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Resource Paper 4

Understanding the potential impacts and drivers of global health threats. Policy options for establishment of one health capacities at national, regional and global levels

UNSIC/World Bank

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Structure and Objectives of this Paper

This paper provides an overview of 'One Health' approaches, which have steadily increased through different disciplines in human, animal and environmental health and across research and program development.

Section 4.1 provides an introduction to the concept of One Health as a paradigm shift for addressing diseases through multidisciplinary approaches, and outlines how this approach has developed. Section 4.2 considers why this approach is needed, and outlines other high burden diseases of concern, matters relating to scarcity of resources, global interconnectedness and the global burden of disease. Section 4.3 focuses on drivers for disease emergence and provides a comprehensive review across three environmental settings. Section 4.4 considers who needs to be involved in one health approaches, and provides suggested actions and practical ways to address prevention and risk reduction, early detection and control, and finally preparedness. Section 4.5 brings all of these aspects together and considers options for institutional arrangements to support implementation of one health approaches.

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4.0 Executive Summary

'One Health' approaches have steadily increased through different disciplines in human, animal and environmental health as well as in research and program development in recent years. Some of the key challenges for one health approaches relate to weaknesses and gaps in local disease control approaches, strengthening dialogue between governments and people, and moving towards more people-centred approaches.

Emerging and re-emerging diseases are increasing incrementally; 65% are zoonotic, and in recent years approximately 75% of new infectious diseases in humans have come from animals. They can arise at the interface between animal, human and wildlife domains. The global community needs to look beyond the current data and norms to examine emergent disease as a symptom of the world's changing interrelationships. All of these changes will impact future animal and human health and the attainment of the Millennium Development Goals.

Major drivers for disease emergence can be classified in three domains (human environments, food and agriculture systems, and natural ecosystems). Factors such as increased density and mobility of animal and human populations, decreased diversity of ecosystems and agriculture intensification can combine to create increased levels of risk for animal and human health. With increased risk comes an increased need for multi-sectoral approaches, as well as opportunities for reassessment of livestock production, urban and rural planning, and other activities that could be mutually beneficial for promoting public health, food security and development goals.

One Health approaches for risk reduction and prevention include multi-sectoral collaboration for priority setting, revised education programs, strengthened veterinary services and public-private partnerships. One Health approaches for early detection, control and preparedness include strengthened surveillance systems at all levels, predictive modeling and foresighting to enable rapid response to emerging disease events. In terms of One Health approaches for preparedness, improved communication strategies across sectors and levels as well as more focus on multi-sectoral business continuity planning to increase societal readiness are important.

All stakeholders need to be engaged in one health approaches. The central role of governments is critical in providing direction and assuming responsibility for one health approaches. Much work is needed to strengthen institutional mechanisms at all levels, as well as the enhanced integration of multi-sector expertise including sociologists, anthropologists, macro-economists, communication specialists, conservation and wildlife specialists, risk analysts, and legislators.

Governments can harness and support local government operational planning structures, including working closely with communities to identify and address diseases of local concern. Ongoing and strengthened international support is needed to promote government and private sector preparedness for emergency response, establish increased resilience to shocks from emerging health threats, and build leadership, technical capacity and expertise.

Strategic mechanisms are needed to support this work such as the development of a global one health knowledge repository, global risk assessment and forecasting, research frameworks, monitoring and review capacities, and global advocacy capacities.

4.1 Overview of One Health

4.1.1 A paradigm shift: One Health approaches

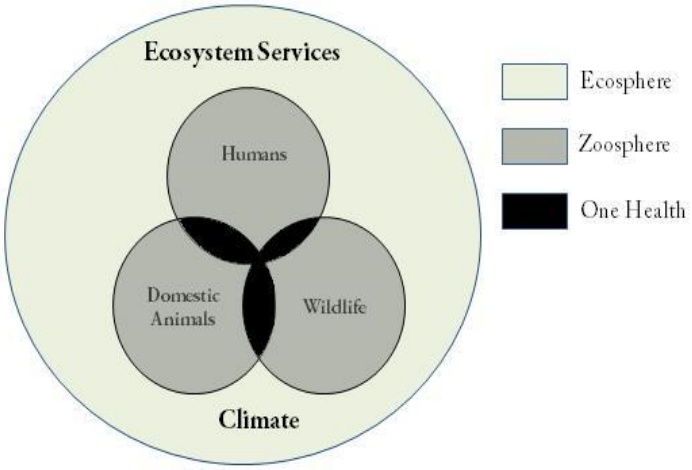
One of the most salient changes in recent years has been an increasing focus on factors predisposing to disease and risk. The need for more comprehensive approaches to reduce uncertainties is fuelling initiatives calling for One Health approaches worldwide.

'One Health' is used to refer to a more integrated or holistic approach to human, animal and ecosystem health. It represents the collaborative efforts of multiple disciplines to understand the inextricable links among human and animal health and the health of the ecosystems they inhabit. The diseases of primary importance are those that have potential to jump species – between wild or domestic animals and humans.[1] This paradigmatic shift is impinged on a transition from emergency activities to more strategic approaches that take longer timeframes and apply multidisciplinary understanding and approaches.

Diseases targeted by the One Health approach generally include emerging infectious diseases (EIDs), which are infections that have newly appeared in the population or have existed but are rapidly increasing in incidence or geographical range.[2] Increases in transmissibility of a microorganism, a shift in virulence or development of characteristics (such as microbial resistance), or a species shift are all considered as emerging diseases.

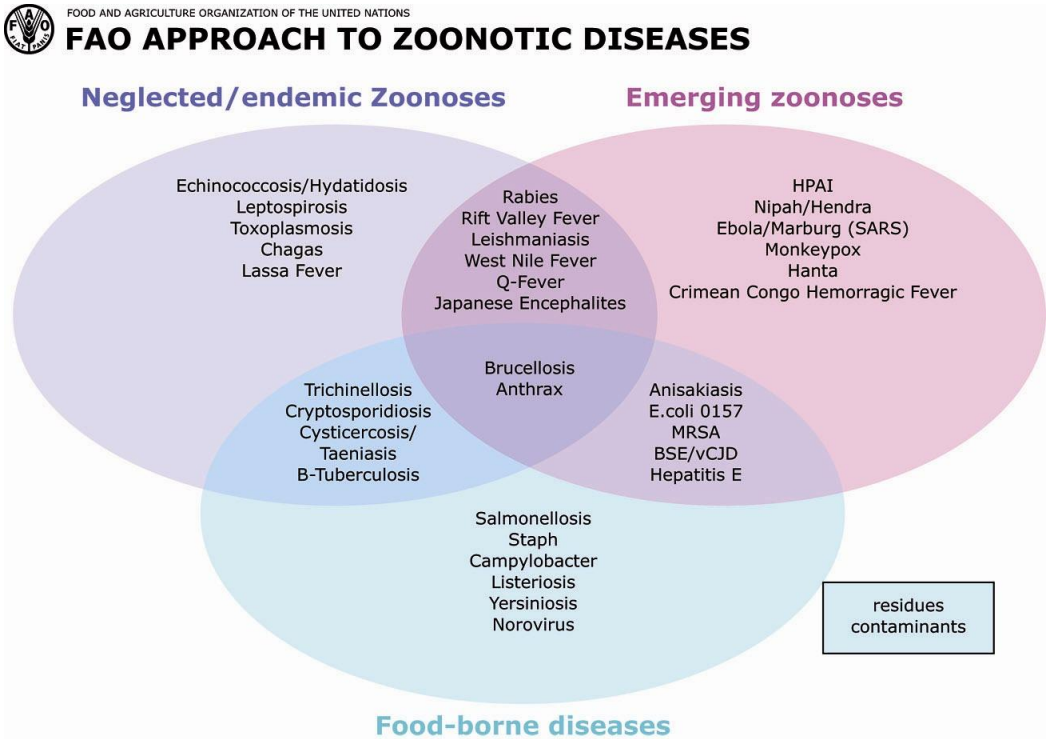
The zoonoses arise at the interfaces between animal, human and wildlife domains; it is an intensely interrelated system with one domain impacted by events or system changes in other domains (See Figure 4-1). The concept of one health also further considers the emergent diseases within the context of environment (See Figure 4-2).

Figure 4-1: **Interacting Health Domains**



Source: World Bank

Figure 4-2: FAO approach to Zoonotic Diseases



Source: FAO

4.1.2 Development of the One Health Concept

One Health approaches have steadily increased throughout different disciplines in human, animal and environmental health and across research and program development. The interrelatedness of the human and animal health domains that are central to zoonotic diseases, the magnitude of these threats, and the need for more purposeful consultation between medical and veterinary health, have motivated scientists and policy makers to establish closer collaboration. The One Health concept has long established historical roots, but has evolved since the 1960's to encompass the additional domains of wildlife and ecosystem health.

The re-emergence of highly pathogenic avian influenza (HPAI) in 2003 and subsequent concern over a potential pandemic threat prompted the international community into action, galvanizing international resolve and unprecedented global collaboration to address the potential of a global pandemic. One example was the resulting series of international meetings bringing countries and international organizations together to produce the groundwork and relationship necessary to effectively respond (See Annex 4-1: Timeline of International Meetings).

In 2004, the One World One Health movement of the Wildlife Conservation Society developed the Manhattan Principles, which reflect the need for inter system collaboration (See Annex 4-2: Manhattan Principles). Six international organizations (FAO, OIE, WHO, UNSIC, UNICEF, and the World Bank) subsequently used the

Manhattan Principles to further the thinking in regard to pandemic influenza risk, preparedness and response, producing a landmark document *'Contributing to One World One Health. A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal-Human-Ecosystem Interface.'*[3] Consultation on this document in an international meeting sponsored by the Public Health Agency of Canada (March 2009) was unanimous in the need to take a one health approach forward. The Winnipeg Conference emphasized the key actions required to progress the objectives of the Strategic Framework (See Text Box 4-1).

Text Box 4-1: Key Actions for One Health, Winnipeg 2009

- Foster political will
- Support partnership and collaboration
- Encourage data sharing and integration
- Build capacity (infrastructure and skills)
- Develop communication strategies and plans
- Provide incentives for reporting adverse events
- Encourage stakeholder and community engagement
- Develop supra-country approaches

Source: Public Health Agency, Canada.

Many challenges exist in implementing one health goals, including a number of institutional and administrative constraints and difficulties in effective collaboration between human and animal health sectors and line ministries. There may also be a lack of political and financial commitment to address EID issues, and in many least resourced countries there are limited human resources to support prevention, detection and response approaches. Difficulties in engaging the private sector can also exacerbate problems. However these challenges are being overcome in a progressive manner at the global, regional and country levels in recognition of the fact that one health approaches are essential long term measures to support EID prevention and control.

At the national level, many countries have also responded by developing human-animal health interface organizations such as the Canadian Science Centre for Human and Animal Health, the Danish Zoonotic Centre, the US CDC National centre for Zoonotic, Vector Borne and Enteric Diseases, the Australian Biosecurity Centre for Research, and the New Zealand National Centre for Biosecurity and Infectious Diseases.

4.2 Why is a one health approach needed?

4.2.1 Zoonotic diseases: what has been learned from H5N1 for other diseases?

Significant experience has been gained over the last decade with diseases such as the 2003 outbreak of SARS in China, and H5N1 HPAI from 2004 to 2010 mainly in South East Asia, but also in Africa and Europe. These experiences can be used as building blocks for improvements and adaptation of practices. The culling campaigns in SE Asia

for example have brought to light the impacts of measures on rural livelihoods as well as the realization that in endemic situations the gamut of approaches needs to be context-based and more flexible, rather than prescription-driven.

There is a common narrative weaving through this experience that provides evidence to the success of the H5N1 response and which can be built upon as preparedness for other animal disease threats (and even other disasters), namely: multidisciplinary, cross-cutting approaches, inter-agency and inter-ministerial collaborations, capacity-building, risk communication, trust-building, cohesion, and the importance of well-equipped veterinary laboratories. Challenges remaining to be resolved are related to addressing the weaknesses and gaps in local disease control approaches, improving dialogue between governments and people, and moving emphasis from pathogens to more people-centred views.

Several actions can help achieve this common vision for zoonotic diseases, including:

- Increased emphasis on disease drivers and ecological landscapes for improved prevention, mitigation, and risk management.
- Continuous re-evaluation of strategies for prevention and control of H5N1 HPAI to detect areas of improvement and discontinue redundant or inconsequential actions.
- Improved availability and distribution of resources, tools and systems to circumvent the impact of these zoonotic disease challenges.
- Targeted approaches and information management strategies for a better spatial and temporal understanding and management of risks at international and local level and to measure progress. The OFFLU model can be applied and expanded to other emerging threats.
- Assessment of epidemiological risk and economic drivers for transboundary management (market movements or pastoralist needs) with improved hygiene through awareness at the production level to avert zoonotic risks.
- Broader multidisciplinary partnerships that include partners outside of classical medicine (veterinary or human) to be incorporated into one health approaches; this should include socio-anthropologists, communicators, macro-economists, conservationists, wildlife specialists, and legislators.

4.2.2 Other high burden animal and human diseases of concern

Emerging diseases are increasing, intensifying, and moving into or spreading to new populations for the first time[4]. Over 60 percent of new diseases arising between 1940 and 2004 were zoonotic diseases, and of these more than 75 percent came from wild animals[5]. In tropical settings the disease burden is higher than that in temperate climates; and with the forecast climate changes, disease burdens, pathogen encroachment, or agent or vector translocation and establishment will become more common[6]. To support the notification of emerging diseases in animals OIE has recently enhanced WAHIS to include wildlife diseases (See Text Box 4-2).

Text Box 4-2: World animal disease notification system, including "emerging diseases"

OIE Members have the obligation to immediately notify animal health events of epidemiological significance to the OIE Headquarters, including the occurrence of OIE listed diseases and also the occurrence of any emerging disease with significant morbidity/mortality or zoonotic potential. The requirement to report emerging diseases among animals based on the zoonotic potential – a parameter that is not directly dependent of the nature of the disease caused in animals – is a key feature in the OIE's ability to identify diseases or pathogens that may pose a risk to humans before animal-human transmission, and thereby reduce the risk of transmission to humans

To support the notification of cases of the main animal diseases (including zoonoses) and the subsequent analyses of these data, the OIE developed and supports the World Animal Health Information System (WAHIS). WAHIS is an internet-based computer system that processes data on animal diseases and then informs the international community, by means of "alert messages", of relevant epidemiological events in OIE Members. Given the role of wildlife in emerging diseases – as source of pathogens for animal diseases and/or human diseases – the OIE recently enhanced WAHIS through development of WAHIS-Wild, to support improved reporting of OIE listed diseases and emerging diseases occurring in wildlife species.

Source: OIE

In addition to the potential impacts on human life and health, the economic losses associated with zoonotic diseases are significant. Examples of economic impact from zoonotic outbreaks in the last decade include bovine spongiform encephalopathy (BSE) with economic losses around US$7 billion. The SARS outbreak in East Asia and Canada resulted in losses of between US$40 - $50 billion, and H5N1 HPAI in East Asia alone has caused US$10 billion in direct losses to the livestock sector. Direct costs from these outbreaks include public and animal health service costs, compensation for lost animals, and production and revenue losses to the livestock sector, as well as broader economic losses to affected countries. Indirect costs affect other parts of the animal market chain, as well as trade and tourism.

Other zoonotic diseases of significant human and economic loss include rabies, bovine-induced human tuberculosis, and brucellosis, which are major causes of morbidity and mortality among predominantly poor people and which are also under-reported. Rabies is one of the 'neglected' and re-emerging diseases killing more than 55,000 people every year, with about 95 percent of these deaths occurring in Asia and Africa. A large proportion of victims are children from poor communities.

Brucellosis causes indirect losses such as decreased milk yield and poor fertility in cattle. It can result in undulant fever in humans, particularly farmers and abattoir workers, which if not treated promptly can lead to personality disorders. *Brucella melitensis* in goats can lead to Mediterranean fever in children and adults through the consumption of unpasteurized milk or cheese. HIV/AIDS also originated as a zoonosis, and has spread globally with major public health impacts. Global estimates for HIV in 2008 indicated that approximately 33.4 million people were living with HIV, and approximately 2.7 million new HIV infections registered that year. Deaths due to AIDS in 2008 were approximately 2.0 million

Food borne diseases such as *Escherichia coli*, Campylobacteriosis, and Salmonellosis caused 1.8 million deaths in 2005 according to WHO reports. Economic impacts of these food borne pathogens were estimated to be up to US$35 billion in 1997 in medical costs and lost productivity in the United States. Recent World Bank studies of direct and indirect costs from food-borne diseases in Vietnam estimate that it could be up to US$1 billion per year.

Social consequences of global health threats include the effects on economic resources and opportunities available to people in a community, changes in family and social networks and support systems, and also on educational development. Children represent a particularly vulnerable group to the impacts of the close interaction of growing human and animal populations. Demographic pressure and its economic consequences are reflected in higher poverty rates especially in the less advantaged segments of the population, with its direct adverse effect in the levels of health and nutrition of households. In addition, changes in the environment represent a fertile soil for the emergence or re-emergence of infectious diseases, spread of vector-borne diseases, higher incidence of water and food-borne illnesses that in this context tend to be disproportionately concentrated on children.

An increasingly fragile environment and the threat that its destruction poses to not only the emergence of infectious disease but also the impacts on the cross-cutting issues of nutrition, food and water security, gender and cultural inequities and poverty demands consideration in all aspects of research and planning.[7];[8];[9] Examination of origins of human disease such as SARS Corona virus and Nipah virus (See Case Study 4-1) demonstrate the impact of environment and people activity in driving wild viruses into urban hosts with or without defined genetic change. [10];[11];[12]

Case Study 4-1: Impact of Nipah virus in Malaysia

Encephalitis causing Nipah virus amongst pigs and pig farmers was first recognized in Malaysia in 1999. In the initial outbreak, 103 of 261 suspected human cases were fatal and many of the remaining had neurological sequelae.

In response, over 1.1 million pigs were culled. The outbreak, which cost the Malay government $US500 million, was traced to fruit bats which had migrated into pig farming areas due to increasing urbanization and change of habitat. The pig was an intermediate host. There have been 12 outbreaks of Nipah virus, all in Asia, and there is evidence in recent outbreaks of human to human transmission.

Source: Epstein et al, 2006[13]

4.2.3 Scarcity of resources

Prevention of highly contagious disease is a global common good, which provides economic benefits to each nation. However, financial constraints particularly in low income countries limit their ability to reduce domestic (and therefore global) risk; thus the importance of significant and sustained multilateral coordination to combat highly

contagious zoonotic diseases, with cost sharing based on economic loss aversion and targeting based on cost-effective risk reduction.

Cost efficiency benefits would be further enhanced through the simultaneous surveillance of disease, joint epidemiological public and animal health studies, including joint laboratory diagnosis and communication (See Case Study 4-2: Joint animal and human vaccination campaigns in Chad). Benefits could include reductions in time to detect emerging zoonoses and accelerate control and prevention.

Case Study 4-2: Maximizing efficiency and learning through joint animal and human vaccination in Chad.

The concept of maximizing efficiency through joint human/animal vaccination initiatives has been effective in Chad, where animal vaccination campaigns were expanded to include human vaccinations. Previously, cattle were largely vaccinated because of compulsory campaigns, though children and women were not receiving immunizations. In 2002, pilot programs in two provinces brought together equipment and transport logistics for veterinary and health personnel, and this merger resulted in a 15% reduction of costs and a 30% increase in childhood vaccination. These programs demonstrated the organizational and technical feasibility of joint animal and human vaccination.[14]

Source: Jacob Zinsstag et al. 2005

4.2.4 Global burden of disease and efforts to address the Millennium Development Goals

Projections of disease based on global populations disproportionately impact on the poor. The Global Burden of Disease Project, published in 1996, projected 1990 data to forecast disease trends through 2030. Lifestyle diseases were listed as leaders of burden of disease into the next (now current) millennia. Researchers note that 'the excess mortality of the poorest population is mostly due to the higher incidence of communicable disease, 77% of excess deaths' and further find that ' a faster overall decline in communicable diseases would decrease the poor/rich gap in 2020, but under an accelerated overall decline in non-communicable disease the poor/rich gap would widen'.

It is clear that in this ecological transition point, the global community needs to look beyond the current data and previous norms, to examine emergent disease as a symptom of a world under a myriad of changing interrelationships. All of these changes impact on future health and the attainment of the Millennium Development Goals (Text Box 4-3).

Text Box 4-3: Millennium Development Goals

1. Eradicate extreme poverty and poverty (halve between 1990 and 2015 the proportion of people who suffer from hunger)
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce childhood mortality

5. Improve maternal health
6. Combat HIV/AIDS, malaria TB and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

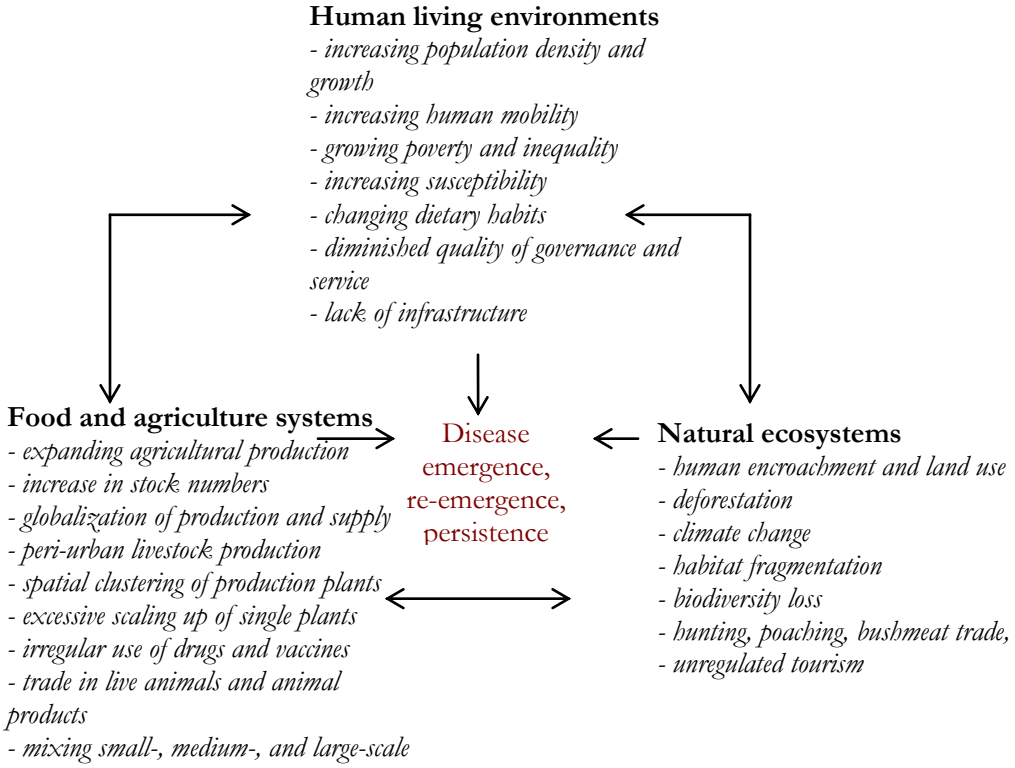
Source: UN Millennium Development Goals

Health inequities need to be addressed through the non-health sectors as well, including through education, food security, employment, water, and sanitation. These non-health sectors address the demand side of health and greatly contribute to the preventive aspects of health, important for improving health equities. The Interim Statement of the Commission on Social Determinants of Health affirms that interventions aimed at reducing disease and saving lives succeed best when taking social determinants of health adequately into account.[15] Through better application of institutional economics and cultural epidemiology, health systems' effectiveness could be improved for populations with limited access whilst also reducing the transmission of zoonotic disease.

4.3 Drivers for Disease Emergence

Factors that drive the emergence of new diseases can be classified into those that occur in one of three environments: in the environment in which humans live, in the food and agriculture system, or in natural ecosystems (Figure 4-3).

Figure 4-3: Interplay of Three Host Health Domains



Source: World Bank, *2010 (*Adapted from Institutes of Medicine 2009).

4.3.1 Drivers in Human Living Environments

Urbanization and human and animal population density

Population density is increasing with more than 50 percent of the global population now living in urban areas. In many urban and peri-urban areas, people raise and share dwellings with livestock and pets. This level of proximity between humans and animals is a critical risk factor for zoonotic disease. Many of these cities are in humid areas, and many have no sanitation services or available means to dispose of wastewater or organic material. People often buy their meat at outdoor wet markets, where the animal is not inspected before it is slaughtered. Public awareness of hygiene measures that can substantially reduce the risk of diseases in these settings is often very limited (ref).

Changing demographics

Factors such as aging populations, the prevalence of HIV/AIDS, the proportion of the population that is undernourished (notably the number of pregnant or lactating women)—in short, any demographic development that increases the number of people who are immunocompromised fosters a favorable environment for the emergence and spread of infectious diseases, among which zoonoses are generally prevalent.

Mobility

Populations are also becoming more mobile, especially as incomes rise, and this dramatically facilitates the spread of diseases that may be transmitted between people. For instance, international tourist arrivals are estimated to reach 1.6 billion by 2020, and internal and international displacements of populations are high, with an estimated 12 million displaced people in Africa alone.[16] Outbreaks of infectious diseases that remained isolated to specific localities in the past are more likely to spread given this mobility. This mobility implies also the mobility of culture, health beliefs, food preferences, and hence epidemiological factors.[17]

Culture

People who have become used to recurrent disasters and living with infectious diseases have deeply embedded understandings of risks and resilience that ultimately influence the way they respond to threats. These social and cultural contexts may sometimes be at odds with the classical medical and veterinary perspectives and approaches. Social, cultural and livelihood dimensions must be carefully examined and made central to bring people, with their incentives and motivations, back into spotlight.

Poverty

Poor, food-insecure people are more vulnerable to both emerging and lingering zoonotic diseases. Impoverished people are less likely to visit a health provider, thus reducing the chance for early detection of a new disease. In some areas poverty leads to greater reliance on bushmeat, which represents one of the most direct risks of contracting a zoonotic disease.

Deteriorating government public health services

Stagnating public health and veterinary budgets in many countries have seriously limited disease surveillance and other preventive operations (World Bank 2009).

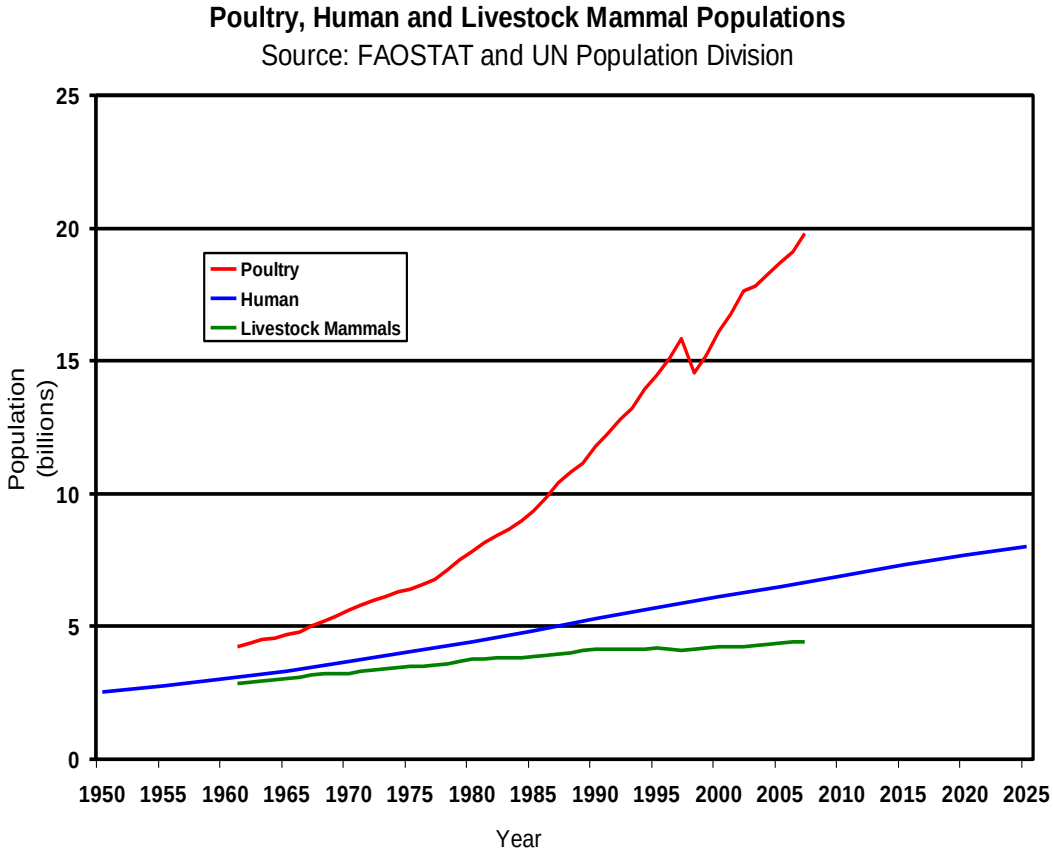
4.3.2 Drivers in Food and Agriculture Systems

Food and agriculture systems constitute a major artificial ecosystem in which diseases can emerge or re-emerge. Many food supply chains involving animals and animal products have become increasingly globalized, and the transport of animals and animal products have become so extensive that food safety hazards and emerging infectious disease risks can travel rapidly and widely.

The number of livestock

Livestock numbers are increasing rapidly in order to meet rising demand for animal source products. FAO estimates that the number of food animals being processed each year will increase from about 21 billion currently to about 28 billion in 2030 (FAO, 2006). The increasing demand for food production is illustrated through the increases in poultry, livestock and human populations as shown in Figure 4-4. There is a positive correlation between poultry, human and livestock population growth from 1960 to 2020. This quantitative evidence supports the published literature that rapidly rising incomes and urbanization, combined with underlying population growth, are driving demand for meat and other animal products in many developing countries.

Figure 4-4: Poultry, Human and Livestock Mammal Population Growth



The spatial concentration of livestock production

The increase in animal numbers had led to a significant restructuring of how production is organized spatially, perhaps most notably in peri-urban areas, and particularly with respect to pig and poultry production. (See Figure 4-5). The scale of large commercial farms has increased dramatically, and has become concentrated in relatively small areas. For example, in Brazil, 85 percent of hens and 56 percent of pigs are concentrated in 5 percent of the country's area. When transport facilities are poor, these large farms typically concentrate in peri-urban areas. With improved transport, large farms tend to move away from large cities to areas with abundant feed supplies (Steinfeld et al. 2006).

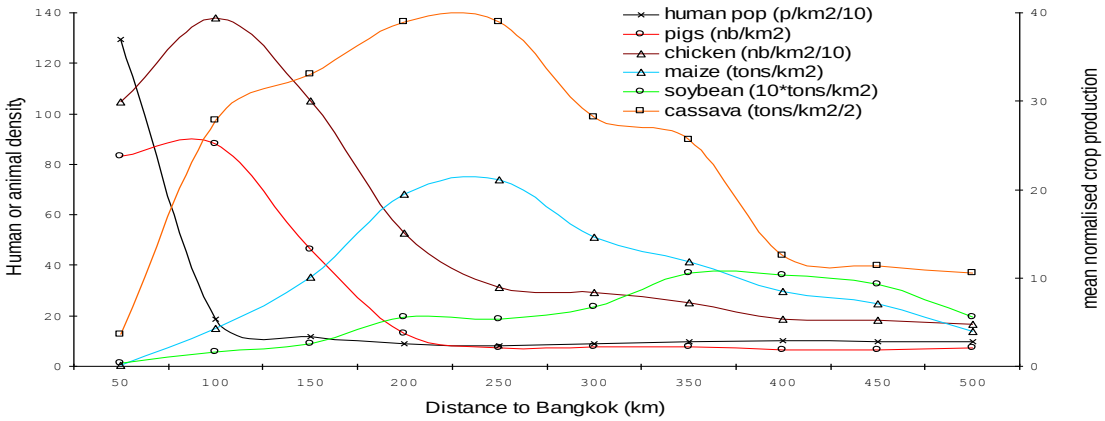


Figure 4-5. Distance from the megapolis of Bangkok and crop and livestock densities. The proximity of people and animals is conducive for pathogen exchange. The emergence of potential zoonotic pathogens of wildlife origin would likely be detected in the livestock production areas and not necessarily in humans[1]

Mixed biosecurity regimes

Livestock producers vary widely in their capacity to protect livestock from disease and to manage disease risk at the farm level. Much of this variation relates to the size of the enterprise, the scale of production, and the amount of capital that is available to its operators. Larger commercial producers can generally afford to invest in more sophisticated forms of biosecurity than small producers, who continue to operate with little if any biosecurity. Little attention has been given to innovations that can help small producers meet their biosecurity needs in their resource-poor circumstances. The coexistence of modern and traditional production, often in close proximity to one another, poses mutual risk. Pathogens that are endemic remain a persistent threat to both (Slingenbergh et al. 2004; Slingenbergh and Gilbert 2008).

Export of animal source products

Export has grown faster than production, as global trade has expanded by 6 percent per year and now constitutes about 13 percent of total food export, reaching US$37 billion in fresh and frozen meat and US$20 billion in live food animals (International Trade

[1] SARS, HPAI, A.H1N1, West Nile Virus, Rift Valley Fever, and Nipah Virus Encephalitis

Centre, UNCTAD and WTO 2009). Potential trade-related diseases include Hendra, Lassa and West Nile viruses (See Annex 4-4)[18].

Inappropriate vaccination and drug use

The inadequacy of health systems causes gaps in vaccination coverage and suboptimal use of drugs, leading to drug resistance and hence increased risk of newly emerging pathogens. Adding antibiotics to livestock feed for non-therapeutic purposes is another cause of induced resistance to antibiotics in animal source foods. Methicillin-resistant *Staphylococcus aureus* (MRSA), circulating in pigs and calves and now a major threat in hospitals, is an example of the results of inappropriate drug use. (ref)

Exploitative farming systems

Settings in which working conditions and animal housing conditions are poor and prone to hazardous interactions between livestock and humans, and between livestock and wild species, are well suited not only for the flare-up of novel agents, but also for the persistence of existing agents, adding to the endemic disease burdens that are already in place. The interplay of complex factors provides opportune environs in which many pathogens co-circulate. Most emerging disease events take place in these unregulated conditions, characteristic of production throughout much of the developing world. Once isolated, these hot spots are today increasingly connected to the larger world through trade and human traffic in a context of globalization.

4.3.3 Drivers at the Earth and Ecosystems Level

In natural ecosystems, pathogens are natural elements of biological diversity, balance, and resilience. The impacts of human encroachment on the system can introduce new disease agents or present existing agents with opportunities to "escape" the habitat they are a natural part of. A variety of human activities may generate ecological vacuums that are filled by invasive predators or parasites that may carry diseases that indigenous species lack immunity to (Slingenbergh et al. 2009; Sakai et al. 2001; Daszak et al. 2000).

While human and domestic animal diseases do sometimes affect wildlife, pathogens that are transmitted from wildlife to humans, often through domestic animals, are considerably more numerous.[19] These include HIV, Ebola, SARS, H5N1, Nipah, and hantaviruses, Lyme disease, Crimean-Congo hemorrhagic fever, tick encephalitis, and West Nile virus. A number of pathogens have also been transferred from wild species to domestic ones in recent years. A diverse reservoir of influenza viruses circulates also in wild birds, and contacts between these birds and domestic poultry and pigs are common. These contacts lead to human exposure and to the exchange of viruses and genetic material between humans and animals.

The pandemic risk these materials pose varies by type. RNA viruses, for instance, are known for their built-in instability, and their tendency to undergo replication errors gives

them greater potential to invade any novel host niches that may be available. Arthropod-borne viral infections are prominent among the group of emerging disease agents, sometimes becoming manifest at medium-to-high latitudes. Insects, bats and birds, as well as humans are renowned spreaders of disease agents between continents.

Major changes in land use and agricultural intensification

The rapidly growing livestock sector has been a principal driver in the conversion of natural habitats into pastures and cropland. More land was converted for the growing of crops between 1950 and 1980 than in the preceding 150 years.[20] The intensification of agriculture with ever-increasing use of inorganic fertilizer, together with increasing livestock density, has been a major source of water pollution, and often provides favorable environments for novel pathogens to emerge in.

Land use change, deforestation, habitat fragmentation, and biodiversity loss

Major land-use changes, including intensification and deforestation, lead to a variety of impacts on ecosystems, including pollution, fragmentation of habitats, and changing host-pathogen dynamics. Deforestation in tropical regions is advancing at the rate of about 130,000 square kilometers annually, driven by cattle ranching and feed production in Latin America, by tree crop (palm oil) plantations in South East Asia, and by smallholder farming in Africa. Degraded ecosystems with diminished biodiversity tend to favor opportunistic or generalist species, many of which are disease reservoirs. For instance, the effects of habitat fragmentation on host-pathogen dynamics were evidenced in the epidemiology of the Nipah virus in Southeast Asia.

Increased hunting, poaching, and bushmeat trade

It is estimated that 4.5 million tons of bushmeat are extracted from the Congo basin each year. This meat is often consumed only partially cooked, thus bringing the principal source of a zoonotic pathogen in direct contact with human beings.[21] Both legal and illegal trade in live animals has increased rapidly over the last decades and is a major factor in the spread of diseases. While exact total figures are not available, the Institute of Medicine (2009) puts the figure at several US$ billion.[22]

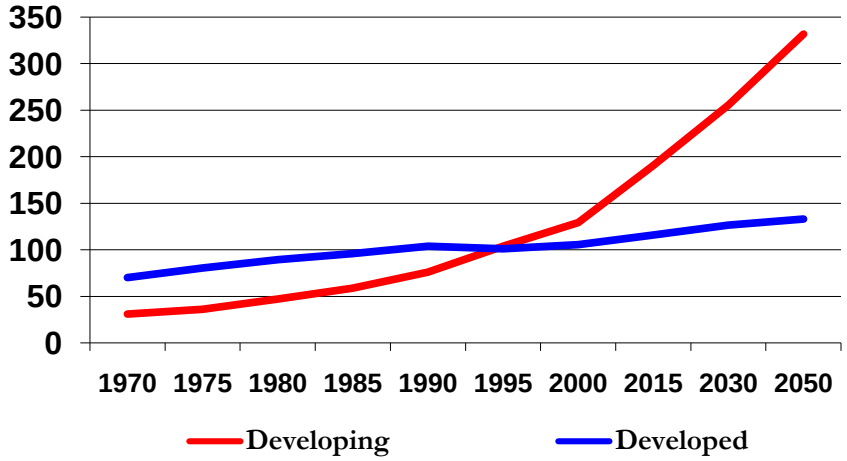
Climate change

Changes in long-term and seasonal weather patterns will have major effects on disease behavior such as spreading patterns, diffusion range, and introduction and persistence in new habitats. The extension of vector habitats will be a major factor in the impact of climate change on the spread of infectious diseases, as, for example, shown by the expansion of Rift Valley fever in East Africa. It might lead also to the emergence of novel pathogens and vectors such as the recent outbreaks of bluetongue disease among sheep in Europe that was caused by a virus carried by a small African midge known as *Culicoides imicola.* The vector appeared in southern Europe in 2000 and led to the evolution of novel *Culicoides* species that also transmit the bluetongue virus. The spread of the virus into more temperate zones was very likely facilitated by the warming trend in the region's climates.

4.3.4 Combinations of drivers – population increases, urbanization, increasing income, livestock production and wildlife ecosystems.

Driven by increasing income, urbanization and population growth, demand for animal source foods is rapidly increasing in the developing parts of the world. As per capita consumption is still relatively low in the developing as compared with the developed countries (31kg versus 82 kg of meat and 50 kg versus 207 kg of milk), demand is likely to continue to grow rapidly in the former countries. In response to this rapidly growing demand, livestock production is rapidly growing (See Figure 4-6: Meat production 1970-2050 in the developed and developing world).

Figure 4-6: Meat production (million tons) 1970-2050 in the developed and developing world Source: World Bank



The rising demand for poultry and poultry products in particular provides a powerful financial incentive for private sector producers of all sizes to supply as much product at competitive prices to satiate this nascent animal protein hunger. The accompanying poultry industry growth and development may be guided by current concepts of avian production, animal health, sustainability, hygiene, biosecurity, and food safety on behalf of national and international health agencies with particular attention paid to how global public health threats –and their accompanying fears– impact economic progress, human development, and national security.

Novel methodologies for understanding disease drivers have been developed by the Foresight Program in the United Kingdom. A recent study based in China is taking new steps to address groups of societal drivers to predict trends in drivers, and developing anticipatory approaches to reduce risk of infection and emergence of disease in at-risk populations (See Case Study 4-3: Identifying future trends in infectious disease and animals in China).[23]

These approaches are increasingly important to achieve an understanding of the causes for disease emergence, enabling urban planners, development agencies, agriculture and public health ministry's to better establish prevention strategies through improved prediction and analysis.

Case Study 4-3: Identifying future trends in infectious disease and animals in China - examining the drivers.

The Foresight China Project group devised a simple but novel methodology for identifying possible future trends in infectious diseases in animals and humans in China, a priority concern of the Chinese authorities (Results published in July 2009). It used a model of disease drivers (social, economic, biological or environmental factors that affect disease outcomes by changing the behaviour of diseases, sources or pathways) devised for the Foresight Programme in the United Kingdom. Nine families of drivers were adapted to Chinese circumstances, and matrices were constructed to identify the likely relationship of single infectious diseases or families of diseases to the drivers.

The likely future trends in China were determined by interviews with 36 independent Chinese experts. These trends included potentially adverse animal and human movements as well as opportunities for innovative surveillance methods, more use of hospitals, antimicrobials and vaccines. The results suggested a number of areas where the Chinese authorities may experience difficulties in the future, such as rising numbers of healthcare-associated infections, zoonoses and other emerging diseases and sexually transmitted infections (including HIV). This work identified priority disease groups requiring surveillance and consideration of countermeasures, and recommended strengthening basic surveillance and response mechanisms for unanticipatable zoonoses and other emerging disease threats.[24]
Source: Foresight China Group

4.4 One health approaches for prevention and risk reduction, early detection and disease control, and preparedness.

4.4.1 Who needs to be involved?

One health approaches require input from all disciplines in society, including health professions, anthropologists, agronomists, ecologists, economists, engineers, town planners. Such approaches also need to go beyond technical disciplines, incorporating skilled coordinators, communicators, monitoring and evaluation specialists, risk analysts, and strategic planning expertise. It needs to incorporate one health considerations (and research) at all levels, from a community to an international level, and needs political will at the highest level to empower all other levels to move forward. Major players include key international agencies, key governmental and national agencies, health, veterinary and agricultural institutes, private sector organizations and foundations, academic institutions, communities and civil society organizations.

"Individuals and organizations need to change their thinking from "What am I responsible for?" to "What needs to be done?" [25]

The bringing together of six international organizations, FAO, OIE, WHO, UNSIC, UNICEF, and the World Bank, in determining a pathway for action through the

document *'Contributing to One World One Health. A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal-Human-Ecosystem Interface.'* is an illustration of breaking down insular roles to get horizontal communication and linkages that are needed for an effective one health approach.

4.4.2 Suggested actions – practical ways to address prevention and risk reduction

Actions which can help strengthen the one health approach, (prevention and risk reduction actions are outlined in greater detail in Resource Paper 2, 2.6; highlights in Text Box 4-4), should be considered from local, national, regional and international policy spheres, and from actions that can be delineated within those levels.

Text Box 4-4: Summary of Key Actions from Paper 2

'Highly Pathogenic Avian Influenza A (H5N1); (a) ensuring an appropriate and sustainable response (b) building on the model to strengthen management of high burden diseases at the animal human environment interface' outlines the need to address the following:

1. Continued and Enhanced interagency and multisectoral collaboration
2. Structures and systems still requiring substantial development
3. Better funding of prevention systems
4. Effective private – public partnerships
5. Cohesion of overarching policies
6. Building core communication capacities and a critical mass of practitioners
7. Gender analysis in livestock production and disease transmission
8. Strengthening links between vets, biologists and environmental agencies
9. Applied research for one health approaches to disease management

Capacity building at all levels is a necessity; this may require a variety of inputs, such as renewed efforts by international organizations to collaborate and share policies and resources; integration of new/different sectors into planning; addition of resources (such as skills and equipment), and changes in national legislation. Capacity development for one health includes developing a holistic way of thinking and understanding across different disciplines and viewpoints. An imperative challenge ahead is the need to advocate for dedicated and sustained political and financial commitment to prevention and risk reduction capacity building as interest in current pandemic wanes.

Further work is also needed to strengthen and encourage interagency and multisectoral collaboration for the management of high impact diseases arising at the animal-human interface. An example of enhanced collaboration is the 'One Health Hub' concept being established in South Asia, with World Bank support (See Case Study 4-4).

Case Study 4-4: Establishing 'One Health Hubs' in South Asia.

South Asian countries are at high risk for the Avian and Human Influenza (AHI), as the H5N1 virus actively circulates in Bangladesh, India, Nepal and Bhutan. Since end-2003, there have been almost 500 outbreaks in animals in the region. In collaboration with WHO, FAO, OIE and UNICEF, the World Bank and the multi-donor AHI Facility (which is funding by the European Commission and nine other donors) finance nine projects in South Asia at a total cost of US$ 92.6 million, which includes a new initiative, "Regional Training Program in Epidemiology and Biosecurity." Benefiting seven countries in the Region—Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka—the regional training program is financed by the AHI Facility and seeks to (i) provide a total of 70 animal and human health specialists with on-line training at Master's level in epidemiology and (ii) establish "One Health" hubs or centres of excellence in epidemiology in the seven countries by strengthening existing national epidemiology institutions. The Programme is implemented by Massey University in New Zealand.

The Regional Training Program is one attempt to support a mid- to long-term strategy to prevent and manage AHI and other zoonoses by building local capacity and a regional network. The ongoing projects have helped contain outbreaks in South Asia; however, countries are now faced with a need to shift from emergency operations to mid- to long-term local capacity development in an effort to manage emerging and re-emerging zoonoses.. The Regional Training Program brings animal and human specialists together with an emphasis on the interface, while providing the trainees with specialized courses. The 70 specialists will play a key role in establishing and managing "One Health" hubs in their respective countries.
Source: World Bank

Joint planning is recognized to be a crucial element at, and between, all levels. International, regional and national level management can be strengthened through increasing the cohesion of overarching policy goals (See Case Study 4-5: Danish Zoonosis Centre).

Case Study 4-5: Danish Zoonosis centre*:* An example of one health integration.

Prior to the mid-1990s, surveillance and control of zoonotic diseases in food production in Denmark was carried out by a number of institutions, resulting in fragmented communication and coordination. An increase in cases of zoonosis in humans, increased awareness of zoonotic pathogens in meat products in Denmark, and the requirement to implement the 1992 EU Zoonosis Directive saw the need for a coordinating body to integrate data on reported zoonosis in animals, humans and food products, resulting in the creation of the Danish Zoonosis Centre (DZC). The DZC was charged with activities involving aspects of the entire food production chain and evaluating its impact on consumer health,research, and monitoring national food safety.

As a result of the interdisciplinary work carried out by medical, veterinary and political fields, surveillance of zoonosis in Denmark has shown a marked improvement,[26] resulting in lower zoonosis incidence in both humans and animals. For example, *Salmonella* incidence and prevalence decreased significantly in poultry, beef and pork, most likely due to the introduction of serologic *Salmonella* monitoring in 1997.[27]

Salmonella incidence in people has also decreased, which may be linked to lower levels of *Salmonella* in meat products from Denmark.[28] [29]
Source: World Bank

More suggestions of different actions to help strengthen the one health approach, such as investments in research, the need for further gender analysis in livestock production and disease transmission, and strengthening links between vets, biologists and environmental agencies, are described in greater detail in section 2.6 of Resource Paper 2.

4.4.3 One health approaches for early detection and disease control

At the March 2009 'One World One Health: from ideas to action' meeting hosted by the Public Health Agency of Canada, several key actions were developed to help the 'One Health' approach progress (Refer to Text Box 4-2). These recommendations included several critical issues for a 'One Health' approach to surveillance; key features of such an approach would include:

- An enhanced knowledge of information and understanding at community level;
- The willingness and ability for reporting though community to national levels, taking into account such factors as dis/incentives, skills and equipment;
- Encouraging similar communications and reporting for surveillance systems, enabling them to 'talk' to one another;
- Development of a systematic method for carrying out wildlife surveillance;
- Establishment of laboratory networks that allow for simple tests at the front lines or in resource poor areas, with more sophisticated laboratories providing support including communication and mentorship;
- Shared laboratory testing and quality assurance to determine validity of tests;
- Training in a wide range of skills that cross the human, animal and environmental health domains.

Current surveillance systems are almost universally human or animal based, with few mechanisms for direct communication or reporting. At local, national, regional and international levels the following options may be considered:

Local surveillance systems: Local systems could conduct investigations and establish databases for monitoring unusual animal and human health events or ongoing current disease outbreaks in animal or human populations. Sentinel systems may be set up to monitor diseases known to become prevalent in certain seasons.

National surveillance systems: National surveillance systems vary considerably; some countries have compulsory notification while others have rudimentary systems which only reflect diseases of national interest. Strengthened national surveillance of disease burden and potential disease outbreaks or niches would strengthen management of the broader burden of disease, in addition to emerging events. There is a need for improved commitment at international and national levels for increased disease surveillance of livestock traded nationally, regionally and internationally – and identification of

mechanisms/standards/agreements etc to achieve this – linked to global frameworks for monitoring and reporting of disease.

Regional/ Cross Border surveillance systems: The development of regional surveillance systems reflects the utility and potential in systems that cross borders. Examples are the Eurosurveillance system the Pacific Public Health Surveillance Network and the Mekong Basin Disease Surveillance Programme (See Case Study 4-6).

Case Study 4-6: Mekong Basin Disease Surveillance

The Mekong Basin is the home of six countries (Cambodia, Yunnan province of the People's Republic of China, Lao PDR, Myanmar, Viet Nam, and Thailand). After a meeting in Bangkok in February 1999, delegates from all countries agreed to start collaboration in disease surveillance under the name, Mekong Basin Disease Surveillance (MBDS). Guangxi Zhuang Autonomous Region of People's Republic of China became the member of MBDS region in February 2008.

The general objective of MBDS is to strengthen national and Mekong sub-regional capabilities in disease surveillance and response to outbreaks of priority diseases. The three specific program areas of MBDS are: i) strengthen sustainable national capacity in disease surveillance, outbreak investigation and responses; (ii) strengthen manpower development in field epidemiology; and (iii) establishment of a sub-regional surveillance network.
Source: (ref)

***International surveillance systems*:** There are a considerable number and diversity of surveillance systems at the international level (several examples of which can be found in Annex 4-3). While additional effort is still needed to fully address the human, animal, environment interface, some of these have been developed to become multi-disciplinary, such as the FAO, OIE and WHO joint Global Early Warning and Response System for Major Animal Diseases, including Zoonoses (GLEWS), which combines the alert mechanism of the three bodies to assist with the prediction, prevention and control of animal disease threats, including those capable of transmission to humans.

Predictive Modeling

Predictive modeling is a useful and developing tool to support decision making. In recent years there have been helpful developments in computer software (including GIS systems) to anticipate emergence and spread of new pathogens. For example, the Wildlife Trust have developed a risk surveillance program with an emerging disease database for point of origin and human interface hotspots.

Predictive modeling has also been used to target interventions to minimize global impacts of an infectious disease. For instance, modeling based on airline activity from Mexico during the H1N1 outbreak gave a reasonable prediction of where outbreaks would occur.[30] The Wildlife Trust added an additional variable of national healthcare spending over the previous year to account for the likelihood that a particular country would report an outbreak – results with rigorous probability emerged. In the event of the next outbreak, this model could be used for targeting of resources to countries that

receive a high volume of travelers and also have low healthcare budgets – thus where cases are less likely to be detected or reported quickly without additional support.[31]

Other techniques such as foresighting, the rapid analyses of and distribution disease reports in association with intelligence gathering can provide valuable support to an understanding of emerging diseases. However the critical information support activity must be provided by people in country – villagers, communities and the like – hence the need for training and rapid reporting of unusual circumstances.

4.4.4 One health approaches for preparedness

Lessons learned for preparedness that have been identified through reviews of responses to global health threats, as outlined in Resource Paper 3, should be taken into account when considering 'One health' approaches for pandemic preparedness.

More emphasis needs to be made on developing multi-sectoral preparedness at the local level, particularly that which is contextually appropriate and effective. For example, to improve accurate surveillance and timely reporting, adequate systems for compensation need to be established for farmers so that they do not avoid reporting a disease outbreak, which in turn spread and impact a larger community (potentially leading to a public health crisis which could in turn cause absenteeism, thus impacting other sectors such as finance, food, public order, transport, etc).

Improved surveillance systems (which create a more solid knowledge base) will also support the strengthening of communication strategies. Given the number of sectors that can be impacted by EIDs, interdisciplinary approaches for communication strategies should be utilized, thus facilitating horizontal as well as vertical reporting. Different sectors at multiple levels (particularly locally) need to be informed so that they can properly plan and respond. For example, ensuring that public health professionals are alerted when there are H5N1 outbreaks in poultry flocks, given the potential implication for human health.

Beyond animal and public health sectors, preparedness planning is essential across all sectors, and must involve a one health approach (see Text Box 4-5 for details).

Text Box 4-5: Whole of society pandemic preparedness as a one health approach

Business Continuity Planning (BCP) activities have been stimulated by the pandemic agenda and the projected risks of H5N1. It is recognised that the robust multi-hazard BCPs serve as a generic disaster preparedness tool, enabling communities, organisations and societies to better mitigate the impact of a range of possible future threats and crises. In this context, planning and capacity-building using BCP processes, which are in line with whole-of-society ideas support strengthening the resilience to a range of emerging infectious diseases with pandemic potential.

The discussion of the whole-of-society approach has promoted the involvement of non-health sectors in planning and preparedness for responding to health threats. This work heavily promotes the participation of civil society and vulnerable groups, which further

contributes towards a comprehensive approach in effectively addressing health issues, especially newly emerging threats that might require a closer cooperation of different sectors.

Whilst some donors and academics recognise the importance of preparing for new emerging global infectious disease threats with pandemic potential at the animal-environment-human interface, due to other more pressing emergencies and health threats, as well as funding constraints, this is not high on the agenda of many governments from developing countries.

Source: UNOCHA Pandemic Influenza Coordination

4.5 Bringing it together – institutional arrangements to support implementation of one health approaches for prevention, management and preparedness

4.5.1 The central role of governments

The role of governments in providing direction and assuming responsibility for one health approaches is central to the success of prevention, management and preparedness strategies for diseases at the animal-human interface. There are several guiding principles which can be usefully applied, including shared goals, principles and strategies; allocation of work in accordance with comparative advantage; retention of identity and relative autonomy; transparency and accountability; trust; and the sharing of information.

Effective partnership arrangements are the key to success and should be encouraged and progressively implemented, taking into account existing one health arrangements as models. Strengthening partnerships, particularly at the in country level, to combat EIDs is a complex task and requires strong efforts at consensus building between political, technical, NGOs, development agencies and other stakeholders. The level of inter-agency and multi-sectoral collaboration, particularly between animal and human health sectors that arose from response to the H5N1 HPAI outbreaks, has been unprecedented and can be built on to support cultural change and a progressive and sustainable approach to one health ideas.

4.5.2 Institutional arrangements to implement one health approaches

There are many ways to strengthen institutional arrangements for development and implementation of one health approaches, including the following options:

At international level options include the establishment of a global alliance or executive level body which includes representation from governments and international agencies, regional bodies and academia to provide foresight, strategic guidance and high level advocacy for one health**.**

Linked to the above, development of a mechanism with overarching responsibility for a range of functions to support strategic oversight such as:

i. a repository of one health knowledge, that is readily available to all stakeholders at international, regional and national levels;
ii. a strategic research framework for applied research addressing global concerns at the animal-human interface;
iii. monitoring and review capacity, and responsibility for establishment of indicators to measure progress; responsibility for development of M&E capacity; maintenance of baseline data, regular collection, collation and synthesis of data on global progress;
iv. risk forecasting and global risk assessment, and
v. reporting functions to international agencies, and governments.

Additionally, the establishment of a targeted one health global program with specific goals identified for achievement within a set timeframe (eg by 2015) could assist with clear goal setting and prioritizing of global funding resources.

There is also a need for strengthened collaborative international support to:

i. promote government and private sector preparedness for emergency animal disease response;
ii. develop further incentives for both public and private sector to increase focus on risk reduction and increase resilience to shocks from emerging health threats at the animal-human-environment interface;
iii. provide rapid, coordinated and strategic support to governments and the private sector responding to animal disease emergencies;
iv. faciltiate action planning with governments and the private sector for development of joint three- to six-month plans for disease prevention and control with private sector investment, and
v. build technical capacity, competency, leadership, and a critical mass of regionally networked epidemiology, surveillance and laboratory, communication and social science specialists as a strategic imperative for the efficient and effective management of classical and novel animal diseases.

At regional level, options include establishing and supporting one health forums that encourage information exchange, identify common areas of interest, and strengthen results-based collaborations between different sectors. Further developing regional surveillance and laboratory networks will provide information for use in assessing the total disease burden, early warning of emergence of new pathogens or changes in behavior of known pathogens; and information to assist with forecasting and risk analysis. In addition, identification of regionally important issues for a research framework that addresses policy and practice in timely and feasible ways would enhance regional policy development and priority setting.

At national level many governments have established ***c***oordinating authorities conferred as a function of executive office, such as a prime minister or deputy minister, who is served in this capacity by an advisory committee that operates with his or her authority. Other options include establishment of Special One Health national government teams, composed of representatives of the human, animal, and ecosystem institutions, with particular responsibility for diseases at the animal-human- ecosystem interface. This

would include responsibility for working closely with local level government representatives (eg Philippines is establishing a multi disciplinary Council on Zoonoses).

Governments can also ensure greater focus on strengthening public sector capacity to:

i. integrate the private sector ideas and suggestions in decision-making processes through joint collaborations, interactive workshops and training;
ii. lead in decision-making processes through technical and leadership training programs;
iii. improve dialogue and collaboration between the public and private sectors for better disease prevention, detection and control of animal diseases;
iv. increase engagement of civil society and community stakeholders in decision making and development of locally-based approaches for one health at the animal-human interface; drawing on local knowledge for planning and risk management;
v. develop applied research programs with co-ownership of research through public/private partnerships.

The creation of an independent agency with responsibility for public health, including zoonoses and food safety has also been proposed and developed in some countries (eg The Danish Zoonotic Centre). Others are of the view that structural changes, or the fusion of organizational elements, are not the best way to go: rather functional cooperative approaches with cultural change are appropriate for their circumstances.

For pandemic preparedness a permanent body that coordinates the preparation and regular update of contingency plans to deal with the eventuality of an outbreak could be established. The coordination function might take place through the exchange of memoranda of agreement among the different sector agencies concerned. The body itself may consist of or be served by a number of working groups. In some countries this has already been established, as part of the disaster management and response authority (eg ASEAN Technical Working Group on Pandemic Preparedness and Response).

At local levels, local government operational planning structures could include one health responsibilities by working closely with communities to identify diseases of local concern, assessing and monitoring the 'total burden' of zoonotic and other animal diseases of concern; or forming communities of practice, with local groups taking responsibility for promoting healthy livestock initiatives and advocating for one health approaches.

4.6 Conclusions

4.1 A paradigm shift: One Health approaches

- One of the most salient changes in recent years has been an increasing focus on factors predisposing to disease and risk. This paradigm shift is impinged on a transition from emergency activities to more strategic approaches that take longer timeframes and apply multidisciplinary understanding and approaches to human, animal and ecosystem health.

- Diseases targeted by the approach generally include emerging infectious diseases, which are infections that have newly appeared in a population or have existed but are rapidly increasing in incidence or geographic range.

4.2 Why is a one health approach needed?

- Emerging and re-emerging diseases are increasing incrementally, with 60 percent of these diseases being zoonotic arising at the interface between animal, human and wildlife domains within the context of the overall environment. Over the last decade about 75 percent of new infectious diseases have been zoonotic in origin.
- Challenges needing resolution relate to the weakness and gaps in local disease control approaches, improving dialouge between governments and people, and shifting emphasis from pathogens to more people-centred views.
- Prevention of disease is based on broader multidisciplinary partnerships beyond the animal and human health sectors, examining broader health and economic impacts. This approach needs to involve socio-anthropologists, communication specialists, macro-economists, conservationists and legislators.

4.3 Drivers for Disease Emergence

- Drivers can be classified into three host health domains: human living environments, food and agriculture systems, and natural ecosystems. Key drivers for the emergence of disease include increased density and mobility of animal and human populations, decreased diversity of ecosystems, intensification of agriculture, and climate change.
- A better understanding of the drivers is needed along with the development of practical means through which the root causes of disease emergence can be addressed and the risks.
- Managing the increased level of risk associated with complex combinations of drivers requires a multisectoral systems approach.

4.4 One health approaches for prevention and risk reduction, early detection and control, and preparedness

- Stakeholders from a range of disciplines need to be involved in one health approaches including health, sociology, anthropology, ecology, conservation, town planning and law; beyond disciplines to skilled coordinators, communicators, monitoring and evaluation specialists, risk analysts, and strategic planners; major players also include local to national governments, international agencies, private sector and communities.
- Key actions for supporting adaption of a one health approach include: multisectoral collaboration for priority setting, novel approaches to surveillance that predict potential disease niches through ecological mapping and determination of factors associated with the emergence of diseases; revised curriculum and education programs; strengthened veterinary systems and public private partnerships; research investment; well regulated systems for livestock transfer, tracing, slaughter, processing and marketing.

- Key actions for early detection and control include: establishment of local, national, regional and international surveillance systems to enhance disease intelligence, surveillance and emergency response; predictive modeling and foresighting to enable rapid response to emerging disease events.
- Additionally there is a need for improved commitment at international and national levels for increased disease surveillance of livestock traded nationally, regionally and internationally – and identification of mechanisms/standards/agreements etc to achieve this – linked to global frameworks for monitoring and reporting on disease.
- Given the complexity of animal and public health threats, a one health research agenda is needed to inform, in a systematic manner, pressing policy and practice questions faced by international and regional organizations, national governments, and communities.

4.5 Bringing it together – institutional arrangements to support implementation of one health approaches for prevention, management and preparedness

- The role of governments is central for providing direction and responsibility for one health approaches for prevention, management and preparedness strategies with diseases at the animal-human interface.
- Institutional mechanisms need to be strengthened at international, regional, national, and local levels to implement one health approaches.
- Comprehensive disease risk management requires multi-sector expertise and insights from sources such as veterinarians, physicians, ecologists, wildlife biologists, epidemiologists, economists, anthropologists, and communication specialists.
- Despite the accomplishments so far, there is common agreement that more is needed to address diseases arising at the animal-human-environment interface, and that sustained economic support is fundamentally warranted.
- The assessment of emerging disease risk (as well as other disaster related risks) should be an integral part of all planning approval for new land usage, and tools developed, adopted and integrated into urban and rural planning and development processes.
- Strategic mechanisms at global, regional and national levels are needed to provide a repository of one health knowledge; a strategic research framework for applied research addressing concerns at the animal-human interface; monitoring and review capacity; risk forecasting and risk assessment; global advocacy and reporting functions for international agencies, and governments.
- Governments should harness and support local government operational planning structures with one health responsibilities, including to identify diseases of local concern and assess and monitor the 'total burden' of zoonotic and other diseases of concern.
- Ongoing and strengthened collaborative international support is needed to: promote government and private sector preparedness for emergency animal disease response; increase resilience to shocks from emerging health threats at the animal-human-environment interface; build technical capacity, competency, leadership, and a establish a critical mass of regionally networked epidemiology, surveillance and laboratory, communication and social science specialists.

4.7 Appendices

Annex 4-1: Timeline of International meetings: Avian and Pandemic Influenza contributions to One Health.

Date	International meeting	Outcomes for one health
October 2005	Ottawa, Canada – First International Meeting of Health Ministers	Declaration: "mulitsectoral approach, beginning with the animal and human health sectors, must underlie global efforts towards coordinated pandemic planning
November 2005	Geneva, WHO Meeting on Avian Influenza and Human Pandemic Influenza (Health Ministers, and others)	Proposal for countries to develop integrated action plans
January 2006	Beijing, China – International Pledging Conference on Avian and Human Pandemic Influenza	International Pledging Conference on Avian and Human Pandemic Influenza – International community pledged US$ 1.9 billion in financial support and discussed prospective coordination mechanisms.
December 2006	Bamako, Mali – Fourth Ministerial Meeting and Pledging Conference on Avian and Pandemic Influenza	Compensation guidelines agreed, and an additional US$475 million financial support committed.
December 2007	New Delhi, India – Fifth International Ministerial Conference on Avian and Pandemic Influenza	Road Map for the control of HPAI, calling for formulation of a strategic framework.
October 2008	Sharm el-Sheikh, Egypt – Sixth International Ministerial Conference on Avian and Pandemic Influenza	Consultation document "Contributing to One World One Health" tabled.
March 2009	Winnipeg, Canada – Expert Consultation on One World One Health	'One World One Health' Key Recommendations developed.

Annex 4-2: The Manhattan Principles on "One World, One Health"

Recent outbreaks of West Nile Virus, Ebola Hemorrhagic Fever, SARS, Monkeypox, Mad Cow Disease and Avian Influenza remind us that human and animal health are intimately connected. A broader understanding of health and disease demands a unity of approach achievable only through a consilience of human, domestic animal and wildlife health - **One Health.**

Phenomena such as species loss, habitat degradation, pollution, invasive alien species, and global climate change are fundamentally altering life on our planet from terrestrial wilderness and ocean depths to the most densely populated cities. The rise of emerging and resurging infectious diseases threatens not only humans (and their food supplies and economies), but also the fauna and flora comprising the critically needed biodiversity that supports the living infrastructure of our world. The earnestness and effectiveness of humankind's environmental stewardship and our future health have never been more clearly linked. To win the disease battles of the 21st Century while ensuring the biological integrity of the Earth for future generations requires interdisciplinary and cross-sectoral approaches to disease prevention, surveillance, monitoring, control and mitigation as well as to environmental conservation more broadly.

We urge the world's leaders, civil society, the global health community and institutions of science to:

1. Recognize the essential link between human, domestic animal and wildlife health and the threat disease poses to people, their food supplies and economies, and the biodiversity essential to maintaining the healthy environments and functioning ecosystems we all require.

2. Recognize that decisions regarding land and water use have real implications for health. Alterations in the resilience of ecosystems and shifts in patterns of disease emergence and spread manifest themselves when we fail to recognize this relationship.

3. Include wildlife health science as an essential component of global disease prevention, surveillance, monitoring, control and mitigation.

4. Recognize that human health programs can greatly contribute to conservation efforts.

5. Devise adaptive, holistic and forward-looking approaches to the prevention, surveillance, monitoring, control and mitigation of emerging and resurging diseases that take the complex interconnections among species into full account.

6. Seek opportunities to fully integrate biodiversity conservation perspectives and human needs (including those related to domestic animal health) when developing solutions to infectious disease threats.

7. Reduce the demand for and better regulate the international live wildlife and bushmeat trade not only to protect wildlife populations but to lessen the risks of disease movement, cross-species transmission, and the development of novel pathogen-host relationships. The costs of this worldwide trade in terms of impacts on public health, agriculture and conservation are enormous, and the global community must address this trade as the real threat it is to global socioeconomic security.

8. Restrict the mass culling of free-ranging wildlife species for disease control to situations where there is a multidisciplinary, international scientific consensus that a wildlife population poses an urgent, significant threat to human health, food security, or wildlife health more broadly.

9. Increase investment in the global human and animal health infrastructure commensurate with the serious nature of emerging and resurging disease threats to people, domestic animals and wildlife. Enhanced capacity for global human and animal health surveillance and for clear, timely information-sharing (that takes language barriers into account) can only help improve coordination of responses among governmental and nongovernmental agencies, public and animal health institutions, vaccine / pharmaceutical manufacturers, and other stakeholders.

10. Form collaborative relationships among governments, local people, and the private and public (i.e.-non-profit) sectors to meet the challenges of global health and biodiversity conservation.

11. Provide adequate resources and support for global wildlife health surveillance networks that exchange disease information with the public health and agricultural animal health communities as part of early warning systems for the emergence and resurgence of disease threats.

12. Invest in educating and raising awareness among the world's people and in influencing the policy process to increase recognition that we must better understand the relationships between health and ecosystem integrity to succeed in improving prospects for a healthier planet.

It is clear that no one discipline or sector of society has enough knowledge and resources to prevent the emergence or resurgence of diseases in today's globalized world. No one nation can reverse the patterns of habitat loss and extinction that can and do undermine the health of people and animals. Only by breaking down the barriers among agencies, individuals, specialties and sectors can we unleash the innovation and expertise needed to meet the many serious challenges to the health of people, domestic animals, and wildlife and to the integrity of ecosystems. Solving today's threats and tomorrow's problems cannot be accomplished with yesterday's approaches. We are in an era of "One World, One Health" and we must devise adaptive, forward-looking and multidisciplinary solutions to the challenges that undoubtedly lie ahead.

Annex 4-3: Examples of Global Disease Information Systems[32]

The Global Public Health Intelligence Network (GPHIN) focuses primarily on four human diseases: influenza, polio, SARS, and smallpox. The GPHIN was developed under the auspices of the WHO and is open to governments on a user fee basis. In addition to its four focal diseases, the network also monitors for certain diseases in which an outbreak would constitute "a public health emergency of international concern" (PHEIC).

The Global Outbreak Alert and Response Network is in place to follow up on any such outbreak identified by the GPHIN. It provides support to national governments on disease identification and characterization, outbreak preparedness and aid to affected populations. It is also under the auspices of the WHO.

The Program for Monitoring Emerging Diseases (ProMED)[2] is a disease reporting system of the International Society for Infectious Diseases. It is based on formal and informal sources of information. Data on human, animal, and plant diseases are collected by volunteers and screened by expert moderators. Most sources of information come from the US. Reporting by developing countries, particularly in sub-Saharan Africa, remains weak.

The Global Early Warning System for Major Animal Diseases (GLEWS) was set up to improve the tracking of diseases among animals in high-risk areas. The two zoonotic diseases it currently focuses on are HPAI and Rift Valley fever. Its principal source of data is the FAO, although it uses information from the OIE and WHO as well. It also uses a number of advanced databases such as ProMED, and the GPHIN.

The World Animal Health Information Database (WAHID) is used to store and summarize information on diseases reported to OIE. OIE requires its 175 members to provide timely notification of, and epidemiological information on, disease in accordance with the international standards. These include notifying OIE within 24 hours on new events of listed diseases and emerging diseases, some of which with zoonotic potential.

Med-Vet-Net is a European network that maintains a database for the prevention and control of zoonoses and food-borne diseases.

The Global Emerging Infections Surveillance and Response System (GEIS) of the US Department of Defense focuses on infectious disease with a potential health risk for US military personnel.

The Emerging Infectious Diseases Network (EIN), developed by the University of Iowa under the auspices of the US Centers for Disease Control and Prevention (CDC), is based on a network of pediatric, internist, and public health officials.

OIE - Program for Strengthening Veterinary Services (PVS) includes surveillance, reporting, early detection and response to disease as well as the management of animal health systems in partnership with farmers, government agencies, industry, educational institutions and other stakeholders.

The International Health Regulations (IHR) are an international legal instrument that is binding on 194 countries across the globe, including all the Member States of WHO. Their aim is to help the international community prevent and respond to acute public health risks that have the potential to cross borders and threaten people worldwide.

[2] ProMED is the only system that brings together information on human, animal, and plant diseases—a feature that must either be brought to other systems, or which new systems may have to be designed to accommodate.

Annex 4-4: Pathogens responsible for a zoonotic disease event in humans driven by international trade and travel.

Pathogen	Year	Country	First Animal Host	All Animal Hosts
Barmah forest	1985		Wild birds	Probably wild birds or marsupials
Hendra	1994		Flying foxes	Natural reservoir for Hendra virus is thought to be flying foxes (bats of the genus Pteropus)
Taenia solium	1978		Dogs	The domestic dog and other canids are definitive hosts; intermediate hosts include herbivores, primarily sheep, cattle, goats, pigs, horses, and other mammals
Yersinia enterocolitica O:5,27	1968	Finland	Horses	Horses, dogs, cats and birds of prey?
Rickettsia mongolotimonae	1996		Cattle	Cattle, sheep, goats, dromedaries, several rodents, wild ruminants, buffaloes, antelopes, wildebeest. Humans are very susceptible (major zoonosis), African monkeys and domestic carnivores present a transitory viraemia
Wesselsbron virus	1989	Madagascar	Vertebrates	Urban areas - humans, mosquitoes; forest areas – vertebrates other than humans (mainly monkeys) and possibly marsupials, forest mosquitoes; transovarial transmission in mosquitoes contributes to maintenance of infection
Lassa virus	1969	Nigeria	Rodents	Old world rats and mice (family Muridae, subfamily Murinae)
Schistosoma mansoni	1999	Oman	Widely Distributed	Widely distributed in nature; parasiting in sea mammals; small crustaceans, squid, octopus, fish
Omsk virus	1941	Russia	Rodents	Rodents, muskrats, and ticks
Angiostrongylus cantonensis	1945	Taiwan	Humans	Humans are principal reservoir; snail as intermediate host
Rickettsia honei	1990	Thailand	Fruit bat	Fruit bat or some other mammal
Penicillium marneffei	1970			Saprophytic growth in the external environment; can be isolated consistently from old pigeon nests and pigeon droppings from soil in many parts of the world
Rickettsia typhi	1983			
West Nile Virus	1999		Vertebrates	Urban areas – humans, mosquitoes; forest areas – vertebrates other than humans (mainly monkeys) and possibly marsupials, forest mosquitoes; transovarial transmission in mosquitoes contributes to maintenance of infection
Rickettsia africae	1992	Zimbabwe		

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