoonotic agents, amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC	2003
Regulation 2160/2003/EC	Regulation on the control of Salmonella spp. and other specified food-borne zoonotic agents	

Table 4.4. List of zoonoses given in the zoonoses Directive 2003/99/EC [107]

A Zoonoses and zoonotic agents to be included in monitoring	B List of zoonoses and zoonotic agents to be monitored according to the epidemiological situation in the Member State
• Brucellosis	1 Viral zoonoses
• Campylobacteriosis	• Calicivirus
• Echinococcosis	• Hepatitis A virus
• Listeriosis	• Influenza virus
• Salmonellosis	• Rabies
• Trichinellosis	• Viruses transmitted by arthropods
• Tuberculosis due to *M. bovis*	2 Bacterial zoonoses
• Verotoxigenic *E. coli*	• Borreliosis
	• Botulism
	• Leptospirosis
	• Psittacosis
	• Tuberculosis
	• Vibriosis
	• Yersiniosis
	3 Parasitic zoonoses
	• Cryptosporidiosis
	• Cysticercosis
	• Toxoplasmosis
	4 Other zoonoses and zoonotic agents

to fulfill the demands of the European Commission, which are also listed in the directive. Various requirements are specified for the annual reports that Member States should submit to the Commission.

Zoonoses that should be monitored are listed in Table 4.4. Eight zoonoses are obligatory (list A); others should be monitored according to the epidemiological situation in each country. For several zoonotic agents, monitoring of antimicrobial resistance is also obligatory, as is investigation of food-borne outbreaks. The monitoring results of all Member States have so far been collected annually by the Community Reference Laboratory for the Epidemiology of Zoonoses (CRL-E) at the former German Federal Institute of Veterinary Medicine and Consumer Protection. The data are published in the annual "Report on Trends and Sources of Zoonotic Agents according to Article 5 of Directive 92/117/EC" [108]. These collected data provide a basis for the evaluation of the current situation of zoonoses and zoonotic agents in Europe. In future, the European Food Safety Authority (EFSA) will be responsible for producing the Community summary report.

Regulation 2160/2003/EC became operative simultaneously with Directive 2003/99/EC and elaborates on this directive. The purpose of this regulation is to ensure that proper and effective measures are taken to detect and control *Salmonella* spp. and other zoonotic agents at all relevant stages of production, processing, and distribution, particularly at the level of primary production, including feed, in order to reduce their prevalence and the risk they pose to public health [109]. To compare data for all of Europe, it is important that the monitoring programmes of all the Member States are similar. At the moment, only a framework for the control of *Salmonella* spp. is specified in this regulation, and requirements for national control programmes are also given. The aim of these rules is to reduce the prevalence of *Salmonella* spp. in each Member State by setting Community targets. More zoonoses and zoonotic agents may be added to this list in the future. A procedure to set targets for zoonotic agents other than that for *Salmonella* spp. is also provided [110].

4.2.3 Legislation for the surveillance and control of animal diseases

Legislation at the EU level is arranged for the surveillance and control of animal diseases alongside the specific zoonoses directives. Legislation for food-borne diseases is especially extensive. Many directives apply to the production, processing, distribution, and introduction of animal products for human consumption (e.g. Directive 2002/99/EC) [111], the requirements for the import of animals and fresh meat (Directive 2004/212/EC) [112], and the specification of programmes for the eradication and monitoring of specific animal diseases (Directive 2003/849/EC; new targets every year) [113]. Legislation for the control of animal diseases is also available, for example for the detection of *Trichinella* in the meat directive, Directive 77/96/EEC [114], but also for the animal health status of herds producing milk (Directive 92/46/EEC) and meat inspection (Directive 64/433/EEC).
Legislation also exists for the definitions of control by Member States during an outbreak of avian influenza (Directive 92/40/EEC) [115]. A regulation for food and feed controls has also been arranged (Regulation 882/2004) [116].

4.3 Coverage of zoonotic diseases by Community networks, reference laboratories, and early warning and response systems

Networks and/or reference laboratories have been arranged for zoonotic diseases of humans and animals.

4.3.1 Communicable disease networks

Decision 2119/98/EC set up a network for the surveillance and control of communicable diseases. Although, due to financial constraints, not all diseases are covered by a disease-specific network, more than 15 networks are in place. Examples of these networks are the International Surveillance Network for Enteric Infections (Enter-Net), the European Influenza Surveillance Scheme (EISS) and Surveillance of Tuberculosis in Europe (EuroTB) that receive funding from the public health programme managed by DG SANCO (Directorate for General Health and Consumer Affairs) [117]. In addition, the Basic Surveillance Network (BSN) will collect routine data of national surveillance systems as from 2004 on all the diseases listed.

4.3.2 Reference laboratories

For every zoonosis listed in category A of the zoonoses Directive 2003/99/EC, a Community Reference Laboratory (CRL) should be appointed. These CRLs are active at European level. Besides CRLs, there are also National Reference Laboratories (NRLs). Member States designate an NRL in their country for each field for which a CRL has been designated. The CRLs have an important coordination role on the Community level in providing technical and scientific assistance to NRLs and the Community on the field of activity. They must provide the NRLs, for example, with details of analytical methods, organise comparative testing, and provide technical assistance to the European Commission. NRLs offer scientific and technical support in their countries and organise national ring trials.

4.3.3 Early Warning and Response System (EWRS)

The Community network (consisting of the Member States and the European Commission) is built on two pillars. The first one is surveillance and the second one is the EWRS. Decision 2000/57/EC organises the EWRS, which is activated when a new or emerging disease with greater-than-national dimensions appears, so that a coordinated EU action can take place. The EWRS is an telematic system (mainly e-mail) linking the designated authorities in the Member States and the European Commission [118].

4.4 European centres involved in implementing the legislation on zoonoses

Two new centres for the surveillance and control of infectious diseases have recently been established in Europe: the European Food Safety Authority (EFSA) and the European Centre for Disease prevention and Control (ECDC).

4.4.1 The European Food Safety Authority (EFSA)

The EFSA was set up provisionally in Brussels in 2002 and will move to Parma in 2005. The EFSA provides independent scientific advice on all matters linked to food and feed safety, including animal health and welfare, and plant protection, and it provides scientific advice on nutrition in relation to Community legislation [119]. From 2005 onward, the EFSA will collect the data (which will be sent by the Member States as mentioned in Directive 2003/99/EG), analyse them, and assess risks on a European level.

4.4.2 European Centre for Disease prevention and Control (ECDC)

The Commission established a Communicable Diseases Network in 1999. This is currently based on ad hoc cooperation among the Member States within the legal framework of the Council and Parliament Decision 2119/98/EC. However, substantial reinforcement is needed for effective control of communicable diseases. In 2000 and 2001, two external evaluations of the Network highlighted how the functioning of the existing structures could be improved and reviewed options for a more effective response capacity at the EU level. In 2002, the State Epidemiologists from the Member States gave their views on the future of the surveillance of communicable diseases at the EU level; they favoured the creation of a centre at the EU level.

The centre will have a small core staff and an extended network of contacts in Member States' public health institutes and academia. Governance of the ECDC will be modelled to be similar to that of EU agencies, such as the EFSA. By pooling expertise around Europe, the ECDC will be able to:

- Provide authoritative scientific advice on serious health threats;
- Assess risks and give advice on control measures; and
- Facilitate the quick mobilisation of intervention teams and thus enable a rapid and effective EU-wide response.

The ECDC will be organised as an epidemiology network instead of a laboratory network. On March 2004 the Council approved the regulation establishing the ECDC that will be operational as an independent European agency by 2005 [120].

4.4.3 The European Medicines Agency (EMEA)

The EMEA is a body of the EU; it is concerned with the control of infectious diseases. Its main responsibility is to protect and promote public and animal health, which it does by evaluating and supervising medicines for human and veterinary use. The EMEA works as a network, bringing together the scientific resources of the Member States to ensure the highest level of evaluation and supervision of medicines in Europe. The EMEA cooperates closely with international partners on a wide range of regulatory issues.

4.5 Discussion

4.5.1 Legislation

As Tables 4.1–4.3 show, the legislation regarding zoonoses and communicable diseases is relatively new, and further implementation is needed. At the level of infectious diseases control for animals, legislation is extensive, well-defined, and regulating, mainly because of cross-border aspects and trade, which have existed for a long time. In contrast, prevention, surveillance, and the control of human infectious diseases was formerly a national, not a European matter, and all the countries had their own rules and procedures [18]. Therefore, it is difficult for the public health sector to apply the different decisions in every country.

4.5.2 Monitoring and detection

There are minor inconsistencies in the list of zoonoses mentioned in Directive 2003/99/EC and the human zoonoses Decision 2000/96/EC. The Member States need to monitor some zoonoses in animals, but not in humans (e.g. cysticercosis) and *vice versa*. Nevertheless, Directive 2003/99/EC says that the Member States need to monitor other zoonoses and zoonotic agents as the epidemiological situation requires. This is not mentioned in Decision 2000/96/EC. However, Article 7 of Decision 2000/96/EC says that relevant information on communicable diseases not covered in the list shall be disseminated whenever this is found necessary.

Although Directive 92/117/EEC states that every Member State needs to develop monitoring programmes for specific zoonoses that form the greatest risk to human health and that monitoring systems should facilitate the detection of emerging or newly emerging zoonotic diseases and new strains of zoonotic organisms, not only appearing from domestic animals, but also from other sources such as wildlife and pets, this is still a point of concern. Newly evolved emerging zoonoses that are not listed in a directive and are not obligatorily reportable, but that may be very important to public health, can go unnoticed. Meanwhile, communication at the laboratory level is only organised voluntarily, though it is based on professional expertise. It is therefore recommend to strengthen the communication between animal and human reference laboratories at the national and European levels with the aim of exchanging information for the development of diagnostic tools, information on strains, and on the control of emerging zoonoses [121, 122].

Not every country uses the same definitions or interprets cases the same way. For example, in countries like France and Germany, acute respiratory infection (ARI) is categorised as influenza whereas in the Netherlands, only influenzalike illness (ILI) is categorised as such. As a consequence, countries like France and Germany report a greater incidence than countries like the Netherlands because they interpret the case definition differently. Therefore, Decision 2002/253/EC was provided by the European Commission; it describes the case definitions for many communicable diseases. However, it is not easy for Member States to change their systems and use these case definitions.

In addition, the ECDC will be organised as an epidemiology network, whereas the laboratory network is not well defined at the EU level. Therefore, it is useful to strengthen the cooperation of laboratory networks at the EU level to facilitate better communication and collaboration [121]. Although the legislation for both the veterinary health sector and the public health sector regulates the comparability of data, differences remain. Real differences in infectious disease incidence between countries may be obscured by a variety of factors that reduce the comparability of the data. Therefore, it is necessary to achieve more harmonisation among the Member States.

4.5.3 Communication and control

For good functioning of the new legislation, communication is necessary on the national, European, and global levels [18] [123]. MacLehose and colleagues describe six critical control points identified from the five analysed case studies regarding internationally relevant major outbreaks of infectious disease [18]: failure to inform other countries, inadequate preparedness planning, inadequate funding arrangements, failure to link information to action, failure to provide capacity for international outbreak investigations, and failure to share lessons. Better harmonisation would improve the collaboration among the Member States, as well as the monitoring and the control of zoonoses [123]. The newly established EFSA and ECDC could accelerate an integrated approach to emerging zoonoses in Europe, provided that these organisations collaborate closely to prevent and contain the emergence of zoonoses. It is not clear where the data collected for notifiable zoonoses given in list A of Table 4.4 will be analysed. Now, the impression exists that the human data will be analysed at the ECDC and the animal and food data will be analysed at the EFSA. Integration of the analysis of the human, animal, and food data throughout the whole chain may improve the situation. In addition, if there is an emerging zoonoses outbreak with a high potential of becoming a European or global threat, it is not clear who is responsible for the supra-co-ordination. If no supra-co-ordination is defined, the lines of communication will have to be set out by some other means. Moreover, it is not clear what the role of the EMEA is in this context.

4.5.4 Research

The US Institute of Medicine emphasises more research, besides improved surveillance and laboratory diagnosis, to better understand and consequently control newly evolving and emerging infectious diseases [121]. In Europe, the organisation of research funding is very complex. There are many research activities concerning emerging infections and public health, but getting an overview of these activities is difficult. Within the Sixth Framework, Networks of Excellence have been established to integrate several research themes. One of these Networks is the MedVetNetwork, an initiative of human and animal reference institutes with the aim of virtually creating a European zoonoses centre (www.medvetnet.org). New research activities concerning zoonoses should take place within this network. However, the MedVetNetwork is dependent on short-term financing, and not every European country is yet involved. In addition, many other surveillance and basic research networks and integrated projects exist within the Sixth Framework; their aim is to gain fundamental knowledge to better predict or control emerging infections. All these initiatives are still dependent on voluntary initiatives and restricted periods of financing (Appendix VIII).

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APPENDICES

APPENDIX I ABBREVIATIONS

AIDS	Acquired Immunodeficiency Syndrome
ARI	Acute Respiratory Infection
ASM	American Society for Microbiology
BAO	Administrative board (in the Netherlands) (*Bestuurlijk Afstemmingsoverleg*)
BSE	Bovine Spongiform Encephalopathy
BSN	Basic Surveillance Network
CCHF	Crimean Congo haemorrhagic fever
CDC	Centers for Disease Control
CIDC	Central Institute for Animal Disease Control
CoV	Corona virus
CRL	Community Reference Laboratory
CRL-E	Community Reference Laboratory for the Epidemiology of Zoonoses
CVO	Chief Veterinary Officer
DG SANCO	Directorate General for Health and Consumer Affairs
EBLV	European bat lyssa virus
ECDC	European Centre for Disease Prevention and Control
EFSA	European Food Safety Authority
EHEC	Enterohaemorrhagic *Escherichia coli*
EISS	European Influenza Surveillance Scheme
EMEA	European Medicines Agency; the European Agency for the Evaluation of Medicinal Products
Enter-Net	International surveillance network for enteric infections
EU	European Union
EuroTB	Surveillance of tuberculosis in Europe
EWRS	Early Warning and Response System
FAO	Food and Agriculture Organization of the United Nations
GD	Animal Health Service (*Gezondheidsdienst voor Dieren*)
GGD	Public Health Service (*Gemeentelijke Gezondheidsdienst*)
GWWD	Animal Health and Welfare Act (*Gezondheids- en Welzijnswet voor Dieren*)
HC	Health Council of the Netherlands
HEV	Hepatitis E virus
HIV	Human Immunodeficiency Virus
IGZ	Inspectorate for Health (*Inspectie voor de Gezondheidszorg*)
ILI	Influenza-Like Illness
IZW	Infectious Diseases Act (*Infectieziektenwet*)
KvW	Inspectorate for Health Protection and Veterinary Public Health (*Keuringsdienst van Waren*)
LCI	National Coordination Structure for Infectious Disease Control (*Landelijke Coördinatiestructuur Infectieziektenbestrijding*)
NRL	National Reference Laboratory

OIE	World Organization for Animal Health (*Office International des Epizooties*)
RIVM	National Institute for Public Health and the Environment (*Rijksinstituut voor Volksgezondheid en Milieu*)
RVV	National Inspection Service for Livestock and Meat (*Rijksdienst voor de keuring van Vee en Vlees*)
SARS	Severe Acute Respiratory Syndrome
TBE	Tick-Borne Encephalitis
TSE	Transmissible Spongiform Encephalopathy
VEE	Venezuelan equine encephalitis
VTEC	Verocytotoxin-producing *Escherichia coli*
VWA	Food and Consumer Product Safety Authority (Voedsel en Waren Autoriteit)
WHO CSR	WHO Communicable Disease Surveillance & Response
WHO	World Health Organisation
WNV	West Nile Virus

APPENDIX II. TABLES OF OUTBREAKS REPORTED BY WHO, 1999-2004

Notes to Tables I.1-I.6:

[a] The information listed in the tables below was extracted from WHO's Disease Outbreak News on the Internet (http://www.who.int/csr/don/en/).

[b] The main transmission of yellow fever, dengue fever and shigellosis does not involve animals and therefore, strictly, these are not zoonoses. However, monkeys can be involved in sylvatic transmission cycles, rarely other animals in case of shigellosis

[c] No causative agents were found for some diseases and syndromes, but the characteristics of these syndromes indicate that they might well be zoonoses (e.g., suspected acute haemorrhagic fever syndrome in Congo, 2002).

[d] The number of cases as reported on the WHO Website reports, unless a literature reference is given.

Table II.1. Zoonosis outbreaks in 2004 (until 1 June) [a]

Period	Zoonosis	Countries involved	Number of cases confirmed/suspected [d]	Number of deaths
Jan	SARS	China	4	0
Feb	Nipah virus	Bangladesh	22	17
Jan-Mar	Avian influenza	8 Asian countries	>40	>25
Feb-May	Dengue fever [b]	Indonesia	58,301	658
Feb-Mar	Yellow fever [b]	Liberia	39 suspected	8
Apr	Nipah virus	Bangladesh	30 (16 confirmed)	18
Apr	SARS	China	9	1
May	Yellow fever [b]	Burkina Faso	25 suspected (4 confirmed)	?
May	Ebola haemmorrhagic fever	Sudan	25	6

Table II.2. Zoonosis outbreaks in 2003 [a]

Period	Zoonosis	Countries involved	Number of cases confirmed/suspected [d]	Number of deaths
Jan	Yellow fever [b]	Brazil	24 (4 confirmed)	5
Jan	Trichinosis	Germany	3	0
Feb	Yellow fever [b]	Guinea	43	24
Feb-May	Ebola haemorrhagic fever	Congo	143 (13 confirmed, 130 epidemiologically linked)	128
Mar	Crimean Congo haemorrhagic fever	Mauritania	30 (11 confirmed)	6
Mar-Dec	SARS	Numerous countries	>8,400	>800
Apr	Avian influenza	Netherlands	453 (89 confirmed) [54]	1
May	Yellow fever [b]	Sudan	178 (17 confirmed)	27
Jun-Jul	Plague	Algeria	10 (8 bubonic, 2 septicaemic, all confirmed)	1
Aug-Sep	Yellow fever [b]	Sierra Leone	90 (4 confirmed)	10
Oct-Nov	Dengue fever [b]	India	2185 confirmed	11
Nov	Shigellosis[b]	Central African Republic	379	23
Nov-Jan (2004)	Ebola haemorrhagic fever	Congo	35 probable	29

Table II.3. Zoonosis outbreaks in 2002 [a]

Period	Zoonosis	Countries involved	Number of cases confirmed/suspected [d]	Number of deaths
Jan-Feb	Leishmaniasis	Pakistan	>5,000	
Jan-Feb	Tularaemia	Kosovo	1,462 (319 confirmed)	0
Jan	Yellow fever [b]	Senegal	18 confirmed	
Feb	Plague	India	16	4
Mar-May	Dengue/dengue haemorrhagic fever [b]	Brazil	317,787	57
May	Shigellosis [b]	Belarus	606	
May	Leishmaniasis	Afghanistan	200,000	
Jun	Plague	Malawi	71	
Jun- July	Suspected acute haemorrhagic fever syndrome [c,*]	Congo (Mbombo district)	8 suspected	5
Jun-Jul	Dengue/dengue haemorrhagic fever [b]	El Salvador	2,249 dengue fever/156 dengue haemorrhagic fever	6
Jun	Suspected acute haemorrhagic fever syndrome [c,*,**]	Gabon	?	2
Jul	Dengue/dengue haemorrhagic fever [b]	Honduras	3,993 dengue fever, 545 dengue haemorrhagic fever	8
Aug	Q fever	France	79	0
Aug	Dengue/dengue haemorrhagic fever [b]	Ecuador	5,833 suspected dengue fever (344 confirmed), 158 dengue haemorrhagic fever (11 confirmed)	?
Aug-Nov	West Nile virus	United States of America	3,734	214
Sep-Nov	West Nile virus	Canada	141 (84 suspected, 57 confirmed)	1
Oct-Nov	Yellow fever [b]	Senegal	60 confirmed	11

* Symptoms of the disease compatible with Ebola haemorrhagic fever
** The patients were probably infected while caring for a similar case in Mbombo district, Democratic Republic of the Congo

Table II.4. Zoonosis outbreaks in 2001 [a]

Period	Zoonosis	Countries involved	Number of cases confirmed/suspected [d]	Number of deaths
Feb	Yellow fever [b]	Brazil	48 (20 confirmed)	9
May	Acute neurological syndrome [c]	Bangladesh	28	9
May	Yellow fever [b]	Peru	8 confirmed	2
May	Yellow fever [b]	Côte d'Ivoire (Dadané & Duekoué districts)	4 (1 confirmed)	3
Jun	Crimean Congo haemorrhagic fever	Albania	4	0
Jun	Crimean Congo haemorrhagic fever	Kosovo	69 (10 confirmed)	6
Aug	Yellow fever [b]	Liberia	3 suspected	3
Sep-Oct	Yellow fever [b]	Côte d'Ivoire	203 (23 confirmed)	21
Sep	Yellow fever [b]	Guinea	18 (2 confirmed)	2
Dec-May (2002)	Ebola haemorrhagic fever	Gabon	60	50

Table II.5. Zoonosis outbreaks in 2000 [a]

Period	Zoonosis	Countries involved	Number of cases confirmed/suspected [d]	Number of deaths
Jan	Lassa fever	Germany	1	1
Jan	Yellow fever [b]	Brazil	1	0
Jan	Yellow fever [b]	Brazil	61 suspected (5 confirmed)	2
Mar	Hanta virus pulmonary syndrome	Panama	12 suspected	3
Mar-Apr	Lassa fever	United Kingdom	2	0
Apr	Tularaemia	Kosovo	699 suspected (56 confirmed)	?
May	Yellow fever [b]	Nigeria	2 confirmed	0
May	*E. coli* O157	Canada	27 hospitalised	5
Jun-Jul	Acute haemorrhagic fever syndrome [c,*]	Afghanistan	27 suspected	16
Aug-Sep	Yellow fever [b]	Nigeria	102 suspected	?
Sep	Leptospirosis	Canada**	6 (2 confirmed)	?
Sep	Leptospirosis	France**	4 (1 confirmed)	?
Sep	West Nile virus	Israel	151 of which 76 hospitalised	12
Sep-Oct	Rift Valley fever	Saudi Arabia (2 provinces)	443 suspected	85
Sep-Oct	Rift Valley fever	Yemen (4 provinces)	653 suspected	80
Dec	Yellow fever [b]	Guinea	512 suspected	190
Aug-Jan (2001)	Ebola haemorrhagic fever	Uganda	425	254

* Disease symptoms compatible with Crimean Congo haemorrhagic fever
** Source of infection: ecochallenge event in Malaysia

Table II.6. Zoonosis outbreaks in 1999 [a]

Period	Zoonosis	Countries ot continents involved	Number of cases confirmed/suspected [d]	Number of deaths
Jan-Mar 2000	Viral haemorrhagic fever/Marburg	Congo	72 Viral haemorrhagic fever/16 Marburg	2
Feb	Yellow fever [b]	Bolivia	27 confirmed	13
Mar	Yellow fever [b]	Brazil	5	
Mar	Japanese encephalitis Hendralike virus	Malaysia	157 (18 confirmed)	58
Apr	Relapsing fever (*Borrelia* sp.)	Sudan	892	24
May	Hendralike virus	Malaysia and Singapore	11	1
May	Plague	Namibia	39 (6 confirmed)	8
May	Suspected viral haemorrhagic feverc	Zimbabwe	3	0
May	Sylvatic yellow fever	South America	53	21
July	Shigellosis [b]	Guinea	7	
Jul	Plague	Malawi	74	?
Jul	Crimean Congo haemorrhagic fever	Russian Federation	65	6
Aug	Hanta virus infection	Kosovo	1	
Sep	West Nile fever	United States of America	50	5
Nov	Yellow fever [b]	United States of America	1	1
Dec	Creutzfeldt-Jakob disease	France	2 confirmed	

APPENDIX III. EXAMPLES OF EMERGING DISEASES: THE RISK FACTORS

III.1 How HIV/AIDS emerged globally

It is unknown when the human immunodeficiency virus (HIV) was first introduced into the human population. For HIV-1, most estimates are close to the early 1930s [73], but the first introduction of the virus from nonhuman primates into the human population might have occurred centuries ago. Although it was apparently initially transmitted through contact with infected blood of primates, HIV is not a true zoonosis as transmission now involves humans only. However, the emergence of HIV clearly shows how interaction between humans and animals can lead to the birth of a new infectious disease, and how this can cause large and uncontrollable epidemics if such diseases are not detected and combatted in time [124].

Researchers have speculated that HIV was introduced into the human population by hunters who were exposed to infected nonhuman primate blood. Initially, the virus was probably less virulent, but it has gained virulence during the last decades. HIV-1 and HIV-0 evolved from chimpanzees native to West Equatorial Africa (Gabon, Cameroon) [125 126]. Whereas HIV-1 was transmitted in a region where people from outside the forest frequently went to hunt for chimpanzees, HIV-0 was probably first transmitted to an isolated forest tribe. HIV-2 originates from sooty mangabey monkeys in Benin. In fact, the transmission of HIV-2-like viruses from mangabeys to humans was not a single event, but happened frequently as mangabeys are common pets in West Africa. HIV-1 is most virulent and has efficiently spread from Africa to other continents. HIV-2 is less virulent, less efficiently transmitted, and it occurs mainly in west Africa and in India. HIV-0 (closely related to HIV-1) spreads almost unnoticed in Africa only. Originally, many variants probably existed, of which the most well-adapted ones evolved into the currently known subtypes. From West Africa, HIV-1 probably travelled to East Africa with German colonists or their African labourers, where it settled near Lake Victoria. The current AIDS epidemic is thought to have really started there. The first African sample of HIV-1 was isolated from a family in Zaire in 1976. The virus has spread throughout Africa from the Lake Victoria region via truck routes. An HIV-1B prototype virus may have arrived in Europe in 1939 with German repatriates from Cameroon. Since then, several unexplained epidemics of opportunistic infections have been reported in Europe. The virus probably reached the USA via Europe and not *vice versa* [124].

The syndrome was first recognised in the USA in the late 1970s, where several young men who had sex with men suffered from a range of opportunistic infections, apparently all being associated with the same syndrome. This was named the acquired immunodeficiency syndrome (AIDS) in 1982. The discovery of AIDS led to a huge amount of research, which uncovered transmission routes and the viral agent, but the epidemic had already spread to many countries. Currently, the global AIDS epidemic kills millions of people each year, and the epidemic is still spreading. Most cases occur in poor communities, especially in Africa, where control and combat cannot easily be achieved [127].

Summary of risk factors probably involved in the global emergence of HIV/AIDS

- Contacts with wild primates in African forests by hunters? (HIV-1, HIV-0)
- Intensive contacts with pets (HIV-2)
- Adaptation and selection of virus
- Long incubation period of disease (infected persons may be symptomless for years)
- (Inter)national travel
- Efficient dissemination in sexually active population with high-risk contacts
- Initially, no knowledge about syndrome, transmission routes, causal agent, or risk factors
- Poverty and war [128]
- Human behaviour, including gender roles, sexual habits, and stigmatisation (partly because of ignorance) leading to denial of the disease and risk of transmission [128].

III.2 The emergence of West Nile virus in North America

West Nile virus (WNV) of the *Flaviviridae* family belongs to the Japanese encephalitis serocomplex. Infection with WNV remains subclinical in an estimated 80% of infected people. About 20% of those infected develop West Nile fever, which can involve mild fever, headache, body ache, nausea, vomiting, and sometimes swollen lymph nodes or a skin rash on the chest, stomach, and back. Severe illness, occurring at a rate of about 1 in 150 cases, can include high fever, headache, neck stiffness, stupor, disorientation coma, tremors, convulsions, muscle weakness, loss of vision, numbness, and paralysis. Neurological damage may be permanent. One in 1500 patients dies of the disease [129].

West Nile virus is believed to have evolved several centuries ago, and to be endemic to Africa, eastern Europe, the Middle East and Australia (where the subtype Kunjin virus is endemic). In several endemic areas in Africa, about 50% of the children and 90% of the adults are immunoreactive against the virus, whereas immunity is believed to be rare in Europe and absent in America. Since 1996, there seem to be more outbreaks. Outbreaks were reported from Romania (1996–1997), Czech Republic (1997), the Democratic Republic of the Congo (1998), Russia (1999), New York (1999), and Israel (2000), and between 1999 and 2003, the virus has become endemic to large parts of the United States and Canada [129].

Birds form the natural reservoir of WNV. The virus is transmitted via an arthropod vector, primarily via bird feeding *Culex* spp. mosquitoes (although in the United States alone, 49 mosquito species have been found to carry the virus). Under natural conditions, the virus is transmitted among birds only. Although transmission to several mammalian hosts is known, mammalian species are believed to be dead-end hosts. In Africa and Europe, antibodies against the virus are found in a large proportion of many (migrating) bird species and in equines [130]. The virus is probably regularly introduced to Europe by migrating birds, but rarely causes human disease. However, mosquito species and bird populations capable of transmitting WNV exist in Europe, and there are no arguments against the probability of emergence of West Nile disease in Europe. Emergence in Europe remains unpredictable because it also depends on the climate (global warming) and changes in ecosystems. These factors may create more appropriate breeding sites for mosquitoes, which would increase the mosquito population density [45].

Recently, the virus emerged in North America [131]. It was probably introduced from Israel, where the same subtype was found, and caused an outbreak in New York City. The virus apparently successfully survived the winter (either in birds or in hibernating mosquitoes) and then progressively spread over the United States and Canada [132]. Apart from the fact that WNV in North America seems to be especially virulent, a recent publication indicates that the dissemination of WNV in the USA is particularly successful because of hybrid *Culex* mosquitoes that do not prefer birds to humans as blood hosts [133]. This observation requires further study. Exposure to mosquitoes was clearly associated with WNV infection in the Romania epidemic (length of time spent outdoors, no regular application of insect repellents, mosquitoes present in the home, and living in an apartment building with a flooded basement) [134].

Summary of risk factors probably involved in emergence of WNV in North America

- Adaptation and selection of virus and mosquito
- Naive hosts (no acquired immunity)?
- Human travel
- Changes in climate?
- Changes in ecosystems (increasing number of mosquito breeding sites?)
- Human behaviour.

III.3 Avian influenza

In the twentieth century, there were three influenza pandemics, all thought to result from reassortment among human and avian influenza virus strains [135,136]. The Spanish flu killed an estimated 40 to 50 million people worldwide in 1918–1919, and was followed by pandemics in 1957–1958 and 1968–1969. Recent, relatively small outbreaks were recorded in Hong Kong with H5N1 in 1997 (severe respiratory disease in 18 humans, 6 deaths) and 2003 (two cases, one death), and with H9N2 in 1999 (mild disease in two children) and in 2003 (one mildly diseased child). In the Netherlands, an H7N7 avian influenza outbreak occurred in February 2003, causing one death and mild illness in 89 patients. Very recently, H5N1 caused an influenza epidemic in South-east Asia, with 34 reported human cases and 23 deaths. In Canada, an H7 subtype caused mild disease in two cullers[137].

Migratory waterfowl – most notably wild ducks – are the natural reservoir of avian influenza viruses, which are transmitted to domestic poultry by direct contact. Influenza A viruses are very contagious and can cause death rapidly in domestic flocks. Live-bird markets play an important role in the spread of bird epidemics. Diseases are also transmitted from farm to farm by mechanical means, such as contaminated equipment, vehicles, feed, cages, and clothing. Viruses can survive in the environment for long periods, especially when temperatures are low. Birds that survive infection excrete virus for at least 10 days, orally and in faeces, thus facilitating further spread [138]. Pigs can serve as a 'mixing vessel' because they are susceptible to infection with both avian and mammalian viruses, including human strains [139]. Several studies indicate that even humans themselves can serve as 'mixing vessels' [91 136 140 141].

There are sixteen H and nine N subtypes of avian influenza virus, providing an extensive reservoir of influenza viruses. The H5N1 subtype is probably most threatening to human public health; it has a documented propensity toward acquiring genes from viruses that infect other animal species. This H5N1 subtype can cause severe disease in humans [142]. Apart from constant small changes (antigenic 'drift') influenza viruses can reassort genomic fragments, leading to antigenic 'shift', which may result in a novel subtype to which humans have no immunity, and no vaccines confer immunity. The pandemics occurring in the twentieth century are all thought to be the result of antigenic shift [138].

Control of outbreaks of highly pathogenic avian influenza is known to be very difficult in areas where poultry ranges freely [143]. In most recently affected countries, up to 80% of the total poultry population is raised in small backyard farms. Thus, there are opportunities for continuous H5N1 virus transmission from wild birds to these free-ranging flocks in this geographical region.

On the basis of historical patterns, influenza pandemics can be expected to occur, on average, three to four times each century. Experts agree that another influenza pandemic is inevitable and possibly imminent. However, thus far, pandemics have occurred in unpredictable patterns of time and aetiology, and do not predict future events.

Summary of risk factors probably involved in emergence of avian influenza H5N1 [138]

- Microbiological adaptation and selection that may eventually lead to human-to-human transmission (no evidence for human-to-human transmission yet)
- Growing density of free-ranging flocks, leading to more contacts between wild and domesticated birds
- Economic development
- Increased contacts of humans with dense populations of poultry
- Naive hosts (no acquired immunity)
- Globalisation of agriculture and trade
- International human travel
- Lack of effective control of epidemics of H5N1 among poultry (poverty)

APPENDIX IV. LIST OF POTENTIAL DISEASES EMERGING FROM ANIMAL RESERVOIRS RELEVANT TO EUROPE

Section 2.3 of Chapter 2 explains how the list of potential emerging zoonoses relevant to Europe, presented in this Appendix, was compiled. This list includes the zoonotic diseases, classed as viral, bacterial, and parasitic diseases and also shows the etiological agent, primary or most likely reservoir, mode of transmission, and, briefly, the geographical distribution.

Etiology	Human disease	Reservoir	Mode of transmission	Geographical Distribution
VIRUSES				
Ss RNA-negative stranded genome				
Orthomyxoviridae				
Influenza A virus (Avian/Swine)	Influenza	Wild birds, poultry/swine	Aerosols, faeces	Worldwide
Paramyxoviridae				
Nipah virus	Respiratory/ encephalitis	Bats, flying fox	Infected swine	Asia,
Hendra virus	Respiratory syndrome	Flying fox	Infected horses	Australia
Menangle virus	Stillbirth	Flying fox	Infected swine	Australia
Bunyaviridae				
Puumala virus	Haemorrhagic-renal syndrome	Rodent spp. (*Clethrionomys glareolus*)	Excreta	Europe, Russia
Sin Nombre virus	Pulmonary syndrome	Rodents (*Peromyscus maniculatus*)	Excreta	United States, Canada
Phlebo virus	Rift Valley fever	Sheep, goat	*Aedes* and *Culex* spp.	Africa, Middle East
Toscana/Sicilian/ Naples virus	Sandfly fever	Unknown	*Phlebotomus* spp.	South Europe, Africa, Middle East, Central Asia
La Crosse virus	California encephalitis	Squirrel, chipmunk	*Aedes triseriates*	North America
Nairo virus	Crimean Congo haemorrhagic fever	Ruminants	Ticks (*Hyalomma* spp.)	East/South Europe, Asia, Africa
Filoviridae				
Marburg virus Ebola virus	Haemorrhagic fever	Not known	Blood	Africa

Etiology	Human disease	Reservoir	Mode of transmission	Geographical Distribution
VIRUSES (continued)				
Arenaviridae				
Lassa virus Lymphocytic choriomeningitis virus	Haemorrhagic fever	Rodents	Contact with infected rodents	Africa
South American arena viruses				South America
Coronaviridae	SARS	Civet cat	Unknown	Asia, Canada
Flaviviridae	Yellow fever Dengue fever	Humans/ monkeys*	Mosquitoes (*Aedes*/ *Haemagogus*)	Tropical Africa/America/ Asia
	Japanese encephalitis	Swine/birds/ wildlife	Mosquitoes (*Culex*)	Asia/Australia
	Tick- borne encephalitis	Wild mammals/ livestock	Ticks	Europe/Asia
	Kyasanur forest disease/Alkurmas	Sheep	Ticks	India, Saudi-Arabia
	Louping ill	Sheep	Ticks (*Ixodes*)	Europe
	West Nile	Wild birds	Mosquitoes (*Culex* spp.)	Africa, Asia, Europe, America
Togaviridae	Equine encephalitis (eastern, western and Venezuelan)	Horses and wild birds	Mosquitoes (*Aedes*/*Culex* spp.)	America, Asia
	Sindbis fever	Birds	Mosquitoes	America
	Ross River virus	Various animals	Mosquitoes	Australia, South Pacific
Rhabdoviridae				
Classic rabies virus	Rabies	Carnivores and vampire bats	Bite	Worldwide except Japan, UK, New Zealand, Antarctica
European bat lyssa virus 1 and 2	Rabies	Bats	Bite	Europe
Australian bat lyssa virus	Rabies	Flying foxes, bats	Bite	Australia
Ss RNA positive stranded genome				
Hepatitis E virus	Hepatitis E	Pigs, rodents	Meat, water	Asia, America, Europe

* Monkeys are the original but humans are now the primary reservoir.

Etiology	Human disease	Reservoir	Mode of transmission	Geographical Distribution
VIRUSES (continued)				
Ds RNA genome				
Reoviridae				
Rotaviruses	Enteritis	Mammals and birds	Faeces	Worldwide
Coltivirus	Colorado tick fever	Rodents	*Dermacentor andersoni*	North America
Eyach virus	Eyach	Rodents	Ticks	Europe
DNA/RNA RT genome				
Retroviridae				
SIV1-2		Chimpanzees/ sooty mangabeys	Bites and scratches	Africa
Simian T-lymphotropic virus, simian retrovirus, simian foamy virus		Human and non-human primates		Africa, Asia
Ds DNA genome				
Herpesviridae	Herpes B	Macaques	Bite, saliva	Africa, Asia
Orthopoxviridae				
Monkeypox	Pustular rash	Rodents	Direct contact	Central and West Africa, America
Cowpox	Skin lesions	Rodents	Direct contact	Europe, Africa, Central and Northern Asia

Etiology	Human disease	Reservoir	Mode of transmission	Geographical Distribution
BACTERIA				
Gram-negative polymorph				
Rickettsiales* and *Bartonellaceae				
Rickettsia conorii, R. slovaca, R. helvetica, R. rickettsia	Spotted fevers	Dogs, rodents, birds, mammals	Ticks (*Rhipicephalus sanguineus, I. ricinus, Dermacentor* spp.)	Europe, America, Asia, Africa
Ehrlichia phagocytophilia	Human granulocytic ehrlichiosis	Rodents in America	Ticks, e.g. *I. ricinus*	Europe, America
Ehrlichia chaffeensis	Human monocytic ehrlichiosis	Deer, raccoon	Ticks	America
Bartonella henselae	Cat scratch disease	Cat	Cat scratch	Worldwide
Coxiella burnetii	Q fever	Ungulates	Ticks, milk	Worldwide
Gram-negative rods				
Yersinia pestis	Sylvatic plague	Rodents	Fleas	America, Asia
Fransiscella tularensis	Tularaemia	Rodents	Ticks, faeces, water	Europe, America
Brucella melitensis	Brucellosis	Sheep, goats	Aerogens, milk	Worldwide
Salmonella DT104 (emerging strains)	Salmonellosis	Wildlife, livestock	Faeces, meat, eggs and direct contact	Worldwide
Shiga-toxin producing *E .coli*	EHEC-infections	Livestock	Meat and direct contact	Worldwide
Campylobacter spp.	Campylobacteriosis	Poultry, insects, pigs	Faeces, meat	Worldwide
Gram-positive rods acid fast				
Mycobacterium bovis	Tuberculosis	Cattle	Aerogens, milk	Worldwide
Spirochaetaceae				
Borrelia spp.	Lyme borreliosis	Rodents, birds, mammals	Ticks	America, Europe
Leptospira interrogans	Leptospirosis	Rodents, dogs, livestock	Water	Worldwide

Etiology	**Human disease**	**Reservoir**	**Mode of transmission**	**Geographical Distribution**
PROTOZOA				
Babesia divergens	Babesiosis	Cattle	Ticks e.g. *I. ricinus, D. marginatus*	Europe, Africa, America
Babesia microti	Babesiosis	voles, mice		
Leishmania spp.	Leishmaniasis	Dog, rodents	Sandflies	South Europe, Africa, America
Toxoplasma gondii	Toxoplasmosis	Mammals, rodents, cat	Meat, oocysts	Worldwide
Cryptosporidium parvum	Cryptosporidiosis	Livestock, wildlife	Water, meat, food, direct contact	Worldwide
Trypanosoma bruceï	Trypanosomiasis	Cattle, wildlife	*Glossina* mosquitoes (Tsetse)	Africa
HELMINTHS				
Taenia solium	Cysticercosis	Swine/humans	Meat	America, Africa, South Europe
Trichinella spp.	Trichinellosis	Wildlife, swine, horses	Meat	Worldwide
Bayliascaris procyonis	Larva migrans syndrome	Raccoon, raccoon dog	Eggs in faeces	America, East Europe, Asia
Echinococcus granulosus	Hydatid disease	Dog	Direct contact, with eggs	South and East Europe, Africa, Asia, Australia
Echinococcus multilocularis	Alveolar echinococcosis	Fox and dog	Direct contact with eggs, water, contaminated food	Europe, Asia, America

APPENDIX V. LEGISLATION AND EXISTING SYSTEMS FOR THE SURVEILLANCE AND CONTROL OF ZOONOSES IN THE NETHERLANDS

V.1 Authorities involved in the monitoring and control of zoonoses in the Netherlands

Several authorities are involved in the monitoring and control of zoonoses and zoonotic agents in the European countries. It is beyond the scope of this report to discuss all these different authorities in the various European countries. However, to give some insight into the complexity of the surveillance and control of zoonoses, as an example, the most important authorities involved in the Netherlands and the opinions of experts are discussed.

V.2 Legislation

The monitoring and control of infectious diseases is arranged at the European level with the aid of many directives (Chapter 4). In the Netherlands, more legislation is arranged at the national level. The Ministry of Public Health, Welfare and Sports (hereafter referred to as the Ministry of Health) and the Ministry of Agriculture, Nature and Food Quality (hereafter referred to as the Ministry of Agriculture) are both responsible for the monitoring and the control of zoonotic diseases and the causative agents (viruses, bacteria, and parasites) in humans, animals (both slaughter animals and wildlife animals), feed and food, according to this legislation [144]. The Ministries are also the national authority responsible for the control of the regulations at the national level. On the human side, the Infectious Diseases Act (*Infectieziektenwet*, IZW) specifies which zoonoses have to be reported and how [145] (notifiable diseases), as well as measures and responsibilities in the monitoring and control of infectious diseases. On the animal side, the Animal Health and Welfare Act (*Gezondheids- en Welzijnswet voor Dieren,* GWWD) [146] specifies the animal diseases to be reported and contains many regulations with respect to monitoring and control of such diseases. Table V.1 shows the notifiable human and animal zoonoses as listed by the Infectious Diseases Act and the Animal Health and Welfare Act.

V.3 Animal infectious disease control and the coordinating organisations

When a veterinarian suspects a disease, she/he will send relevant samples to the Animal Health Service (*Gezondheidsdienst voor Dieren,* GD) or, when a notifiable disease as defined by the Animal Health and Welfare Act is suspected, she/he will inform the National Inspection Service for Livestock and Meat (*Rijksdienst voor de keuring van Vee*

Table V.1. Notifiable zoonoses in the Netherlands

Zoonoses	Humans: Infectious Diseases Act (IZW)	Domestic animals: Animal Health and Welfare Act (GWWD)
Anthrax	X	X [1)]
Botulism	X	-
Brucellosis (*Brucella abortus*)	X	X [1)]
Brucellosis (*Brucella suis*)	X	X [2)]
Bovine spongiform encephalitis	-	X [3)]
Campylobacteriosis	-	X [3)]
Echinococcosis	-	X [3)]
Enterohaemorrhagic/verotoxigenic *Escherichia coli* (Enterohaemorrhagic and verocytotoxin-producing)	X	-
Leptospirosis (*Leptospira hardjo*)	X	X [3)]
Listeriosis	-	X [3)]
Psitacosis	X	X [4)]
Rabies	X	X [1)]
Salmonellosis	-	X [3)]
Toxoplasmosis	-	X [3)]
Trichinellosis	X	X [2)]
Tuberculosis	X	X [1)]
Yersiniosis	-	X [3)]

[1)] Notifiable only when occurring in mammals; [2)] Notifiable only when occurring in cattle; [3)] Notifiable when occurring in all animals; [4)] Notifiable only when occurring in birds (except poultry)

en Vlees, RVV), and a regional crisis team of the RVV will visit the farm and take further action, including sampling. Relevant samples will be sent to the Central Institute for Animal Disease Control (CIDC) and will be examined. The CIDC will report the test results to this National Inspection Service. When a potentially dangerous disease is suspected, depending on its properties (significance, contagiousness), either instantly or after confirmation by the CIDC, the National Inspection Service (RVV) will inform the Chief Veterinary Officers (CVO of Animal Health and CVO of Public Health) and the crisis team of the Ministry of Agriculture. The CVO has an independent function and gives advice when a crisis occurs. When a disease is also important for human public health, the Ministry of Agriculture contacts the Dutch Food and Consumer Product Safety Authority (*Voedsel en Waren Autoriteit,* VWA). This Authority and the CVO of Public Health will decide if the situation warrants informing the Ministry of Health (Figure V.1.).

V.4 Human infectious disease control and the co-ordinating organisations

In the Netherlands, notifiable human *zoonotic* diseases have to be reported to the Public Health Service (*Gemeentelijke Gezondheidsdienst,* GGD). A report of such a disease can reach the Public Health Service via a general practitioner, hospital staff, a laboratory or occasionally directly via the patient. The registration of these diseases is the responsibility of the Inspectorate for Health (*Inspectie voor de Gezondheidszorg,* IGZ) of the Ministry of Health.

When a zoonotic disease is reported in a community, the mayor is responsible for seeing to it that action is taken to minimise public health implications of the reported disease and to identify the source of the infection. The Public Health Service will take these actions. If more than one Public Health Service is involved, the National Coordination Structure for Infectious Disease Control (*Landelijke Coördinatiestructuur Infectieziektenbestrijding,* LCI) is responsible for the coordination of all actions to minimise the infection-risks. Diagnostic tests of samples sent by GPs are performed at regional laboratories. For some diseases, laboratories may send isolates to the RIVM for confirmation of their results. Besides the registration of zoonotic diseases, the Inspectorate for Health can initiate monitoring and surveillance programmes for zoonotic agents and zoonotic diseases in humans. Activities are carried out in close collaboration with the VWA in case of food-borne diseases and contact zoonoses.
In case of a national threat or crisis, the LCI will also inform a national outbreak management team of professionals which will advise the Ministry of Health through an independent administrative board (*Bestuurlijk Afstemmingsoverleg,* BAO) authorising the advice before it reaches the staff of the Ministry of Health. The Minister or the State Secretary will authorise action on the advice, after which action to combat and control the disease will be undertaken (Figure V.2.).

V.5 Coordinating organisation: the Food and Consumer Product Safety Authority (VWA)

Before 2003, the Inspectorate for Health Protection and Veterinary Public Health (*Keuringsdienst voor Waren,* KvW) was part of the Ministry of Health. Since 2003, this Inspectorate is one of two delivery units of the VWA. The other delivery unit is the National Inspection Service for Livestock and Meat (VWA/RVV) and this Authority consists further of a central coordinating unit. The Authority coordinates the exchange of information about cases of zoonoses between the human and veterinary sector. The Authority operates under the umbrella of the Ministry of Agriculture but is also a delivery agency for the Ministry of Health [147]. The VWA/KvW is responsible for the status of public health in relation to food-borne and animal zoonoses, and the VWA/RVV is involved in meat inspection and in the registration and control of diseases, including zoonoses, in live animals and slaughtered animals. As a result of the activities of the VWA/KvW and the VWA/RVV, the protection of food-safety during all stages of the production chain and the health protection of animals is now the responsibility of one single Authority (the VWA) [144].

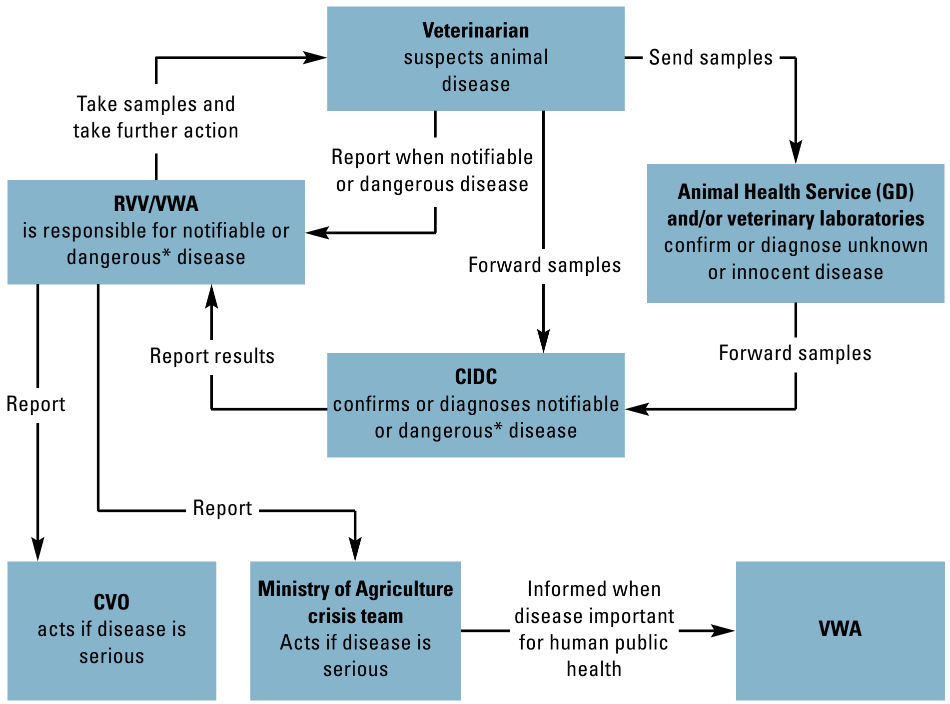

Figure V.1. Organisation for a (zoonotic) disease outbreak in animals.
** Dangerous: is contagious or forms a risk to human and/or animal health*
CIDC, Central Institute for Animal Disease Control; CVO, Chief Veterinary Officer; RVV, National Inspection Service for Livestock and Meat; VWA, Food and Consumer Product Safety Authority

V.6 Discussion

As an example, this appendix describes the Dutch situation regarding surveillance and control of zoonoses to give some insight into the complexity of the system. Legislative issues and opinions of Dutch experts derived from the Dutch questionnaire (Appendix VI) and in-depth interviews are included. In general, the legislation on the surveillance and control of zoonoses in the Netherlands is well organised. However, according to Dutch experts, the implementation of appropriate surveillance and control systems needs further improvement, especially with respect to harmonisation of veterinary and human public health. These examples show that, even in a country as well-organised as the Netherlands, improvements in the harmonisation of the veterinary and human public health sectors may enhance the early response to new threats from the animal reservoir. Analysis of the recent influenza crisis in the Netherlands as an example will be helpful in this respect.

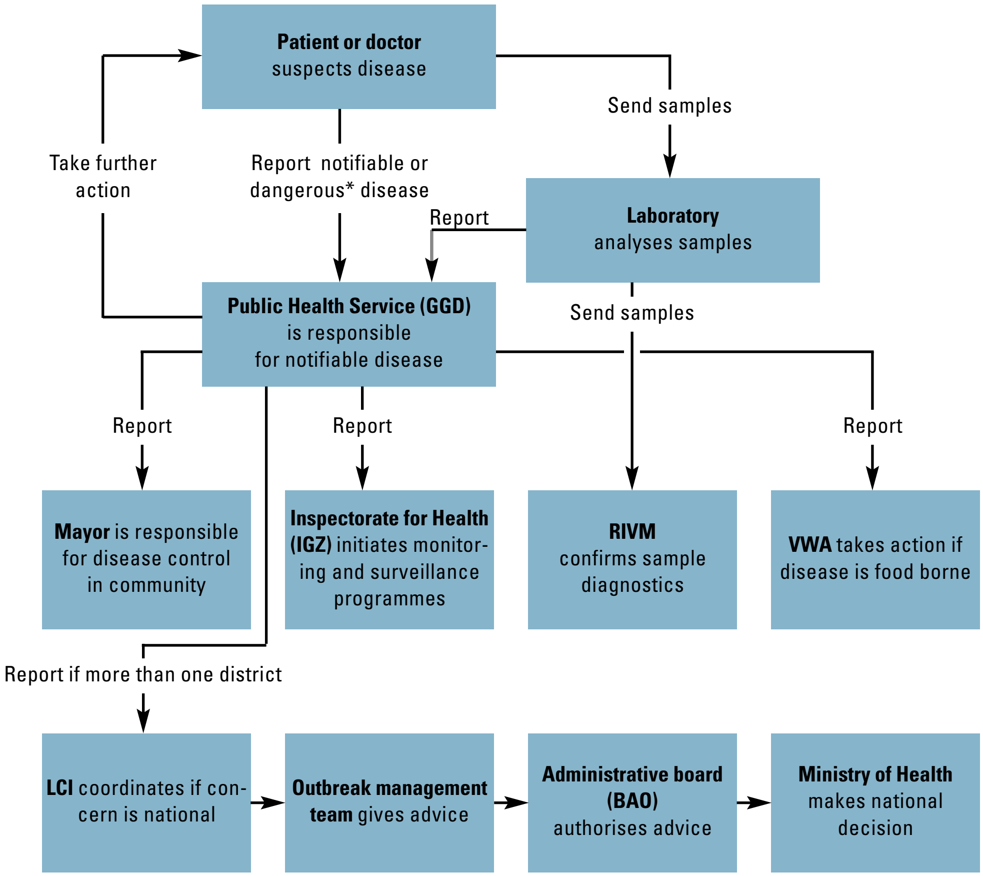

Figure V.2. Organisation of health services for combatting zoonotic outbreaks in the Dutch population.
**Dangerous: is contagious or forms a risk to human and/or animal health*
LCI, National Coordination Structure for Infectious Diseases Control; IGZ, Inspectorate for Health; RIVM, National Institute for Public Health and the Environment; VWA, Food and Consumer Product Safety Authority

V.6.1 Legislation

Some zoonoses are notifiable diseases according to the Infectious Diseases Act (for humans), whereas they are not to be reported according to the Animal Health and Welfare Act (the equivalent for animals) and *vice versa* (Table IV.1). This is also the case for some zoonoses that are regarded to have a high potential for emergence, such as VTEC, which is notifiable for human contagion, but not for animal contagion. In addition, echinococcosis, for example, is a potential emerging disease in Europe, but is notifiable for animals only.

V.6.2 Surveillance according to the experts

The experts felt that the surveillance of emerging zoonoses in the Netherlands could be improved. Surveillance of new or emerging infectious diseases will be difficult because a limited set of zoonoses is monitored and syndrome surveillance is still in a preliminary stage. Apart from the early recognition of some zoonoses, there is no natural exchange of data between scientific institutes. Better integration of the data could be achieved and timely recognition and control of zoonoses would be enhanced if data exchange were supported. Every year, authorities send a report about the current zoonoses situation to the Community Reference Laboratory for the Epidemiology of Zoonoses (CRL-E). This is made obligatory by Directive 2003/99/EC (Section 4.2.2). According to several experts, it is unclear what happens with the data they report after the annual reports are compiled.

V.6.3 Communication and control according to the experts

Most of the communication is ad hoc and mainly based on network contacts. At the ministerial level, the communication between the Ministries of Health and Agriculture is hampered by differences in the way animal and human infectious diseases are being controlled and managed. If a zoonotic disease outbreak with public health implications, the communication between the Ministries of Health and Agriculture is crucial. This was clear during the avian influenza crisis in the Netherlands in 2003. Several studies were carried out to evaluate the different organisation structures and communication after the avian influenza outbreak in the Netherlands. Partly because of this, the ministries decided to arrange an Interdepartmental Policy Team, which will facilitate the communication between the ministries. However, this is now only organised at the highest level. It should be stressed that communication needs to be more structured on several levels between the human and animal health fields. The first diagnosis of an emerging zoonosis at the laboratory level can be crucial for both the medical and veterinary fields. Therefore, not only *ad hoc* intercollegiate fine tuning, but also more structural communication lines are needed. One of the main aspects mentioned by all experts is that the harmonisation between the veterinary and the human public health sectors is fragile and should be strengthened at various levels (Appendix VI). All the experts mentioned that better harmonisation is necessary to improve the control of zoonoses. As this appendix shows, the VWA plays a linking role between the animal and human public health sectors. Experts mentioned that they would appreciate other links besides the VWA at other levels in the control of zoonoses. Because zoonoses are not only nationally but also internationally vital, the control of zoonoses should also be discussed at European and global WHO levels.

APPENDIX VI. QUESTIONNAIRE FOR DUTCH EXPERTS

Appendix VI-A. Overview of the Dutch questionnaire results

VI.1 Introduction

Apart from the literature study described in Chapter 2, a self-administered questionnaire was completed by experts in the medical and veterinary fields of zoonotic infections and public health in the Netherlands for the purpose of gaining more insight into the emerging zoonoses that are a potential risk for public health in Europe (questionaire see page 93).

The aims of this questionnaire were:
- To list the emerging and re-emerging zoonoses relevant to Europe
- To inventorise the potential risk factors for the emergence of new zoonoses
- To get insight from expert opinions about existing national and European surveillance systems for emerging and re-emerging zoonoses.

VI.2 Data collection and analysis

The questionnaire was distributed to 26 experts on emerging zoonoses or related topics, among whom were members of the Health Council of the Netherlands (a full list of experts is given at the end of this appendix). Twenty people responded (77%). More than one answer could be given for each question. Respondents were requested to answer the questions according to their personal expertise, and if they could not answer a question, to specify this with 'don't know' or otherwise leave the question unanswered. The questionnaire consisted of nine questions. The first question concerned a table of currently emerging zoonoses, and zoonoses that have a high potential of emergence. Moreover, there were both open and multiple choice questions. Two questions contained lists of factors possibly associated with emergence. Respondents were asked to score these factors according to a three-scale semiquantitative score (+++ major importance, ++ medium importance + minor importance). Appendix VI-B shows the questionnaire.

The data were analysed in Excel. The scores of the semiquantitative questions were, if necessary, translated to the three-scale score indicated in the questions (as not all respondents used the score proposed) and were subsequently summed per factor. We also counted the number of respondents that scored each factor as being of major importance. Multiple choice questions were scored per option, according to the number of respondents who ticked the option. The answers to qualitative questions were summarised. If an answer was given by more than one respondent, we counted the number of times the answer was given.

VI.3 Results

VI.3.1 Important zoonoses causing public health risks

The first question asked the experts to complete the table of zoonoses. Answers to this question were also used to make the table in Appendix IV. The second question focused on which zoonoses will bring the most public health risks in the (near) future in Europe. (Avian) influenza was most often mentioned, followed by West Nile virus, Lyme borreliosis, *Salmonella*, and *Campylobacter* (although food-borne zoonoses are not considered in this report). Other diseases that were often mentioned were hepatitis E and leishmaniasis (Table V.1). Motivations given for naming these zoonoses were the epidemic potential, the high morbidity or mortality, serious symptoms, ecological factors, and global warming.

Table VI.1. List of zoonoses mentioned by the experts

Zoonosis	Number of times mentioned*	Motivation**
(Avian) influenza	13	Epidemic potential, high virus load, import from Asia, combination human/animal influenza, human-to-human transmission
West Nile virus	5	Unpredictable, lack of knowledge, large bird distribution, transmission by mosquitoes, no treatment
Lyme borreliosis	5	Ecological and climate changes, economical problems, serious symptoms
Salmonella spp.	4	Increasing antibiotic resistance, vulnerability of food chain, high incidence leading to high morbidity and mortality
Campylobacter spp.	4	High morbidity
Hepatitis E	2	Lack of good screening and prevention
Leishmaniasis	2	Risk of horizontal spread, global warming, vectors difficult to control
Shiga toxin-producing *E. coli* or Enterohaemorrhagic *E. coli*	2	Epidemic potential, food production, hygiene
SARS	1	-
Bovine spongiform encephalitis (BSE)	1	-
Dengue	1	High susceptibility, various viruses, mosquito elimination difficult, no effective treatment
Echinococcus multilocularis	1	No treatment, endemic in Europe, no good prevention
Poxviruses	1	-
Trichinella spp.	1	Outbreak potential, serious symptoms, chronic
Tick-borne encephalitis, Hanta viruses, and Q fever	1	Restoration of biotopes, human recreation causes closer contact with vectors

* Eighteen respondents answered this question
** All explanations for naming the pathogen are mentioned.

VI.3.2 Risk factors for emerging zoonoses

Question 3 inquired which factors would contribute greatly to the development of new zoonoses or re-emerging zoonoses in Europe. According to the experts (*n* = 18) the risk factor of major importance is microbiological adaptation and selection. Fourteen experts gave this answer, and 8 of them said it would be of major importance. Furthermore, changing ecosystems was mentioned by 16 experts (4 said major importance). Globalisation of agriculture and trade, and international travel are also important factors, but most experts did not mention them as being of major importance (mention was made by 18 and 15 experts, respectively. Three of the experts said that both of these factors are of major importance).

VI.3.3 Origin of new threats

Question 4 asked for the origin of new zoonoses (taxonomic order, reservoirs, and geography). According to the experts (*n* = 14), RNA viruses, DNA viruses, and bacteria have the greatest potential for emergence. Fifty-seven percent of the experts considered the RNA viruses of major importance. The overall motivation to mention viruses as being of (major) importance was the mutation rate and the possibilities for adaptation. For bacteria, the main motivation was their potential for antibiotic resistance and changes in pathogenicity. Protozoa and helminths were considered less important in causing unknown new threats.

Birds and rodents were most often mentioned as reservoirs for emerging zoonoses. Poultry was mentioned by four people as being of major importance. The motivations were especially bird migration, the types of influenza carried by birds, and the amplifying potential of poultry because of the factory farming, the new pathogen types, and the opportunities for diseases to spread. For rodents, the motivations were the wide range of distribution, the abundance of rodents, and the contacts with livestock and humans.

With respect to geographical area, Asia was mentioned as the most important region for emerging zoonoses, especially South-east Asia, next to Eastern Europe and Central Africa). Motivations for these answers were the high population density for both people and animals in Asia, the increasing intensity of trade between the Member States in Europe, and new and exotic diseases in Africa, which will probably also emerge in Europe when the temperature rises.

In addition, the experts were asked to name specific orders (and, if possible) families of microorganisms that they considered most likely to emerge. Although the answers to this question largely overlapped with those given for the previous question (Section VI.3.3), some experts specifically mentioned families, especially *Poxviridae, Flaviviridae,* and *Rickettsiae*.

VI.3.4 The main problems in the recognition of zoonoses in the Netherlands and Europe

The questionnaire gave a choice of various factors contributing to the problems of recognising zoonoses. The factors the experts (n = 17) chose as the most important were the lack of surveillance systems (88%) and the lack of harmonisation between the veterinary and public health (83%) organisations. The lack of syndrome surveillance (71%) was mentioned often as well.

The experts stated that these factors apply not only to the Netherlands, but also to Europe. However, many mentioned that they were not fully aware of the situation in Europe and that they were therefore unable to answer all the questions about Europe.

The category 'Lack of harmonisation between veterinary and public health' gave the experts a choice of options to specify this lack of harmonisation. The fact that institutions responsible for the surveillance and control of zoonoses are organised separately for the medical and veterinary fields was mentioned the most. In addition, good education and training might improve the harmonisation between veterinary and public health organisations. Problems with legislation were mentioned as less important.

VI.3.5 Problems in the surveillance and control of zoonoses

Open questions asked the experts which zoonoses cannot be recognised appropriately and in a timely fashion via current systems, and what the key will be to improve timely recognition of new developments.

With respect to zoonoses that now cannot be recognised in time, the answers differed from 'all', 'all zoonoses for which no active syndrome surveillance and early warning exists', to 'zoonoses emerging via wildlife or import of animals or animal products'. Some experts mentioned specific species or diseases, such as Hanta virus, West Nile virus, Lyme borreliosis, TBE, cowpox (via rodents), arboviruses, monkeypox, tularaemia, echinococcosis, and *Salmonella enteritidis*.

The experts mentioned some shortcomings in the timely recognition of new developments. We first discuss the problems with surveillance and improvements for the detection of new, emerging, or re-emerging zoonoses, then the control of zoonoses in the Netherlands and Europe.

Diagnostics. Fifty-three percent of the experts mentioned that there is a lack of laboratory facilities for diagnostic analysis. The poor availability of robust diagnostic tests was seen as a problem, both at the Dutch and European levels. Lack of knowledge about zoonoses among physicians and laboratory technicians complicates the timely recognition of individual cases and outbreaks.

Surveillance. According to some experts, Europe, including the Netherlands, lacks monitoring and surveillance systems for wildlife, arthropods, and birds. Furthermore, the tracing of imported exotic animals to find the origin of an infectious disease out-

break needs improvements. Syndrome surveillance as a tool for the early detection of unknown diseases is still premature. The experts also confirmed that the harmonisation between veterinary and human public health sectors should be improved.
Suggested improvements for the surveillance of zoonoses are the development and implementation of active surveillance and syndrome surveillance/early-warning systems at the national, but more importantly, at the international level. However, it was also mentioned that monitoring every possible new emerging disease is too costly and time consuming.

Control. The lack of good communication and coordination between human and veterinary health sectors, might be improved by forming coordinating bodies with clear responsibilities. This lack was mentioned as an important shortcoming in the control of emerging zoonoses. We now discuss some of the specific problems and suggestions.
In the Netherlands, some uncertainty exists about the responsibilities of the various authorities involved in the control of a crisis. According to the experts, the communication and harmonisation between veterinary and public health sectors is not good at present (81%). For this reason, the Dutch Food and Non-Food Authority (VWA) which links the Ministries of Health and Agriculture, should improve the cooperation between these two sectors (Appendix V), but at present, cooperation is fragile and more links at different levels for the control of zoonoses would be appreciated. For Europe, the same uncertainties and problems were mentioned. Moreover, large differences exist between Member States in the monitoring and control of zoonoses.
The monitoring and control of alimentary bacteria and some parasitic zoonoses (*Salmonella* spp., *Campylobacter* spp., *Trichinella* spp.) at the food chain level are fairly well developed and organised in Europe, in the opinion of the experts. However, this is not the case for other zoonotic agents. The reasons mentioned were diverse (lack of political will, inexperience of the authorities, and conflicting interests of veterinary and public health sectors).
In general, the experts considered the policy on zoonoses in humans secondary to policy on zoonoses in the veterinary field. To improve this situation, an inter-European centre for the registration, surveillance, and control of zoonoses could be very valuable.

Specific suggestions mentioned:

- More emphasis on syndrome surveillance
- Installation of reporting stations and Internet-based systems for rare diseases
- Continued education of laboratory technicians and physicians to improve recognition of rare diseases
- Risk avoidance (in international trade and transport, extensive animal husbandry, etc.)
- Better education of the general public about the risks of zoonoses and risk avoidance
- Installation of coordinating bodies to improve communication and harmonisation of monitoring and control of zoonoses at the national and international levels.

VI.4 Discussion

Although it should be kept in mind that the avian influenza outbreak in South-east Asia was ongoing at the time of the questionnaire and interviews (February-March 2004), most experts agreed on the major topics of this questionnaire. According to the experts, (avian) influenza will be responsible for most public health risks in Europe in the near future. Another issue to consider is that most experts could not answer all the questions as they had different fields of expertise. Some experts also said that the answer to a question sometimes depended on the microorganism. In addition, several experts said that it is impossible to predict the next infectious disease to emerge, and it is impossible to predict the source or risk factors involved. However, global warming or ecological factors can direct us to certain problems (vector-borne disease). Another important outcome of the questionnaire is that almost all the experts stated that research funding for zoonoses is minimal, and consequently the knowledge about zoonoses is thin. Improvements are desirable, specifically with respect to fundamental and applied research, the surveillance of zoonoses, the communication between actors, and the control of zoonoses.

List of experts who participated in questionnaire and/or interviews
M.W. Borgdorff, medical epidemiologist; A. Bosman, medical epidemiologist, M.A.E. Conyn-van Spaendonck, medical epidemiologist; A.R. Elbers, epidemiologist [on behalf of A. Bianchi (Health Council member, immunologist and microbiologist), E.M.A. van Rooij, W.L.A. Loeffen, G. Koch and P. van Rijn (virologists)]; G.A. van Essen, Health Council member and general practitioner; A.W. van de Giessen, bacteriologist; F. van Knapen, Health Council member, veterinarian, and parasitologist; M.P.G. Koopmans, Health Council member, virologist, and veterinarian; L.M. Kortbeek, medical microbiologist and parasitologist; P.W. de Leeuw, Chief Veterinary Officer; J.W.M. van der Meer, Health Council member, internist, and medical microbiologist; J. van der Noordaa, Health Council member and virologist; R.A.A. van Oosterom, Inspector of the Food and Safety Authority; A.D.M.E. Osterhaus, Health Council member, virologist, and veterinarian, W. van Pelt, epidemiologist; W.H.M. van der Poel, virologist and veterinarian; T. Rietveld, policy official of the Ministry of Agriculture; E.J. Ruitenberg, Chair of the Health Council, immunologist, and veterinarian; V. Rutten, immunologist; J.F.P. Schellekens, medical microbiologist and bacteriologist; W. Takken, entomologist; A. Timen, physician infectious diseases; J. van der Velden, Health Council member, epidemiologist, and general practitioner; J.A. van Vliet, medical epidemiologist; P. van der Wal, Chief Veterinary Officer; F. van Zijderveld, bacteriologist and veterinarian.

Appendix VI-B. Questionnaire

Threats of (re)emerging infections from animal reservoirs to humans in Europe

Note: This questionnaire was translated from Dutch and was used before the redefinition of emerging zoonoses by the WHO in May 2004.

Definitions

Infectious agents from animal reservoirs: (zoonoses): pathogens transmitted between vertebrate animals and man under *natural* conditions [4].
This includes pathogens that are transmitted through an arthropod vector, pathogens transmitted from animal products (such as meat, other animal foods, and excretions; mechanical transmission are excluded) to man and pathogens transmitted from man to animals.
It also includes newly emerging pathogens that, after crossing the species barrier, are subsequently mainly transmitted between humans (e.g., SARS).
The definition excludes pathogens that are deliberately introduced into human populations. Species, such as HIV, that originally evolved from animal pathogens, but that have not been transmitted between animals and humans for decades are not included. Diseases that are primarily the result of toxins produced by animal-borne pathogens are not covered by this definition either.

Emerging disease: a new infection resulting from the evolution or change of existing pathogens, or a known infection spreading to new geographic areas or populations or species, or a previously unrecognised infection spreading to new geographic areas, populations or species, or a previously unrecognised infection or disease diagnosed for the first time (Source: Questionnaire 'Emerging and re-emerging zoonotic diseases: challenges and opportunities', 2004, OIE, unpublished).

Europe: is defined here as all countries affiliated with the European Union, including candidate countries.

Note. The infections to be covered are those considered to be relatively likely to emerge or re-emerge in Europe, thereby creating the relevant risks to human public health in Europe. However, pathogens that are very likely to emerge globally and rapidly, such as diseases caused by avian influenza viruses, should also be considered. Existing, well-described and monitored food-borne zoonoses such as *Campylobacter* spp. and *Salmonella* spp. are not to be considered, except for the emerging and re-emerging strains.

Table VI.2 lists zoonoses that are important or may become important to European public health, including zoonoses that have caused increasing problems during the last 10 years (information relevant for Europe was retrieved from various Web sites [9 148 149] and EU Decision 2000/96/EC and Directive 2003/99/EC [107]).

Table VI.2. Emerging zoonoses considered relevant to European public health

Zoonosis	Geographic dissemination
Viral agents/diseases	
Orthomyxoviruses:	Worldwide
• Avian influenza	
Paramyxoviruses:	Asia, Australia
• Nipah virus	
• Hendra virus	
• Menagle virus	
New Castle Disease	Worldwide
SARS	Asia
BSE	Europe, America
Hepatitis (Hep. E virus)	Asia, Europe
Ebola haemorrhagic fever	Africa, Europe*
Marburg virus	Africa, Europe*
Rift Valley fever (phlebovirus)	Africa, Middle East
Crimean Congo haemorrh.fever (CCHV)	Africa, Asia, Europe*
Flaviviruses:	Worldwide
• Tick Borne Encephalitis	Europe
• Louping ill	Europe
• West Nile	Africa, America, Europe
Lyssaviruses:	Worldwide
• Classical rabies	
• Bat lyssavirus	
Hantaviruses:	Worldwide
• Haemorrhagic/renal syndrome	Europe, Asia
• Pulmonary syndrome	America
Orthopoxviruses:	Africa, America, Europe
• Monkeypox	
• Cowpox	
Parapoxviruses:	Worldwide
• Sheep/goatpox	
• ORF	
African horse sickness	Africa, South Europe
Bacterial/Protozoal diseases:	
Tick-borne:	Europe/America/Asia
• Borreliosis (*Borrelia* spp.)	
• Ehrlichiosis (*Ehrlichia* spp.)	
• Bartonella (*Bartonella* spp.)	
• Babesiosis (*B. microti/divergens*)	
Anthrax (*B. anthracis*)	Worldwide
Brucellosis (*B. abortus, suis, melitensis*)	Worldwide
Tuberculosis (*M. bovis*)	Worldwide
Salmonellosis (DT104/emerging strains)	Worldwide
EHEC (shiga toxin prod. *E. coli*)	Worldwide
Leptospirosis (*L. interrogens* serovars)	Worldwide
Sylvatic plague (*Y. pestis*)	Asia, America,
Vibriosis (*V. vulnificus*)	Africa, Asia
Tularaemia	Worldwide
Q-fever (*C. burnetii*)	Worldwide
Psittacosis (*C. psittaci*)	Worldwide
Leishmaniasis (*L. infantum*)	South Europe, Africa, America
Cryptosporidiosis (*C. parvum*)	Worldwide
Toxoplasmosis (*T. gondii*)	Worldwide

Table VI.2. Emerging zoonoses considered relevant to European public health

Zoonosis	Geographic dissemination
Helminth diseases:	
Cysticercosis	
• *T. solium*	America, Africa, South Europe
• *T. saginata*	Worldwide
Trichinellosis (*Trichinella* spp.)	Worldwide
Larva migrans syndrome	Europe, Asia, America
• *Bayliascaris procyonis*	
• *Toxocara canis/cati*	
• *Ascaris suum*	
Echinococcosis	
1. E. granulosus	Europe, Africa, Asia, Australia
2. E. multilocularis	Europe, Asia, America

* Risk through human cases or import of infected animals (CCHF) from Africa

1 Do you think this list is complete for Europe?
☐ yes
☐ no → can you complete the list with zoonoses that you consider to pose a risk to public health in Europe, now or in the future?

2 Which of the zoonoses mentioned in Table VI.2 (including the ones you added) will cause most problems in Europe and why?

Zoonosis	Motivation

3 Which of the globally occurring factors below will contribute greatly to the emergence of new or re-emerging zoonoses (relevant to Europe)? Please indicate the importance of <u>each factor</u> (+++ = major importance; ++ = medium importance; + = minor importance; – = unknown).

Factor	Importance	Motivation
Microbiological adaptation and selection		
Changes in (host) sensitivity		
Climate and weather		
Changing ecosystems (e.g. deforestation)		
Changes in demography and human behaviour		
Poverty, war, hunger		
Lack of political will		
Economic development and land use		
Deterioration of public health systems		
International travel		
Globalisation of agriculture and trade		
(Agro-)technological developments		
Developments in animal husbandry:		
Factory farming		
Extensivation		
Other		
Contacts with wild animals:		
Increasing interaction between humans and wildlife		
Trade in exotic/wild animals		
Consumption of exotic animals		

4 In Question 2, we asked for known threats. In this Question, however, we ask you to indicate from which side we can expect new and currently unknown threats from animal reservoirs to public health in the near future (relevant to Europe). Please indicate the importance of each factor (+++ = major importance; ++ = medium importance; + = minor importance; – = unknown).

Factor		Importance	Motivation
Taxonomy			
RNA viruses			
DNA viruses			
Protozoa			
Bacteria			
Helminths			
Other (specify)			
Reservoir			
Wild animals:	birds		
	rodents		
	game		
Pet animals			
Animal husbandry:	cattle		
	pigs		
	poultry		
Other (specify)			
Geography (see map)			
a.			
b.			
c.			
d.			
e.			
Other factors			

5 Which taxonomic order specified in Question 4 can we expect to cause the greatest threats to human public health in the near future and why?

Taxonomic order (please specify as precisely as possible)	Motivation

6 What are, in general, the main bottlenecks for the timely recognition of (re) emerging zoonoses in Netherlands, and as far as you know, in Europe?

☐ No or insufficient laboratory facilities for diagnostic analyses

Netherlands	*Europe*
☐ veterinary laboratories	☐ veterinary laboratories
☐ human laboratories	☐ human laboratories
☐ both	☐ both

☐ Lack of good surveillance systems

Netherlands	*Europe*
☐ veterinary surveillance	☐ veterinary surveillance
☐ human surveillance	☐ human surveillance
☐ both	☐ both

☐ No or insufficient syndrome surveillance

Netherlands	*Europe*
☐ veterinary syndrome surveillance	☐ veterinary syndrome surveillance
☐ human syndrome surveillance	☐ human syndrome surveillance
☐ both	☐ both

☐ No surveillance on the import of animals, animal feeds and animal products (e.g. quantities, countries of origin)
☐ *Netherlands* ☐ *Europe*

☐ Insufficient knowledge about infections in wildlife reservoirs in general
☐ *Netherlands* ☐ *Europe*

☐ Insufficient knowledge about zoonoses among physicians
☐ *Netherlands* ☐ *Europe*

☐ Insufficient knowledge about possible threats of animal diseases to human public health in the veterinary sector
☐ *Netherlands* ☐ *Europe*

☐ No or poor harmonisation between veterinary and human sectors in relation to:

Netherlands	*Europe*
☐ legislation	☐ legislation
☐ surveillance	☐ surveillance
☐ separate organisation	☐ separate organisation
☐ during training	☐ during training

- ☐ Lack of clarity about administrative/governmental and practical responsibilities
  Netherlands, please motivate ______________________________
  Europe, please motivate ______________________________
- ☐ Other,specify ______________________________

7 Can you briefly explain why you choose the answers in Question 6?

____
____
____
____
____
____
____
____
____
____
____
____

8 To which zoonoses applies that we are not able to recognise these timely, should they (re-) emergence?

Zoonosis	Motivation

9 How can surveillance of zoonoses be improved to ensure timely recognition of new developments?

____
____
____

APPENDIX VII. QUESTIONNAIRE FOR EUROPEAN EXPERTS

Appendix VII-A. Overview of the European questionnaire results

VII.1 Introduction

European experts in the field of zoonoses who attended the WHO Geneva conference completed a self-administered questionnaire, either with a human or veterinary public health approach. The aim of this questionnaire was to achieve more insight into the risk factors associated with emerging zoonoses in Europe and in the strong and weak points of surveillance and control of zoonoses in the various European countries (Questonnaire see page 104).

VII.2 Data collection and analysis

In comparison with the questionnaire given to the Dutch experts, the European questionnaire was substantially shorter (Appendix VII-B) and consisted of four important open questions. A total of 14 experts responded (93%); most experts were from north-

Table VII.1. List of zoonoses mentioned by the experts

Zoonosis or agent	Number of times mentioned	Motivation
Avian influenza	7	Recent developments, worldwide concern, fast spread, potential for mutation
Food-borne bacteria [*Salmonella* spp., *E. coli* (VTEC, EHEC), *Campylobacter* spp.] (including antibiotic resistance)	7	Increase in antimicrobial resistance, incidence increases
West Nile virus (flaviviruses)	4	Climate change, recent outbreaks
Corona virus (SARS)	2	Worldwide concern
Rift Valley fever	2	Global warming, airborne infectious
Lyme borreliosis	2	Reservoir in wild animals
Bovine spongiform encephalopathy (BSE)	1	Recent developments
Mycobacterium paratuberculosis	1	Survival of M. *paratuberculosis* in milk
Protozoa (*C. parvum*)	1	Food-borne transmission
Cowpoxlike viruses	1	Increasing incidence
Tick-borne encephalitis	1	Climate change
Echinococcus multilocularis	1	Increase of fox and racoon dog, habitat changes
Travel-associated diseases	1	-
Hanta viruses	1	Wild/domestic animals, travel

ern European countries (i.e. Norway, Sweden, Denmark, UK, Germany and the Netherlands). Only two experts came from eastern European countries (Latvia and Slovak Republic) and a few experts were from southern Europe (France and Italy). For a list of the European participants, see Section VII.4 of this appendix.

VII.3 Results

VII.3.1 Zoonoses of major concern

In the first question, we asked which zoonoses would probably be of major concern in the near future in the expert's country. (Avian) influenza and food-borne zoonoses like salmonellosis, campylobacteriosis, and *E. coli* infections (VTEC/EHEC) and associated resistance were most often mentioned. Other diseases mentioned more than once were West Nile virus, Corona virus (SARS), Rift Valley fever and Lyme borreliosis.

VII.3.2 Origin of new threats

This question asked for the origin of new zoonoses (taxonomic order, reservoirs and ecological system). The question evoked answers mainly concerning potential risk factors of emergence (6 of 11 experts answered the question this way) and reservoirs. Three experts could not answer this question. No conclusion about taxonomic order can be drawn since only two experts mentioned the taxonomic order. The risk factors that were most often mentioned were climate and environmental changes, animal breeding, global trade of food/feed/animals, and microbial adaptation. Reservoirs most frequently mentioned were exotic animals (including exotic pets), wildlife (including rodents), and (migratory) birds.

VII.3.3 European preparedness

Question 3 asked the experts if Europe is in a position to detect and control new threats from the animal reservoir. The answers for this question differed. Of the 10 experts who answered this question, six experts were positive (however, 2 of them mentioned that although new threats can be detected, detection will be inefficient or too late). The other 4 experts answered the question negatively because of insufficient surveillance and lack of good response and control systems.

VII.3.4 Strengths and weaknesses

The last question asked the experts for the strengths and weaknesses of the timely recognition and control of emerging and re-emerging zoonoses in their countries. The most often mentioned strengths in the recognition of zoonoses were the existence of capable reference laboratories and well-functioning surveillance systems, the existence of national and international networks for collaboration, and in some Nordic countries, the existence of a national zoonosis centre. Other items mentioned (by two experts) as strengths were the existence of good legislation, education, and infrastructure, and interaction between the human and veterinary public health sectors. The weaknesses indicated in the recognition of zoonoses were the chance that non-notifiable diseases (e.g. exotic diseases) may be missed because reporting is voluntary, and the lack of awareness and limited interaction between human and animal sectors. Other weaknesses mentioned were budgetary and resource constraints, weaknesses in surveillance systems, national reference laboratories (NRLs) that do not cover all the important zoonoses, and delayed action due to organisational and logistic problems. The opinions on strengths in the control of emerging zoonoses varied among the countries. Items mentioned several times include well-functioning networks, infrastructure, and organisation of services and authorities at the national and district levels, and political support. Some countries have national centres for zoonoses or disease control, which was mentioned as a strength in the control of emerging zoonoses. Weaknesses in the control of emerging zoonoses also differed by country. Several experts mentioned the lack of communication and cooperation (decentralised and fragmented systems).

VII.4 Discussion

The outcome of this questionnaire is the result of the opinions of the experts present at the WHO Geneva conference. These results could be biased because there were only a few representatives from eastern and southern Europe. In addition, answers varied from country to country and between experts.

MacLehose *et al.* described six critical control points (Section 4.5.3) [123]. Two points mentioned in this study were also mentioned in this research by the experts: inadequate funding arrangements and failure to link information to action. Because of this, recognition of the nature of events requires effective reporting to national surveillance authorities, coordination of national surveillance and response systems, and support for enhanced surveillance and control activities in developing countries.

List of European experts responding to questionnaire

R. Anderson, United Kingdom, infectious disease epidemiologist; R. Bennet, United Kingdom, agriculture and animal health economist; G. Duffy, Ireland, microbiologist (food safety); M. Forster, Switzerland, epidemiologist; O.R. Kaaden, Germany, virologist (zoonoses); V. Kalnina, Latvia, virologist; Z. Kristufkova, Slovak Republic, infectious diseases epidemiologist; H. Kruse, Norway, microbiologist (zoonoses, antimicrobial resistance); A. Laddomada, official of European Commision; J.C. Manuguerra, France, virologist; C. Potsch, Germany, epidemiologist and veterinarian; S. Quoillin, Belgium, infectious diseases epidemiologist (surveillance); D. Schoder, Austria, epidemiologist (food safety and public health); I. Vagsholm, Sweden, veterinary epidemiologist (risk assessment); H. Wegener, Denmark, zoonoses epidemiologist.

Appendix VII-B. Questionnaire

Threats of infections emerging and re-emerging from animal reservoirs to humans in Europe

Note: This questionnaire was made before the redefinition of emerging zoonoses by the WHO in May 2004.

Definitions

Infectious agents from animal reservoirs (zoonoses): pathogens transmitted between vertebrate animals and man under natural conditions [4].
This includes pathogens that are transmitted through an arthropod vector, pathogens transmitted from animal products (such as meat, other animal foods, and excretions; mechanical transmission are excluded) to man and pathogens transmitted from man to animals.
It also includes newly emerging pathogens that, after crossing the species barrier, are subsequently mainly transmitted between humans (e.g., SARS).
The definition excludes pathogens that are deliberately introduced into human populations. Species, such as HIV, that originally evolved from animal pathogens, but that have not been transmitted between animals and humans for decades are not included. Diseases that are primarily the result of toxins produced by animal-borne pathogens are not covered by this definition either.

Emerging disease: a new infection resulting from the evolution or change of existing pathogens, or a known infection spreading to new geographic areas or populations or species, or a previously unrecognised infection spreading to new geographic areas, populations or species, or a previously unrecognised infection or disease diagnosed for the first time (Source: Questionnaire 'Emerging and re-emerging zoonotic diseases: challenges and opportunities', 2004, OIE, unpublished).

Europe: is defined here as all countries affiliated with the European Union, including candidate countries.

Note. The infections to be covered are those considered to be relatively likely to emerge or re-emerge in Europe, thereby creating the relevant risks to human public health in Europe. However, pathogens that have a very likely to emerge globally and rapidly, such as diseases caused by avian influenza viruses, should also be considered. Existing, well-described and monitored food-borne zoonoses such as *Campylobacter* spp. and *Salmonella* spp. are not to be considered, except for the emerging and re-emerging strains.

NAME: ______________________________

COUNTRY: ______________________________

FIELD OF EXPERTISE: ______________________________

1 Which zoonoses will probably be of major concern in the near future in your country and why?

Zoonosis	Motivation

☐ Don’t know

2 Can you indicate from which direction (in terms of taxonomic order, animal reservoir, ecological system) we can expect **new and currently unknown** threats from animal reservoirs to public health in the near future (specify as far as possible)?

Direction	Motivation

☐ Don’t know ☐ Can’t answer

3 Is Europe in a position to detect and control new threats from the animal reservoir?

☐ Yes ☐ No ☐ Don’t know

If no, why not ______________________________

4 What are, in general, the strengths and weaknesses for the timely recognition and control of (re-) emerging zoonoses in your country?

Strengths (recognition):

____
____
____
____

Weaknesses (recognition):

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____
____
____

Strengths (control):

____
____
____
____

Weaknesses (control):

____
____
____
____

☐ Don’t know

APPENDIX VIII. EUROPEAN WORKING GROUP REPORT: WHO/FAO/OIE CONSULTATION ON EMERGING ZOONOTIC DISEASES IN COLLABORATION WITH THE HEALTH COUNCIL OF THE NETHERLANDS, 3-5 MAY 2004

Within the scientific expert meeting on emerging zoonoses organised by WHO in Geneva in collaboration with the Health Council of the Netherlands, regional workshops on the aspects of emerging zoonoses were organised. One of these regional workshops was related to Europe. Experts in the field of human and veterinary public health from European countries discussed 4 main questions. The report of this European regional working group is given here, and the description is structured according to the 4 questions discussed.

Workshop participants: H. Wegener, Denmark; J.-C. Manuguerra, France; O. Kaaden and C. Potsch, Germany; G. Duffy, Ireland; V. Kalnina, Latvia; H. Kruse, Norway; R. Aalders, S. Beukema, J. van der Giessen, L. Isken, F. van Knapen, M. Koopmans, J. de Kroon, A. Osterhaus, J. Ruitenberg, E. Schoten and E. Tiemersma, The Netherlands; I. Vagsholm, Sweden; M. Forster, Switserland; R. Bennett, United Kingdom; A. Laddomada, European Union; B. Ganter, WHO/Europe.

This report follows the questions in the Guidance for working groups provided by WHO Head Quarters.

1. Identify and prioritise the key zoonotic infections of current and future concern in the region.

List of emerging endemic zoonoses in Europe

Zoonoses that will have a major impact on public health if they emerge

- Avian influenza
- Drug resistant and more virulent strains of food-borne bacteria

Zoonoses/zoonotic agents with ongoing impact

- Transmissible spongiform encephalitis (TSE)
- Hanta virus*
- Rabies (eastern Europe): EBLV/classic
- Orthopox virus*
- Tick-borne encephalitis
- Hepatitis E (porcine)
- Lyme borreliosis*
- *Rickettsia* spp.
- Tuberculosis (bovine/avian)
- Tularaemia

Brucella melitensis
Marine brucellosis
Echinococcus multilocularis *
Echinococcus granulosus
Leishmania spp.
Taenia solium
Trichinellosis
Larva migrans: *Baylisascaris ascaris* *
Toxoplasmosis
Cryptosporidiosis/giardiasis

* Prevalence currently increasing

Zoonoses from outside the European region

Introduction with potential for spreading via existing vectors and reservoirs
Rift Valley fever
Dengue and West Nile virus
Alpha viruses
TSE

Introduction followed by human-to-human transmission
Pandemic flu
SARS Corona virus
Monkeypox

Agents of unknown zoonotic potential
Paratuberculosis
Borna virus

Other agents
Pathogens transmitted via blood and other biological agents
Pathogens from marine environments (*Vibrio* spp., influenza A/B, calicivirus, *Brucella* spp., nematodes)
Chronic infections
Burkholderia pseudomallei: potential?

New as yet unknown emerging threats
Virtually unpredictable, but probably with involvement of one or more risk factors. Monitoring changes in these factors may increase alertness.

Discussion

The zoonoses listed here are not further prioritised. This list is the result of the opinion of the experts in the Working Group, and it is possibly biased because there were only few representatives from Eastern and Southern Europe. Furthermore, several 'old' and well-known zoonotic diseases are perhaps re-emerging in the European region because of civil war, disruption of the traditional centralised economies, and decreased income in general. During the last 3 years, WHO/Europe has been involved with Crimean Congo haemorrhagic fever (CCHF) in South-east Europe and Turkey, with tularaemia in Albania and Kosovo, with anthrax in Romania during a heat wave, and with leishmaniasis in the countries around the Mediterranean Sea. WHO/Europe has been involved specifically with leishmaniasis in HIV-immunodepressed people in Albania, Spain, and Italy, and in a Tajikistan outbreak as a result of cases imported from Afghanistan. Recently, an outbreak of Q fever was reported; over 100 people were affected in Bosnia, close to the town of Banja Luca. In Europe, the increasing spread of tick-borne encephalitis into Central and Western Europe from the Baltic States and Eastern Europe is also of concern.

2. Identify the main risk factors and suggest ways to better contain them or assess them.

Social

Human behaviour:
Travel, eating habits, outdoor life
Increasing number of immunocompromised people (e.g. elderly people)
Increasing movement of people and animals/products

Ecology

Wildlife and game farming
Extensivation (free ranging animals) and factory farming

Medical technology

Xenotransplantation
Blood transfusion

Agricultural practices

Trade, potential shift of factory farming from Western to Eastern Europe

Global warming and its effect on Europe (especially applies to vector-borne diseases)

Other general risk factors

Differences in quality of Public Health and Veterinary Public Health infrastructure and lack of coordination at the European level
Insufficient investment in Public Health-related scientific research
Complacency (professionals, politicians)

Risk factors for avian flu
Primary risk factor: mixed farming and insufficient biosecurity leading to indirect contact with wildlife
Amplifying risk factors: flock density (many intensive contacts), followed by animal-to-human transmission, and human-human contacts (incl. containment strategy)

Discussion
Risk factors involved in the emergence of zoonoses are complex and often multifactorial. Here, we categorised the risk factors and took avian influenza as an example to show that some risk factors are primarily involved followed by amplifying risk factors.

3. Review surveillance and early warning system needs for the region.

In the EU, several actions are currently being undertaken 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 the establishment of pandemic influenza preparedness plans, for example. In addition, recently the funding was established for an EU network of excellence, the MedVetNet, to promote veterinary-medical coordination and collaboration among national reference laboratories (NRLs) in relation to zoonoses surveillance and research. Although this is only one of the examples of EU funding in the field of zoonotic research, now it is not clear whether sustained financial support will be given to such initiatives. Systems that allow for syndrome surveillance and verification of signals by laboratory research are in their infancy, and they are limited to a few national or regional pilots without European oversight or (long-term) investment. National animal, food, feed, and human data on zoonoses and zoonotic agents listed in the Zoonoses Directive 2003/99/EC need to be collected at the national levels and communicated to the ECDC and the EFSA. In the current situation, the zoonoses report is not available until more than 12 months after the end of the year that is reported. Furthermore, there are no established links between the human surveillance networks (Directive 2119/98/EC) and their reporting on the one hand and reporting done on the veterinary and food side on the other. 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 the ECDC and the EFSA. Neither is it clear how the containment of outbreaks of newly emerging zoonotic diseases that can become supranational will be coordinated.

4. Propose specific actions that could be undertaken to control and prevent zoonoses in that region.

The current organisation of the public health system in Europe is fragmented and lacks the authority that is needed in case of severe supranational health threats. The first step in this context is the formation of the ECDC as a centralised monitoring analysis and response capacity. However, there is a concern of how this can be a rapid response system, because no laboratory budget for targeted investigations is being incorporated.

The responsibility for signalling and responding to emerging infections lies with the national authorities, each with their own decision-making structure for responding to a crisis. There is concern about how emerging infectious disease outbreaks of European significance will be coordinated. Within this Working Group, two different opinions existed on the coordination in European perspective. The first one is based on the ECDC as a supranational coordinated effort to build a response structure for such emergencies. This structure should have (access to and funding for) sufficient and sustained epidemiological and microbiological expertise, and needs the political mandate to be able to override national and economic interests in case of an infectious disease emergency. The second opinion focuses on a role of the ECDC in coordinating and facilitating responses to serious public health events of international significance, but that does not have to imply a competence to override national law. It should be stressed that a rapid response in case of a (newly) emerging zoonosis is of crucial importance.

More than 40% of Europe's territory is covered by non-EU Member States in east and southeast Europe (>4,000,000 km^2). Many of the health problems and emerging zoonoses occur in these regions. The enlargement of the EU to 25 and later to perhaps 28 Members States (to include big countries like the Russian Federation, Ukraine, Belarus, and the smaller countries in the former Yugoslavia) is critical to the emergence of zoonotic diseases. Therefore, it was mentioned that close collaboration, not only within the EU, but also with other European neighbouring countries outside the EU and with the WHO is strongly recommended. As zoonoses that emerge today in developing Eastern European countries will probably cause problems in affluent European countries tomorrow, affluent countries should take responsibility for good zoonosis prevention and control programmes in developing countries.

COLOPHON

General: This report was written at the request of the Health Council (HC) of the Netherlands. The HC will use this report as a reference document in advising the Dutch Government on zoonotic risks for public health and on improved organization of prevention and control of emerging zoonoses in Europe.

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