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SCIENCE FOR A SUSTAINABLE DEVELOPMENT

Risk of emergence of viral diseases driven by eco-climatic changes and socio-economical situations

«VIRORISK»

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SCIENCE FOR A SUSTAINABLE DEVELOPMENT
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Cluster Project
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FINAL REPORT

Risk of emergence of viral diseases driven by eco-climatic changes
and socio-economical situations
VIRORISK

SD/CL/09

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D/2013/1191/3
Published in 2013 by the Belgian Science Policy
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Fabiana Dal Pozzo, Catherine Fallon, Catherine Zwetkoff, Marc Coosemans & Etienne Thiry ***Risk of emergence of viral diseases driven by eco-climatic changes and socio-economical situations "VIRORISK"***. Final Report. Brussels : Belgian Science Policy 2013 – 56 p. (Research Programme Science for a Sustainable Development)

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SUMMARY

A. Context

The emergence, re-emergence and increased incidence of infectious viral diseases are threats for human and animal populations. These phenomena have a negative influence on human and animal health, but also socio-economical consequences on a regional, national and international level. Likewise, the emergence, re-emergence and increased incidence of viral diseases are influenced by several factors involving the virus, the human and/or animal hosts and also multiple environmental, climate, social and economical conditions. In Belgium, several public health authorities are responsible for the epidemiological surveillance, the detection and the control of human and animal viral diseases. Policy makers need instruments allowing the best allocation of resources: surveillance programs, diagnosis, control measures and scientific research need to be supported based on the results of a risk analysis.

B. Objectives

The aim of the project was the elaboration of an integrated approach of surveillance of risk factors combining environment, climate and health, focusing on viral infections.
VIRORISK wanted to identify lacking data and design a scientifically based methodology of an integrated risk analysis. The developed methodology would enable to establish conditions for emergence of viral diseases in Belgium driven by climatic, environmental en socio-economic factors.
The project wanted to establish a dynamic dialogue with regulatory institutions and relevant stakeholders in order to apply the developed model of risk analysis and risk management to the emergence of viral diseases.

C. Conclusions

The situation of the country with regards to the identified parameters (presence and prevalence/incidence) and the preparedness of the surveillance systems and the authorities have been investigated, and a strength/ weakness/ opportunities/ threat (SWOT) analysis was performed with regards to the preparedness, the collaboration, the efficiency and communication of the Belgian institutions.
VIRORISK allowed the collaboration between scientists having competences in different domains and disciplines (virologists, entomologists and experts in the evaluation of environment-socio-economical risks), with the resulting added value of an integrated approach.

D. Contribution of the project in a context of scientific support to a sustainable development policy

The identification of the hazards through the realization of a list of viral diseases ended in a closed list which could not be exhaustive and especially did not take in consideration the possibility of emergence of unknown and uncharacterized viruses. Furthermore in the context of a qualitative risk analysis, the hazards should be identified and prioritized in order to accomplish the risk assessment and to give useful information to the decision makers.

Some points of contrasts were pointed out between the two main surveillance systems, the one concerning human health and the other one related to animal health and food chain security issues.

The human health networks are open to observe emerging health issues, even under uncertainty, as long as there is a probability of large epidemic hazard. It means that the list of diseases to be declared is not closed in the legal frame.
As far as animal health is concerned, there is less space for open or uncertain "emerging" issues in the legal frame: all lists are closed and only in the frame of "exotic diseases" does the legal frame provide some space to organize epidemiological research in order to search for vectors of the disease.

An open list of risk factors has been described.
Vector-borne viruses are emerging pathogens, and several factors are increasing the risk of their emergence in Belgium and in Europe: climate change (migration patterns of birds and wildlife, vector population, landscape), human activities (landscape, human international movements), trade, virus genetic mutations.
For mammalian-borne viruses the following risk factors can influence their emergence, re-emergence and increased incidence: climate change (migration patterns of birds and wildlife, landscape), human activities (landscape, human international movements, human habits, occupational risks), trade, virus genetic mutations.
For directly transmitted viruses, their increased incidence can be influenced by the following factors: climate change (resistance of the virus in the environment, migration patterns of birds and wildlife, human activities), human activities (human habits, occupational risks), human demography, trade, virus genetic mutations.

The control measures against viral diseases are mainly organized by the Scientific Institute of Public Health in coordination with other institutions such as the CERVA and the AFSCA in case of zoonotic pathogens, or the Institute of Tropical Medicine for tropical infectious diseases. They are mainly dependent on already known viruses and are less adapted to a quick reaction in face of an emerging disease.

Regarding vector-borne viral infections, a list of current possible control measures against arthropod vectors was drawn in this report. As a major outcome of this analysis, it was pointed out that, in Belgium, despite a recent intervention in Natoye (province of Namur), a vector surveillance system is lacking and once a problem does occur, the decision-making process is not straightforward, especially regarding the responsibility and skills for implementing the control, and the kind of intervention that should be applied in case of epidemics, prevention of epidemics and presence of invasive species.

In human health, the federalization of the health prevention responsibilities led to the development of a fragmented system with a complex distribution of responsibilities between policy levels, and which is different for animal and public health. The three regions kept the same logic of notification (via general practitioners or laboratories) but the Region of Bruxelles-Capital and the Vlaamse Gemeenschap developed a new specific legal frame. However, concerning human health, the coordination between actions organised by sub-federal entities should be improved. Animal health is organized at a federal level and does not suffer from the same issue, except for matters in relation with wildlife that are region-dependent.

A major pitfall was identified in the communication between human and animal health systems in Belgium, especially taking into account the fact that 70% of emerging human diseases are zoonotic. The creation of structural links between these human and animal health systems needs a profound reorganization of the federal, regional and community institutions.

E. Keywords

Viral disease, arthropod-borne virus, mammalian-borne virus, directly-transmitted virus, case study, disease surveillance, management, qualitative risk analysis, methodology, SWOT analysis

1. INTRODUCTION

Viral infectious diseases are caused by intracellular obligatory pathogens having genetic and physico-chemical properties influencing their epidemiology and pathogenicity. They represent a threat for human and animal health, as well as for the society and the economy in general (direct and indirect consequences). In Belgium, several public health authorities are responsible for the epidemiological surveillance, the detection and the control of human and animal viral diseases. These institutions collaborate with European and international authorities in order to assure an international network of surveillance. However, despite the general preparedness towards well known viral pathogens, problems can arise in case of emergence, re-emergence or increased incidence of viral diseases. Emerging infectious diseases are not easy to predict (geographical and temporal occurrence) and they can cause sanitary, social and economical consequences hardly measurable. According to the World Organization for Animal Health (OIE), 75% of the emerging diseases find their origin in domestic or wild animals, underlying the need of extensive collaboration in all aspects of health care for humans, animals and environment. This collaboration is particularly necessary in case of zoonoses. The emergence, re-emergence or the increased incidence of a viral disease can be caused by many different factors, such as intrinsic features of the virus (for example, high rate of genetic mutations), parameters depending from the human, animal or invertebrate hosts (for example, trade of infected animals or animal products), modifications occurred in the society, in the economy or in the environment (climate change for example). The disease prioritization is a process aiming to provide a tool for decision in human and animal health. It is of particular importance when applied to the selection of diseases for which urgent and defined policy measures have to be implemented.

VIRORISK is a cluster project that aimed to develop a methodology which enables to establish conditions for emergence of viral diseases in Belgium driven by climatic, environmental en socio-economic factors. VIRORISK allowed the collaboration between scientists having competences in different domains and disciplines, giving the opportunity to exchange knowledge and to have an integrated approach to multidisciplinary research. An open dialogue between virologists, entomologists and experts in the evaluation of environment-socio-economical risks was created. Their integration allowed the comprehension of the multiple and different factors influencing the emergence of viral diseases and the quality of their management.

Policy makers need instruments allowing the best allocation of resources: surveillance programs, diagnosis, control measures and scientific research need to be supported based on the results of a risk analysis.

2. METHODOLOGY AND RESULTS

The main objective of the cluster project was the **implementation of the methodology of risk analysis**, in particular, a qualitative risk analysis focussing on viral diseases and on the preparedness of the surveillance and management systems already existing in Belgium.

The risk analysis was performed following the common approach: hazards identification, inventory of surveillance systems, risk assessment and risk management.

It was followed by a study of different cases representing the three main patterns of virus transmission and by a swot analysis.

A. Hazards identification

The **hazards** were identified as viral diseases that could emergence, re-emerge or have an increased incidence in Belgium. Inclusion critera were defined, as well as three categories of viral diseases, based on their main transmission pattern (directly transmitted, vector-borne and mammalian-borne viruses). This classification allowed including within the same group or category, viruses recognizing similar risk factors influencing their transmission and their distribution within the human and/or the animal population (zoonotic viruses).

Among the diseases with the **risk of emergence in Belgium**, the following inclusion criteria were used:

a. Absence in Belgium and in Europe
b. Causing mild to severe health consequences
c. Having a potential epidemic evolution
d. Absence of active surveillance
e. Absence of vaccination strategies
f. Absence of specific treatment

The hazards identified and responding to these criteria are listed in **Table 1.**

	Risk of emergence
Directly transmitted viruses	Influenza A (seasonal subtypes)
	New pandemic influenza A
Vector-borne viruses	Chikungunya virus
	Crimean-Congo haemorrhagic fever virus (zoonosis)
	Dengue virus
	Eastern and Western equine encephalitis virus (zoonosis)
	Hendra virus (zoonosis)
	Japanese encephalitis virus
	Nipah virus (zoonosis)
	Rift Valley Fever virus (zoonosis)
	St. Louis encephalitis virus (zoonosis)
	Tick borne encephalitis virus
	Usutu virus
	Venezuelan equine encephalitis virus (zoonosis)
	Yellow fever virus
Mammalian-borne viruses	Hantavirus (other serotypes than Puumala and Tula virus)
	Cowpox virus (zoonosis)
	Monkeypox virus (zoonosis)

Among the diseases with the **risk of re-emergence in Belgium**, the inclusion criteria were:

a. Presence in the past in Belgium and in Europe
b. Causing mild to severe health consequences
c. Having a potential epidemic evolution
d. Absence of active surveillance
e. Absence of vaccination strategies
f. Absence of specific treatment

The hazards identified and responding to these criteria are listed in **Table 2.**

	Risk of re-emergence
Directly transmitted viruses	Coronavirus SARS
	Influenza A virus H5N1
	Poliovirus
Vector-borne viruses	/
Mammalian-borne viruses	Rabies

Among the diseases with the risk to have an **increased incidence in Belgium**, the following inclusion criteria were used:

a. Presence in country
b. Presence of a surveillance system

The hazards responding to these two criteria are listed in **Table 3**

	Increased incidence
Directly transmitted viruses	Adenovirus (respiratory)
	Hepatitis A virus
	Hepatitis B virus
	Hepatitis C virus
	Hepatitis E virus
	Human Immunodeficiency virus
	Influenza A virus (seasonal subtypes)
	Influenza B virus
	Influenza A virus H1N1
	Measles virus
	Metapneumovirus
	Norovirus
	Parainfluenza virus
	Rotavirus
	Rubella virus
	Syncytial Respiratory virus
Vector-borne viruses	Tick-borne encephalitis virus
Mammalian-borne viruses	Hantavirus (Puumala and Tula virus)

Although the criteria of inclusion were defined for each category of disease, the lists of the hazards did not appear to be the best approach to be used in the implementation of the methodology of risk analysis. Especially for viruses with the risk of emergence in Belgium, the list was not an exhaustive inventory of all the viruses potentially emerging in the country, but mostly of the hazards internationally recognized with a higher potential to emerge out of their endemic regions (AFSSA, 2005). The identification of the hazards through the realization of a list of viral diseases ended in a closed list which could not be exhaustive and especially did not take in consideration the possibility of emergence of unknown and uncharacterized viruses. Furthermore in the context of a qualitative risk analysis, the hazards should be identified and prioritized in order to accomplish the risk assessment and to give useful information to the decision makers. A ranking of the viral diseases identified within the lists of pathogens with the risk of emergence, re-emergence and increased incidence in Belgium would represent an important achievement in terms of risk assessment. It would give objective arguments to the decision makers for activities of risk management and for a better allocation of the economical and human resources.
The **prioritization** considers several points of interests such as the risk of exposure, the consequences of the infection (for the infected persons, for the public health, for the economy, etc.). The ranking of the viral diseases is the result of the collaboration of a group of experts (virologists, epidemiologists, decision makers, sociologists etc.) giving their contribution and allowing the formulation of a unanimous result (ANSES, 2010). Several works have been published recently with the purpose to apply a methodology of prioritization to human and animal diseases (Havelaar et al., 2010; Humblet et al., 2012; Krause, 2008).
The aim of the cluster project was the development of a methodology to be applied to viral diseases and to be delivered to policy makers as a tool in their decision process. Considering the difficulty in predicting the viral diseases representing a future threat for public and animal health, the analysis continued taking in consideration the **risk factors** conditioning their emergence, re-emergence and increased incidence (chapter 2. C).

B. Inventory of surveillance systems

An inventory of surveillance systems was carried out. It concerned surveillance systems applied in Belgium to viral diseases (affecting humans and animals for zoonotic diseases) and extended to the surveillance programs of vectors (vertebrate and invertebrate vectors) having a role in the transmission and geographic distribution of the viral diseases.

Concerning the **surveillance of the vector population**, in Belgium a very thorough survey has been accomplished in 2007 and 2008 (Belspo Project MODIRISK), but no regular surveillance focusing on invasive species has been set up. Indicators on vector abundance, vector species, vector behavior and viral detection can be very valuable in terms of public health risk assessment. Vector surveillance is very labour intensive and therefore costly, although the cost of an outbreak that was not averted might well be greater (Vazquez-Prokopec et al., 2010).

The inventory of the institutional and organizational framework of the **surveillance system in Belgium concerning viral diseases** has been performed using two approaches:

1. The overview of the legislation and its application through official documents and personal interviews with officers involved in the system
2. A Mesydel investigation (online Delphi questionnaire) which allowed the evaluation of the system.

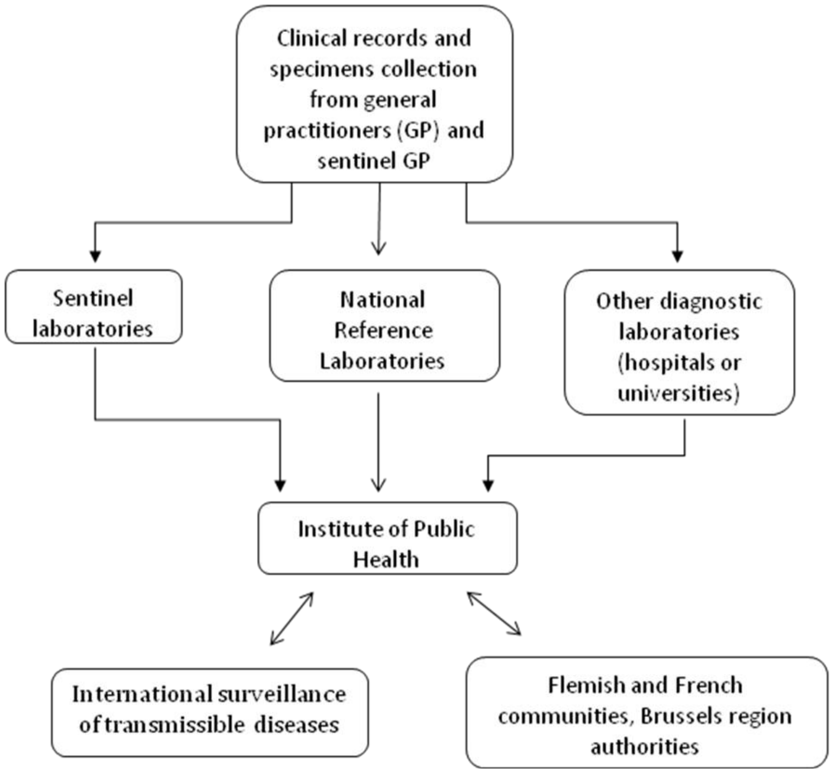

Figure 1: General flow chart of the surveillance system of human viral diseases

General Practitioners (GPs)
Clinical surveillance and sampling. Samples are sent to laboratories for diagnosis. The laboratories refer the data to a National Reference Laboratory (if present) or to the Scientific Institute of Public Health.

Sentinel GPs
They register specific health problems on a voluntary and weekly basis. The participants (at present about 200) are representative for the profile of physicians in Belgium, i.e. according to age, sex and homogeneous geographical distribution. A number of European countries have organised comparable surveillance networks and in the framework of several projects financed by the European Union, an international surveillance concerning among others, measles, mumps and blood tests, HIV tests in particular, has been undertaken.
This surveillance network allows the monitoring of diseases, the measuring of their incidence and the study of their most important epidemiological characteristics. Main topics covered are measles, mumps and requests for HIV tests, which permit impact studies for prevention and vaccination campaigns.

Sentinel Laboratories
Objectives:

- Yearly following of trends in numbers of isolates of different organisms reported to the network in order to carry out surveillance of infectious diseases,
- monitoring clusters of infectious diseases,
- following up of clusters and outbreaks of infectious diseases,
- providing estimates of the incidence of reported infections on a national as well as a local level (departments).

Methods:

- voluntary unpaid participation by 100 sentinel microbiology laboratories representing 58% of all in 2009 recognized private or hospital microbiology laboratories situated in 33 of 43 Belgian districts;
- participation of reference laboratories, responsible for laboratory diagnostic testing for specific organisms, for confirmatory testing of samples from other laboratories or for subtyping of isolates or antibiotic resistance testing;
- reporting of respiratory tract infections and central nervous system infections, gastro-intestinal infections, imported infections, sexually transmitted infections and zoonoses;
- daily real-time feedback through the electronic program (Epi-Lab) or by Internet or weekly paper reporting;
- collection of information on food-borne diseases.

Flemish and French Community Inspection and Hygiene

The inspector working within this service receives the declarations of the physicians on suspected viral diseases. The inspector takes prophylactic measures to contain the transmission and he follows the evolution of the disease in the population. The inspector makes reports and gives information to the Scientific Institute of Public Health.

Scientific Institute of Public Health (WIV-ISP)

The operational directorate Communicable and infectious diseases (OD-CID) is responsible for the detection, early and rapid identification, and microbiological monitoring of existing and (re-)emerging communicable and infectious agents, and for preventing and treating these diseases. It has a vital part in the Belgian, European and international network of surveillance, as well as reference laboratories and centres of expertise for infectious diseases and food safety.

Through its actions and expertise, the OD-CID reliably informs policymakers and the public about new developments in public health, safety of the food chain, food & environment.

Within the OD-CID, the virology scientific service aims at detecting, monitoring, prevention and treatment of existing viral diseases or (re)-emerging diseases. It plays an important role in national and international network of monitoring, reference and expertise. The main themes developed by the service are: the respiratory viruses, viral encephalitis, viral hepatitis and viral (re)emerging diseases.To finalize this it comprises:

- The National Influenza Centre (NIC)
- The National Centre for Viral Hepatitis (NCVH)
- The National Laboratory for Measles and Rubella (NLMR)
- An L3 quarantine laboratory, to perform the diagnosis of some emerging viral infections representing a threat for public health (e.g. SARS, bird flu, West Nile…)
- The National Reference Laboratory for Rabies (surveillance, diagnosis in humans and animals, delivering preventive and curative treatments and research in the field of viral encephalitis)

The IPH, as a federal state institution, is involved in the management of national or international crises caused by threatening (re)emerging viruses. The role of the Virology Division is to develop, to validate and to perform in routine sensitive and specific diagnosis tests (Nucleic acids Amplification Techniques) in order to respond rapidly to health authorities. The Division takes also part in the epidemiological surveillance of these viral infections in close collaboration with the Epidemiology Division of the Institute.

Within the OD-CID, the service food-borne pathogens is responsible for scientific research, laboratory detection and monitoring of food-borne pathogens. It includes the National Reference Laboratory for Food-borne virus outbreaks (e.g. hepatitis A, norovirus).

Based on the research, the expertise and the services of the WIV-ISP, 1) the WIV-ISP gives recommendations and keep informed the national and international stakeholders about their work and the results of their research (via international publications, scientific reports, participation to national and international networks); 2) the WIV-ISP gives scientific information to the press.

Institute of Tropical Medicine of Antwerpen (ITM)

It is the national reference centre for tropical and infectious diseases.
National Aids Reference Laboratory (ARL):
The Aids Reference laboratory of the ITM is one of the seven centers accredited and funded by the Belgian Ministry of Public Health and Social Affairs. Their task includes reference and confirmation diagnosis of HIV (serology, viral load, resistance); assessment, development and quality control of existing and new tests; data collection and surveillance. They collaborate in a national network coordinated by the national Scientific Institute of Public Health.
WHO collaborating Centre for HIV/AIDS Diagnostic and Laboratory Support:
This reference centre offers expert advice, reference service, quality control, research and training on the diagnosis and *surveillance* of retroviral diseases and blood-transmissible diseases, particularly HIV and HTLV-I/II.
The Service for Tropical and Import Pathology provides specialized outpatient, diagnostic, clinical and preventive care to returning travelers, expatriates and migrants. As national reference centre for tropical and infectious diseases, they are permanently on call to advise other healthcare workers throughout Belgium on diagnostic and therapeutic problems, and the authorities on the surveillance and management of imported diseases.
Communication of research results and services by organization of workshops and conferences, publication on national and international scientific journals…..

Research Laboratory for Vector-borne Diseases and National Reference Center for Hantavirus infection
This laboratory works for the diagnosis of the following viral diseases: hantavirus, tick-borne encephalitis virus (TBEV) and dengue virus. For all these pathogens a serological test is performed and for hantavirus and TBEV the viral genomic detection is also performed.

French community hospitals

Flemish community hospitals

Brussels hospitals

University laboratories of virology (KUL, UCL, ULg, ULB, VUB, UGent)
With their research activities, they contribute to the surveillance of viral diseases.

International surveillance of transmissible diseases
The ECDC is promoting the integration of the European national surveillance systems and it is uncharged of giving common advices and recommendations at a European level.

- Routine surveillance of the 46 diseases plus SARS, West Nile and avian influenza (TESSy system).
- Disease-specific European surveillance networks (influenza, HIV, food and water-borne diseases and zoonoses).
- Disease-specific programs (influenza, HIV, food and water-borne diseases and zoonoses, emerging and vector-borne diseases).
    - program on influenza deals with seasonal influenza, avian influenza, pandemic influenza, vaccination, antivirals and antiviral resistance

- program on emerging vector-borne diseases: it is supported by some networks dealing with laboratory diagnostic, risk assessment and communication, arthropod vector surveillance and distribution.

Epidemic intelligence has the aim to minimize impact on the EU citizens

- early warning
- outbreak investigation (detect, verify, assess)
- Establishment of procedures
- risk management

Emergency operating centre:

- structure dedicated to management of emergency and crisis situations at EU level
- collaboration with EU national institutes dealing with emergency and crisis management

Eurosurveillance is the European scientific journal devoted to the epidemiology, surveillance, prevention and control of communicable diseases (http://www.eurosurveillance.org/)

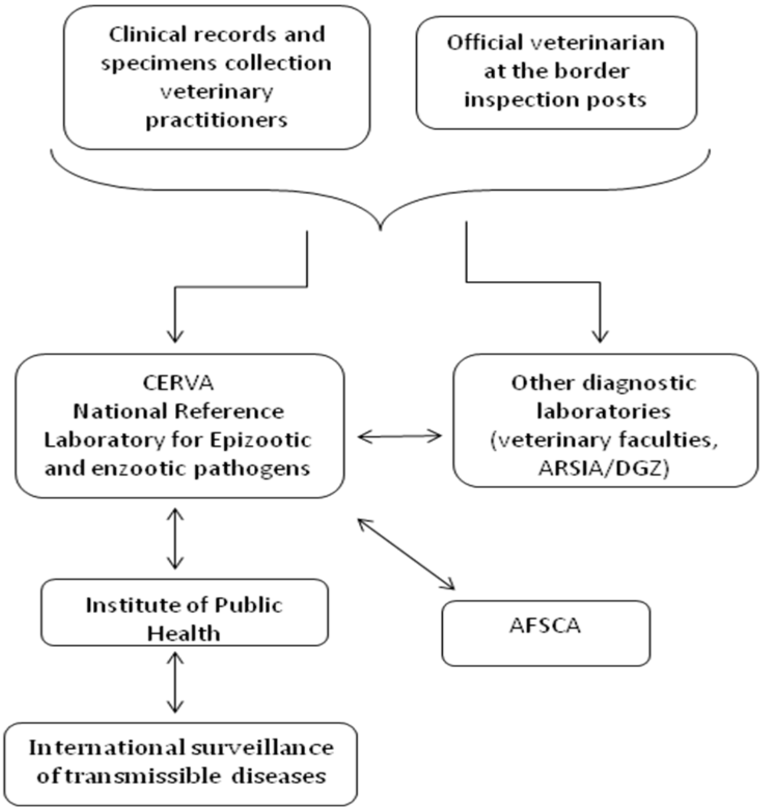

Figure 2: General flow chart of the surveillance system of live animals for animal and zoonotic viral diseases.

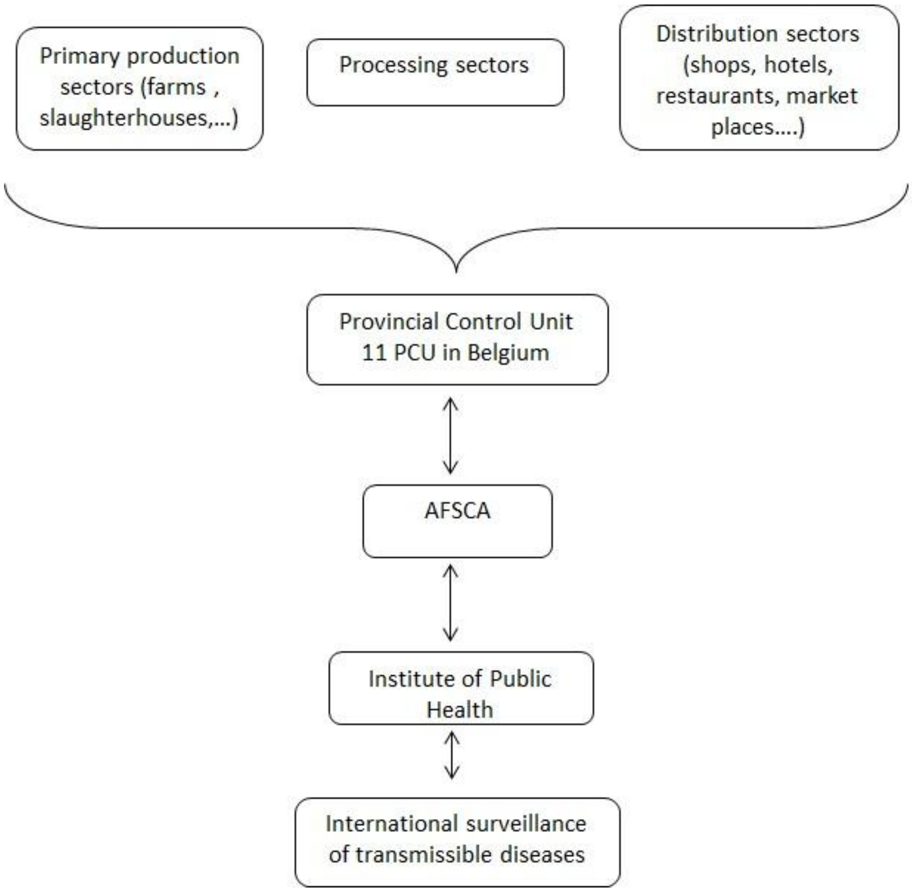

Figure 3: General flow chart of the surveillance system of animal products for animal and zoonotic viral diseases.

Veterinary practitioners
Clinical surveillance and sampling.

ARSIA (Association Régionale de Santé et d'Identification Animales) and DGZ (for Flanders) (http://www.arsia.be/; http://www.dgz.be/)
They are active in two sectors: animal identification and animal health.

Border Inspection Posts
The European Union lays down procedures for veterinary checks on animals entering the Community from third countries. These take the form of reinforced checks to be carried out by the competent authorities. When the veterinary import conditions are respected and there is no danger to public or animal health, the official veterinarian responsible for the inspection post shall issue a certificate. If these animals do not meet the conditions laid down in Community legislation, the competent authority can decide to place them in quarantine, or arrange for their re-exportation or slaughter. Safeguard measures: if warranted by any serious threat to animal or public health, the Commission may, as a precautionary measure, prohibit the direct or indirect importation of animals from a third country (or from part of its territory), or subject it to special conditions. Veterinary experts from the Commission, in conjunction with the competent authorities, shall verify that the inspection posts and quarantine stations satisfy the approval requirements.

CERVA (Veterinary and Agrochemical Research Centre)

It is a Belgian federal scientific institute, administratively linked to the federal public service health, food chain safety and environment (SPF). It is under the supervision of the Minister of Small and Medium Enterprises, Traders, Agriculture and Scientific Policy. It is the Belgian National Reference laboratory for the identification of:

- <u>epizootic and enzootic pathogens</u> listed by the World Animal Health Organization (OIE)
- transmissible diseases leading to sanitary measures by AFSCA
- zoonotic organisms that are a danger for human

Within the CERVA you can find the following operational directorates offering services and doing research in the field of animal virology:

1) <u>Interactions and Surveillance:</u> it includes the unit of electron microscopy (diagnostic via EM), the unit of epidemiology and risk analysis (it collaborates with AFSCA and SPF, it ensures the coordination of diagnostic tests between laboratories, the economical evaluation of existing or future surveillance programs, the follow-up of existing or future control programs).
2) <u>Viral diseases:</u> it includes the unit of vesicular and exotic diseases (foot and mouth disease, vesicular swine disease, vesicular stomatitis, bluetongue, goat and sheep pox, lumpy skin disease), the unit of enzootic and re-emergent or emergent viral diseases (bovine leucosis, IBR, peste des petits ruminants, Aujeszky, classical swine fever, African swine fever, African horse sickness), avian virology (Newcastle, avian influenza, west Nile).

AFSCA

It is a Federal organism and it is an executive body uncharged of the inspection and control within the agricultural and food sector. Its task is to guarantee the safety of the food chain for public health, and to protect human, animal and plant health. It is responsible for risk evaluation, management and communication. This is done via controls, analyses and expertise of food, tracing primary compounds of foodstuffs, and communication.
The Agency relies on the opinion of an advisory body (representative of the AFSCA, of public authorities, business associations, animal protection associations…) and a scientific committee (members of university and research centers). The scientific committee is in charge of risk assessment.
To make the controls, AFSCA relies on provincial control units (11 PCU).
The results of the controls are the object of annual reports and reports to the EU.

University laboratories of Animal Virology (ULg and UGent)

Already after the initial overview of the epidemiological system of surveillance for infectious diseases, some points of contrasts were pointed out between the two main surveillance systems, the one concerning human health and the other one related to animals health and food chain security issues. In human health, the federalization of the health prevention responsibilities led to the development of a fragmented system. The three regions kept the same logic of notification (via GP's or laboratories) but the Region of Bruxelles-Capital and the Vlaamse Gemeenschap developed a new specific legal frame. In the northern part of the country, the authorities have developed their own legal frame, coordinated through an autonomous agency, with the support of a network of laboratories. They seem to succeed enrolling the GP's in their virtual network for the declaration of emerging health issues. In the southern part of the country, the original legal frame (drafted in 1971) has not been revalidated and still organizes the network for the transfer of information in the surveillance system. The ISP (federal institution) still plays a central role here, together with the network of laboratory systems while the enrolment of the GP seems to be quite limited. These networks (and the one of Bruxelles-Capital) are organized differently but present all a logic of precaution: they are open to observe emerging health issues, even under uncertainty, as long as there is a probability of large epidemic hazard. It means that the list of diseases to be declared is not closed in the legal frame. The surveillance system organized around animal health issues is still structured at the federal level, with a thoroughly developed administrative structure for the transfer of information covering the whole Belgian territory (through the provincial units), while CERVA plays an unique role as reference laboratory for zoonoses. The importance of rules adopted by the European Union contributes to the development of a still more rational organization of the surveillance system, AFSCA playing here a central role in terms of coordinating information and the network of associated actors (while the SPF Santé Publique, Sécurité de la Chaîne alimentaire et Environnement is in charge of organizing the legal frame). There is less space for open or uncertain "emerging" issues in this legal frame: all lists are closed and only in the frame of "exotic diseases" does the legal frame provide some space to organize epidemiological research in order to search for vectors of the disease. The differences between these two types of surveillance networks do not preclude the possibility of common activities in term risk management, as well as exchanges of information and expertise. The effectiveness of such shared practices has been investigated together with other topics in the course of the online Delphi questionnaire.

Delphi questionnaire

From the social sciences perspective, the goal of the Delphi questionnaire applied to VIRORISK was to:

1. Fine-tune the risk analysis methodology in the field of the potential risk of emergence, re-emergence and increased incidence of viral diseases in the context of global changes.
2. Identify key aspects for a better functioning of surveillance, control and mitigation of risk occurrence policies (SWOT analysis).
3. Reduce the systemic vulnerability to the potential risk of emergence, re-emergence and increased incidence of viral diseases in the context of global change by focusing on a methodology of vulnerability analysis in addition to risk analysis.

The respondents were selected because of knowledge ability and belonging to the range of institutions related to the targeted issue. 64 experts were invited to participate, coming from Universities, BELSPO, ITM, ECDC, ISP, CERVA, AFSCA, SPF, ITG, and 12 general practitioners.

The Delphi focussed on a series of questions about the relevance and feasibility of the approach/methodology designed in the course of the VIRORISK project. This **methodology** is not specific to any region or to the target of the risks (human health and animal health – zoonotic dimension). It combines **5 steps**.

1. Establish an **open list of viral diseases** which represent a potential risk for human or animal health under the effects of global changes. Diseases are categorised depending on the type of potential risk: emergence, re-emergence or increased incidence in Belgium.
2. Establish a **hierarchy between risks** based on their evaluation (risk ranking).
3. **Prioritise the risks** with regard to the need for public action.
4. Analyse the **vulnerability of the system**: identify the internal and external factors of vulnerability as well as the barriers to increase the robustness and the resilience of the system.
5. Address the quality of the **communication**

The questionnaires aimed at pre-evaluating the proposed methodology including a new approach developed in France and promoted in Belgium (MoSS, Monitoring and Surveillance System) - using relevance – usefulness of the added information - feasibility – strengths, weaknesses, opportunities and threats - criteria.

The items of the first questionnaire are derived from the normative framework (report) and some experts' comments. The second questionnaire explores the main results from the first round.

Delphi: 1st round and its results

Question 1. Has the proposed methodology a formal existence today?
The answers are not convergent.
The approach is applied by some institutions (WHO, ECDC, ISP, DG2 SPF).
The approach is formal for lack of implementation.
Its inadequacy varies with the institutions and the level of territorial competency.
The approach is partially implemented (steps 1 to 3).
The methodology might be useful if clarified and applied.
The ISP is a potential key actor to promote the methodology.

Question 2. Considering the steps which actually exist, how do you evaluate the quality of their implementation?
Most respondents are critical about the conditions of the actual implementation of the steps actually implemented with regard to their effectiveness.
Major drawbacks:

- The **complexity** of the system (a hindrance for communication)
- Lack of **coordination**, too many measures and approaches
- Lack of **foresight**,
- **Under-evaluation** of human health problems,
- The difficulty of **updating**,
- The ignorance of **public perception** at the stage of prioritization:

Some respondents underline the smooth functioning of the system and more specifically for animal health thanks to a good collaboration between ISP, CERVA, veterinarians and universities.

Question 3. The usefulness of the proposed approach?
For 21 subjects, the approach is useful.
1 subject: it exists.
The steps to be developed are:

- Risk hierarchyzation,
- Vulnerability analysis
- Communication.

The benefits should be:

- A better coordination between actors,
- A better role definition,
- Harmonization,
- A better communication
- A decision-making process resulting in outputs which are at the same time global (transversal) and updated (at the difference with decisions taken in emergency).

The conditions of an effective implementation of the methodology:

- The agreement of all the competent actors,
- The involvement of the main partners – the actual system is very complex-,
- Resources to collect and distribute updated information.

Question 4. In what way the approach might be useful for the decision-maker?
Respondents are invited to select the propositions with which they agree:

- More effective choices to mitigate a specific risk. More effective choices to reduce the system vulnerability,
- More efficient choices (make more with the same resources).

-Risk management taking into consideration the long term and the complexity of the problem for human health.

-Risk management taking into consideration the long term and the complexity of the problem for animal health (zoonotic dimension).

-Greater concern for more fairness for the groups at risk.

The first three propositions are agreed on by a majority of subjects

For some respondents, the goal is not risk specific.

For some respondents, the issue is the vulnerability of the system and a decision founded on a scientific, logical and independent basis.

Question 5. How feasible is the proposed approach given the actual the institutional setting and resources?

Two respondents consider the approach as an utopia.

The answers of the other subjects are not clearcut: yes but if… No, except if….

- The actors are coordinated, even substituted;
- ISP acts as coordinator;
- Human health is modelled after animal health, and on the KCE in the role of facilitator of a contradictory procedure;
- More likely in Flanders than in Wallonia for the prioritization step.

The means:

- They do not match the needs of the approach.
- Two respondents: one can make more with the means we have.
- One suggestion: bringing ISP and CERVA closer.

Question 6. Does the list of diseases to be reported… fits the actual needs in Belgium?

The list differs from region to region.

This difference is rated positively – contextualization- or negatively – "what is the meaning of the regional boundary"?

The openness of the list seems to be irrelevant (except for one expert)

The relevance of a list of **diseases** to be notified versus a list of **risk indicators** is not discussed (the issue is on the scientific agenda)

The effectiveness of the principle of a mandatory list of diseases to be reported is questioned because of the bad performance of the reporting system.

Question 7. What are the relevant criteria to include or exclude diseases in/out of the list?

Many criteria are quoted.

Respondents focusing on human health mobilize inclusion criteria such as:

- The severity of health effects
- The potential epidemic evolution

Respondents from the animal health sector:

- The economical impact, strongly related to the epidemic potential.

Pragmatic indicators for inclusion are mobilized:

-Existence of vaccines;

-Existence of treatment action (human health);

-Ease of detection by the cattle breeders themselves.

Are excluded diseases causing mild effects, prevalent diseases (human health) and low economic impact diseases (animal health).

Question 8. Criteria for risk ranking ?

The same (see criteria for inclusion)

Question 9. Criteria for prioritization
The ranking – and the weighing – of the criteria vary.
The individual consequences as well as the public health impact are prevalent
The difference between ranking and prioritization is unclear for one respondent.
For another one, prioritization is unrealistic considering the importance held by the political context.

Question 10 What strategy for prioritization (deciding for or against a public intervention): a sequential risk ranking or simultaneous/comparative risk ranking
A majority of respondents stand for a comparative strategy (more objective).
Three respondents suggest a combination of both strategies. First, a comparative approach and secondly, a focus on the risk on the agenda ("risk of the month").

Questions 11. Did the lessons learnt from recent sanitary crises developed sensitivity to the vulnerability of the system?
The answers do not converge.
Some experts are positive.
Other experts are sceptical about the learning itself…
Time is needed to adopt new practices.
No detailed plan can achieve this task.
For one respondent, a specific risk is identified accidentally and its management is reactive.

Question 12. How do you evaluate the quality of the information circulation?
Several respondents point at the misrepresentation of the communication schemes.
The communication circulates better from the ISP to the communities than the reverse.
The reporting from GP and veterinarians to the public actors is qualified as unsatisfactory.
The effectiveness of the sentinel GP network is noted.
One respondent mentions the need to diversify the sources of information for better effectiveness.
For another respondent, the causes of a bad communication stem from individuals and a lack of organizational flexibility.

Question 13. A bad performance of the reporting system?
Numerous causes of the bad performance of the human health sector and to a lesser degree of the animal health sector are evoked:
- Culture;
- Role expectations of the GP/veterinarian do not include acting on behalf of public health;
- Lack of knowledge among GP about infectious diseases and lack of information about emergent diseases;
- Reporting is a complicated, time consuming and unrewarding task for GP;
- In the specific case of the veterinarian, his relationship with the cattle breeder is strongly biased by economic considerations (much to loose if reports);
- AFSA fails to legitimate the reporting system as a tool of detection/surveillance because of a negative perception of this institution by cattle breeders (control, sanction, economical threat).

Question 15. Would it be useful to inform GP about risk factors?
In the whole, yes.
It depends on the channels of communication

Question 16. The usefulness of a system like the MoSS?
The results are not clearcut.
Yes if used.

Drawbacks:

-Risk of redundancy with the mandatory reporting system;

- For animal health, the same obstacle – economical link- between the veterinarian and the cattle breeder;

- Limits of the syndromic surveillance;

- The feasibility of the focus on « atypical cases"?

Question 17. What incentives to participate to a system like the MoSS?

A feedback to GP (information);
A financial compensation;
Software resources.

<u>Delphi: 2nd round and its results</u>

Question 1. Answers to the first round suggest a twofold need: an internal need in the human health and animal health systems for more coordination and transparency (who makes what?) and a need for bridging both systems. Do you agree? Comments?

On the whole, respondents agree on the need to reinforce the link between both systems, to strengthen collaboration beyond the scientific domain.

Suggestions:

-Work on the individual motivations inside each system;

-Give the ISP a central role with an opening to actors who are not only medical doctors or epidemiologists, to CSS and to the Scientific Committee of AFSCA;

- Take example on the ANSES project of a permanent platform of epidemiologic surveillance (benchmarking).

Question 2. Who should be in charge with coordination?

Internal coordination

-Human health: ISP
-Animal health: AFSCA
-Zoonotic dimension: ISP and AFSCA

Coordination between both systems

-CERVA-ISP-AFSCA
-ISP merged with KCE
-ISP with CERVA
-Monitoring by health (hygiene) inspectors

Question 3. Some suggestions to override the difference between concerns – health effects and economical impact – ruling each of the systems- to facilitate the « working together"?

-Increase the human and financial resources to collect field data;
-Mixed groups;
-Information;
-Coordination.

Question 4. Respondents provided different explanations and suggestions to solve the bad performance of the reporting system (GP). (See question 1st round).
Proposal 1. Privilegiate the sentinel network system (versus the GP reporting system) or Proposal 2. Mobilize the GP and veterinarians?

-Develop and motivate the sentinel network;
-Involve hospitals;
-Provide a targeted but simple information in a continuous way;
-The reporting system is useless;
-Focus on pathogenic agents rather than on clinical aspects;

-Use slaughterhouse data;
-Take example on performing networks as CDC, PUlSNET or inf@ct

Question 5. For some experts, the detection and surveillance system is more effective in animal health than in human health. Do you agree or not? Why?

Agree

-The economical stakes and the media pressure are very high in animal health, especially when animal health has an impact on food safety;

-The medical secrecy and the lack of attention to the economical impact of individual health;

-Veterinarian data are collected on a great number of cases;

-Cases are very visible in cattle farms;

-Effectiveness of the veterinarian epidemiological surveillance network.

Disagree

- The relationship between the GP and the patient is not economically biased
- GP are eager to ask laboratory confirmation of suspected cases.

Question 6. Effectiveness of the (open) mandatory list of reportable diseases (option 1) versus an information of GP and veterinarians about potential risk indicators (option 2)?

-Two subjects stand for option 2;
-One subject: option 2 is not feasible;
-Three subjects suggest combining both options.

Question 7. Should international cooperation be further developed?

-Yes for mutual learning;
-Yes in a context of global change;
-No (ECDC and EFSA perform well).

C. Risk assessment

Risk factors having an influence on the emergence, re-emergence or increased incidence of viral diseases:

- **Climate changes** can have an influence on:
  - The resistance of the virus in the environment (water, ground, biological material, fomites..) (for example: influenza virus and norovirus resistance in the water in function of water T°)
  - The migration patterns of birds and wildlife, possible intermediate viral hosts (for example: bird migration for influenza virus, West Nile virus; rodents concentration for hantavirus)
  - The vector population (T°, humidity, wind, etc). (arthropods, including ticks and mosquitoes). An indigenous vector can increase its geographic spread and increase the viral distribution and the risk for the population; an exogenous vector once introduced in Belgium can encounter favorable climatic conditions and become persistent. (increased winter temperature=reduced or absent vector-free period; dry and wet alternated periods=increased mosquito's proliferation; more frequent sweet temperatures=increased temporal tick activity)
  - The landscape (more humid or drier areas with an impact on the virus resistance on the environment or on vectors and vertebrate being possible viral hosts).
  - The human activities (ecological disasters can cause increased human emigrations, local reduced hygienic conditions, concentration of people in restricted areas). Increased risk for respiratory and digestive viral infections.

The role of climate change on human and animal health has been investigated by the project AGORA "MCS". The role of climate change has been studied towards bacterial and parasitic agents of food and water-borne diseases (Brits et al., 2010). No viral agents have been included within this category, while it is assumed the influence of water temperature and UV radiation on the survival of viral food-borne pathogens such as norovirus, hepatitis A and E virus, and rotavirus.

- **Human activities**:
  - Modification of the landscape via urbanization, changes in the agricultural practices (can influence wildlife habitats and natural equilibrium between species, with opportunistic or exotic species increasing and indigenous or endangered species decreasing) (this can influence the emergence of re-emergence of viral diseases).
  - Human international movements (depending on the destination and on the reasons of the movements, we can identify different type of risks) (For business, tourism: to which countries and to which part of the country? (coast, forests, cities…), immigration: from which countries? (higher risk for workers in direct contact with immigrant and refugees), human help (higher risk for medical and para-medical personnel), military help, political refugees.
  - Human habits (for example the consumption of row or not sufficiently cooked meat, fish, consumption of not pasteurized milk (risk of tick-borne encephalitis); the frequency of wildlife contacts (for tick-borne encephalitis); religion practices with higher exposure; waste management)
  - Occupational risks
- **Human demography** (this has an influence on directly transmitted viral diseases).
- **Trade** can represent a risk for the introduction of novel viruses:
  - Plant trade: introduction of viral vectors
  - Animal trade (mammalian, birds, reptiles, amphibians, fish) (pets and exotic) (for example: birds infected with influenza virus; prairie dogs and Monkeypox virus human infections in USA, viraemic ruminants for bluetongue virus; zebra's for African horse sickness virus; import of fish in infected water;
  - Animal products (milk, milk derivatives, meat, fish products, eggs…..)
  - Illegal trade
  - Postes d'inspection frontalière (PIF): airports, ports, roads, rails.
- **Virus genetic mutations** can influence:
  - The virulence
  - The host spectrum (for example influenza virus, SARS, Chykungunya virus, etc).
- **Laboratory manipulation** of exotic viral pathogens
  - Involuntary accident
  - Voluntary accident
  - Bioterrorism
- Emergence of viral disease and/or risk factors in a neighbouring country = **sanitary conditions of the neighbouring countries** (geographic proximity, movements can influence the emergence in Belgium) (for example: West-Nile virus in France, BTV-1 in France, BTV-11 in The Netherlands, Equine infectious anemia from Romania, *Aedes albopictu*s in The Netherlands, sylvatic rabies in Italy, etc)
- **Efficiency of the public health institutions** in the prevention of the viral pathogen, its identification, its control, its eradication.

Although making a list of hazards was not the most suitable working methodology, Tables 1, 2 and 3 allowed formulating several considerations concerning the category of diseases which will represent in the future a risk for public and animal health.

Vector-borne viruses are emerging pathogens, and several factors are increasing the risk of their emergence in Belgium and in Europe: **climate change** (migration patterns of birds and wildlife, vector population, landscape), **human activities** (landscape, human international movements), **trade**, **virus genetic mutations**.

For **mammalian-borne viruses** the following risk factors can influence their emergence, re-emergence and increased incidence: **climate change** (migration patterns of birds and wildlife, landscape), **human activities** (landscape, human international movements, human habits, occupational risks), **trade**, **virus genetic mutations**.

For **directly transmitted viruses**, their increased incidence can be influenced by the following factors: **climate change** (resistance of the virus in the environment, migration patterns of birds and wildlife, human activities), **human activities** (human habits, occupational risks), **human demography, trade**, **virus genetic mutations**.

D. Risk management

Control measures against viral diseases

The control measures against viral diseases are mainly organized by the Scientific Institute of Public Health in coordination with other institutions such as the CERVA and the AFSCA in case of zoonotic pathogens, or the Institute of Tropical Medicine for tropical infectious diseases. For example, in Belgium the detection of human hantavirus is based on a collaboration between the Belgian Sentinel Laboratory Network (ISP) and the National Reference Laboratory (Queen Astrid Military Hospital, Brussels). A specific disease surveillance network exists in Europe (ECDC) and it is based on the collaboration of the different European Reference centers. The control measures include the control of the rodent population, information campaigns in endemic areas to reduce human activities at risk. Another example is represented by influenza virus, towards which a weekly surveillance of seasonal influenza exists in Belgium and is based on a clinical surveillance (National Reference Laboratory, ISP) and a virological surveillance in patients with influenza-like symptoms (ISP). A European Influenza Surveillance Network (EISN) directed by ECDC ensures the exchange of information among the European member States during the epidemic period. The surveillance of avian influenza in birds is anterior to the emergence of H5N1, but the appearance of this virus in Europe improved the network of surveillance between CERVA, AFSCA and ISP and it involved passive surveillance of dead birds, active wild birds. Surveillance and increased serological surveillance in poultry, exclusion diagnosis in poultry flocks with abnormal symptoms. Control measures were also defined, in order to reduce any contact between domestic and wild birds, strict regulation in case of bird expositions or markets, definition of high risk areas (close to natural birds reservoir). Considering the zoonotic potential of the highly pathogenic avian influenza H5N1, and the WHO declaration of a pandemic alert phase 3, in Belgium since December 2005, an emergency procedure was applied:

- sampling kits and procedures sent to clinical biological laboratories
- informative letters to physicians
- severe acute respiratory illness and presence of risk situations (travel in endemic regions, contact with poultry or consumption of uncooked poultry product)

In case of H1N1, the control measures applied in Belgium included:

- EU countries recommended simple public health measures of respiratory hygiene, handwashing (no mask wearing recommendation)
- international movements to and from infected countries: informative documents
- antiviral treatment (differences among EU countries)
- monovalent vaccine
- common EU policy for vaccination of categories at risk;
- each EU country adopted own strategies for the rest of the population

In the post-pandemic phase, an active surveillance of H1N1 has been set-up in domestic pigs, with evidences of the circulation of this human virus within the pig population. Nevertheless, the H1N1 study case stays an example of respiratory human to human transmission virus, without presence of an animal reservoir.

For food-borne viral diseases or viruses with an oro-faecal route of transmission, a well established surveillance networks exists in Belgium, and it involves the service food borne pathogens within the OD-CID of the Scientific Institute for Public Health, the AFSCA, microbiology laboratories, and university research laboratories.

Control measures against arthropod vectors

By implementing control measures against arthropod vectors it is possible to manage their population and reduce their damage to human and animal health. A distinction should be made between the control of native and invasive species however. Native species that pose a threat are impossible to eliminate as they are usually too widespread. Moreover their role in the ecosystems/ food chain cannot be underestimated. Local control measures can be used to control population size. Invasive species on the other hand generally have negative effects on local ecosystems and, if an invasive population is discovered in time before the species had the opportunity to establish itself, elimination, although sometimes difficult, should be a priority.

As mosquitoes and other insects can pose a severe public health threat and cause great nuisance, several techniques have been developed to control populations:

1) Preventive measures (mainly applied to invasive species)

Since 1992, several countries in South America have dictated embargoes on used tire importations in an attempt to prevent the introduction of mosquitoes and particularly infected mosquitoes into areas where a potential vector, *Ae. aegypti*, is already present (Eritja et al., 2005). Quarantine and inspection measures in Australia have allowed detection of larval introductions of *Ae. albopictus* and thanks to the application of immediate control measures, it has not yet become established on this continent (Eritja et al., 2005). As mentioned before, an inventory of used tire depots in Belgium would be very useful, including information on the origin of the tires. If tires are being imported from high risk areas like China or Italy, measures should be implemented (embargo, treatment of containers).

Also regular surveillance on introduction pathways like tire depots, container terminals and sea ports should be set up. France, the Netherlands and Germany have implemented regular surveillance in certain regions specifically focussed on the detection of *Ae. albopictus* (ECDC, 2009a). Also in the Netherlands some horticultural companies have tried to reduce the risk, for instance, by treating shipments before leaving China (Enserink, 2008) or spraying chemical insecticides in greenhouses where lucky bamboo is stored (Scholte et al., 2008).

2) Physical control

Eliminating unnecessary water sources like emptying flower pots, covering rainwater containers and swimming pools, regularly refreshing bird baths and pet dishes, clearing roof drains and gutters and so on will reduce the number of breeding sites and keep mosquito populations low locally. Removal of manure on farms, which is an important component of the breeding site of several *Culicoides* species, should drastically reduce populations as well. Through water management, like encouraging water flow or deepening semi-permanent water bodies, breeding habitats can be modified to discourage breeding and allow better access to predators feeding on larvae. Mosquitoes or midges can also be caught with traps. Several different designs and mechanisms exist with ranging efficiencies (Collier et al., 2006; Meeraus et al., 2008). Overall mass trapping has failed to prove a significant reduction of mosquito numbers however (Smith et al., 2010), making it more suitable for monitoring purposes rather than as a control measure. Physical control methods also include reducing human-mosquito contact by wearing covering clothes, using (impregnated) bed nets and insect repellents, and excluding mosquitoes from entering buildings by using screens in windows and doors.

3) Chemical control

Application of insecticides continues to be one of the main control methods against vectors worldwide. Many types of insecticides are currently used to control these vectors, belonging to 4 major chemical groups: chlorinated hydrocarbons, organophosphates, carbamates and pyrethroids (Becker et al., 2003). However, extensive insecticide use has enabled the development of insecticide resistance, which is nowadays a global problem. Resistance monitoring should be an integral part of any mosquito control programme. The susceptibility of mosquitoes should be verified before the start of control operations, to provide baseline data for insecticide selection and choice of technique to be applied (Becker et al., 2003).

Another method used against larval stages since the early 1980's is monomolecular films (MMF) such as alcohol-ethoxylated surfactants. A major concern of pesticide use is the environmental contamination and impact on non-target organisms, conducting legislators to limit or prohibit the use of specific pesticides (Dorta et al., 1993). Despite the notable successes of chemical control, many control programmes were not sustainable in the long term due to many reasons, including insecticide resistance, re-invasion, environmental damage and poor control program implementation (Becker et al., 2003). However some highly specialized organizations approved and supported by the local and national authorities are very successful in controlling nuisance, invasive vectors, and outbreaks of arboviruses. This is mainly the case in France and Germany were specialised institutions concentrate their effort mainly on larval control either through physical methods such as management of wetland or by using larvicides (microbial control agents or chemical compounds) (Becker et al., 2003; Fontenille et al., 2009).

4) Biological control and bio-insecticides

Biological control is defined as the reduction of the target population by the use of predators, parasites, pathogens, competitors or toxins from microorganisms (Woodring & Davidson, 1996). Biological control also aims to avoid side-effects to the ecosystem like maintaining biodiversity and avoiding (eco)toxicological effects (Becker et al., 2003). A prerequisite for the successful use of predators, parasites or pathogens is a precise knowledge of the biology of the antagonist and its interaction with the ecosystem. For example, the introduction of foreign predators risks damaging or displacing non-target populations. Mosquitoes inhabit very different habitats, and have developed various life strategies by adapting to habitats with very different abiotic and biotic conditions. Antagonists can only successfully reduce a target population if their own life strategy is adapted to the target population (Becker et al., 2003).

As the use of predators such as fish is often dependant on specific ecological criteria, efforts have led to the use of a variety of pathogens over the past decades (Davidson & Becker, 1996). Especially the bacterium *Bacillus thuringiensis israelensis* (Bti) has become one of the most widely used bio-insecticides in mosquito control programs. Bti is able to produce specific insecticidal toxins during sporulation, which are highly toxic to insects such as mosquitoes and blackfly larvae. The use of Bti based insecticides in pest control programs is now considered as a viable strategy, which has proven to be both safe and reliable over the last decades (Nester et al., 2002).

5) Sterile insect technique and genetic manipulation

The Sterile Insect Technique (SIT) uses the mass release of sterile insects as a highly effective area-wide, environmentally safe method of pest control. There has been a recent attempt to develop SIT against *Ae. albopictus* in Italy (Bellini et al., 2007). In this trial a method was developed to mass rear the insects to achieve a release rate of 100-1000 sterile males per hectare per week. They used irradiation to sterilize the mosquitoes and showed a significant decrease (about 36%) in the number of viable eggs in the release area compared to the control area, although only one treated and one control area were used and no data is given for previous numbers or population trends of mosquitoes at these sites.

6) Integrated management

The most successful approach for dealing with a potentially dangerous vector population is when an integrated control strategy is implemented, in which all appropriate technological and management techniques are used, to bring about an effective decline of target populations in a cost-effective manner. With the development and successful use of powerful chemical insecticides like DDT, most control programs after WWII were based on the sole use of these insecticides. However, the onset of resistance against these products and the increasing environmental and public health concerns, led to a more integrated approach involving environmentally safe measures which may also be more effective in the long run. For example, a strategy applied by several countries to respond to invasive species is to set up a monitoring system at high risk locations like highways, ports and tire depots and spray the surrounding area within a certain perimeter with insecticides as soon as an invasive species is detected. Stagnant water in the area can then be treated with larvicides and Bti, and the local public can be advised to remove all unnecessary stagnant water in their gardens and to use insect repellents.

So far, three invasive species have been detected in Belgium (*Ae. albopictus, Ae. japonicus* and *Ae. koreicus*). *Ae. japonicus* was first detected in Belgium in 2002 and over the last eight years it managed to establish itself due to the lack of control despite repeated information and alerts to regional and national health authorities (Versteirt et al., 2009). The same has been the case for the recent invader, *Ae. koreicus* (Versteirt et al., 2012). Besides the control of tropical vectors, Belgium did not have experience in controlling invasive species, until the recent action authorized and supported by the SPF (Federal Public Service, health, food chain safety and environment), the Flemish, French and Brussels authorities. For the first time an intervention aiming to eradicate a local population of *Ae. japonicus* established in the village of Natoye (Namur Province) has been organized and realized with the use of biocidal products active against the larvae and the adult vectors. Under the supervision of entomologists, the products have been used in an area of 5 km around the sites where the vector was used to replicate. The intervention could rely on the active participation of the local municipality, the fire brigades and the people working in the used tire depots of the village. The Ministry of the Environment gave the authorization to use the biocidal products in the context of the above action, with precise descriptions of the time, space and modalities of their application.

In Belgium, despite this recent intervention, a vector surveillance system is lacking and once a problem does occur, the decision-making process is not straightforward

- Who is responsible and has the skills for implementing the control? (Federal state, Region, communities, communes?)
- What kind of intervention should be applied in case of epidemics, prevention of epidemics, invasive species or outbreaks of nuisance?

What is the legislation regarding pesticides used for vector control in Belgium?

E. Case studies

The case studies were used to make an inventory of the existing surveillance systems and the management organization, applied to three categories of viral diseases:

- the Arthropod-borne viruses, with 3 case studies: Chikungunya virus (human disease); West Nile fever virus (zoonotic) and bluetongue virus (animal disease));
- Mammalian-borne viruses, with one case study (hantavirus);
- Directly-transmitted viruses, with 2 case studies (zoonotic (avian and swine) influenza A viruses)

Arthropod-borne viruses

Several environmental and ecological factors play a role whether an outbreak will occur or not. Only in certain circumstances will the interaction between host, vector and pathogen lead to an outbreak (Fig. 1).

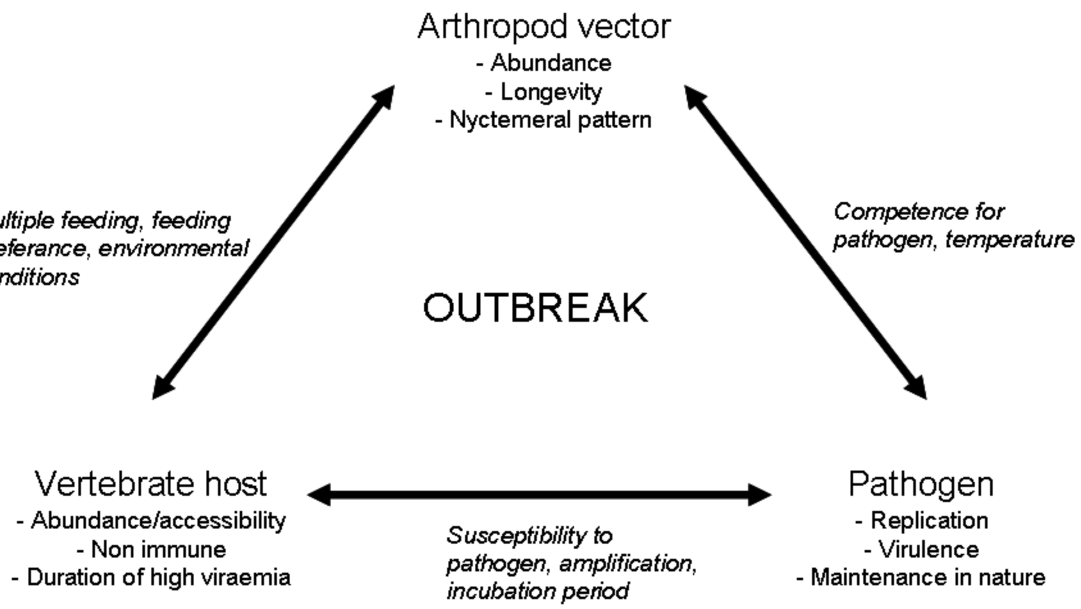

Fig. 4: Different environmental and ecological factors that interact and can lead to an outbreak.

An arthropod becomes infected with an arbovirus by feeding on blood from an infected host during viraemia, and after proliferation in the vector the virus can be transmitted to another host (horizontal transmission). In some cases, arboviruses can also be passed from one arthropod generation to another through vertical transmission (Becker et al., 2003). In mosquitoes, where only females are taking blood meals, the magnitude of this vertical transmission in one specific epidemiological setting can be assessed by the proportion of infected males.

There are between 500 and 600 known arboviruses in the world, of which about 100 may give rise to disease in humans (WHO, 2004). Arbovirus is not a taxonomic classification; the viruses belong to four different families: *Togaviridae*, *Flaviviridae*, *Bunyaviridae* and *Reoviridae*. Some of the most important known arboviruses are listed below:

- ***Togaviridae***
  - Genus *Alphavirus*: Sindbis, **Chikungunya**, O'nyong-nyong, Ross River, Ockelbo, Eastern Equine Encephalitis, Western Equine Encephalitis, Venezuelan Equine Encephalitis
- ***Flaviviridae***
  - Genus *Flavivirus*: Dengue, Japanese Encephalitis, Yellow fever, Usutu, **West Nile fever**, St Louis Encephalitis, Russian Spring Summer Encephalitis, Tick-Borne Encephalitis, Powassan, Murray Valley Encephalitis.
- ***Bunyaviridae***
  - Genus *Bunyavirus*: Tahyna, Inkoo, La Crosse
  - Genus *Nairovirus*: Crimean-Congo Haemorrhagic Fever

    - Genus *Phlebovirus*: Rift Valley Fever, Phlebotomus fever
    - Genus *Orthobunyavirus*: Akabane, Aino, Shamonda, Schmallenberg virus
- ***Reoviridae***
    - Genus *Orbivirus*: **Bluetongue**, African horse sickness

Case study 1: Chikungunya virus (CHIKV)

As first case study, CHIKV was chosen because it involves the scenario of an imported pathogen as well as invasive vectors, namely *Aedes albopictus* and *Ae. aegypti* (Fig. 5). It is a perfect example of globalisation: how an Asian mosquito infected with an African pathogen introduced by humans can cause epidemics in Europe and other continents.

Although *Ae. albopictus* has only been reported once in Belgium in 2000 (Schaffner et al., 2004), intense globalisation and transport, and expected climate changes are increasing the risk of a further spread of the vector and pathogen in Europe. *Ae. aegypti* has been reported during August 2010 in the Netherlands, but was quickly eliminated. Apart from CHIKV, *Ae. albopictus* and *Ae. aegypti* are vectors for several other arboviruses including Dengue virus and Yellow fever virus, which have a similar transmission cycle. Therefore a considerable public health risk would rise if one of these mosquitoes would become established in Belgium. Hence, it is important to continue mosquito surveillance, especially in high risk areas (ports, tire depots, green houses) and to eliminate newly introduced mosquitoes as soon as possible.

In Belgium 54 cases of chikungunya have been confirmed between 2006-2008 (38 in 2006, 9 in 2007, 7 in 2008) mainly in travellers returning from countries with recent epidemics such as Mauritius (n=17), Réunion Island (n=10), Sri Lanka (n=4), Madagascar and India (n=3 for each). As no vectors for CHIKV are currently established in Belgium, the cycle has always come to a dead end.

However it seems very likely that *Ae. albopictus* would be able to establish itself in Belgium given the high chance of repeated introduction through global transport, the climate conditions that would allow temperate strains to survive a Belgian winter and the highly adaptive ecology of this vector. Therefore, to avoid the risk of arboviral diseases like CHIKV and dengue in Belgium, it remains crucial to avoid establishment of *Ae. albopictus* and other invasive species through surveillance and early elimination campaigns.

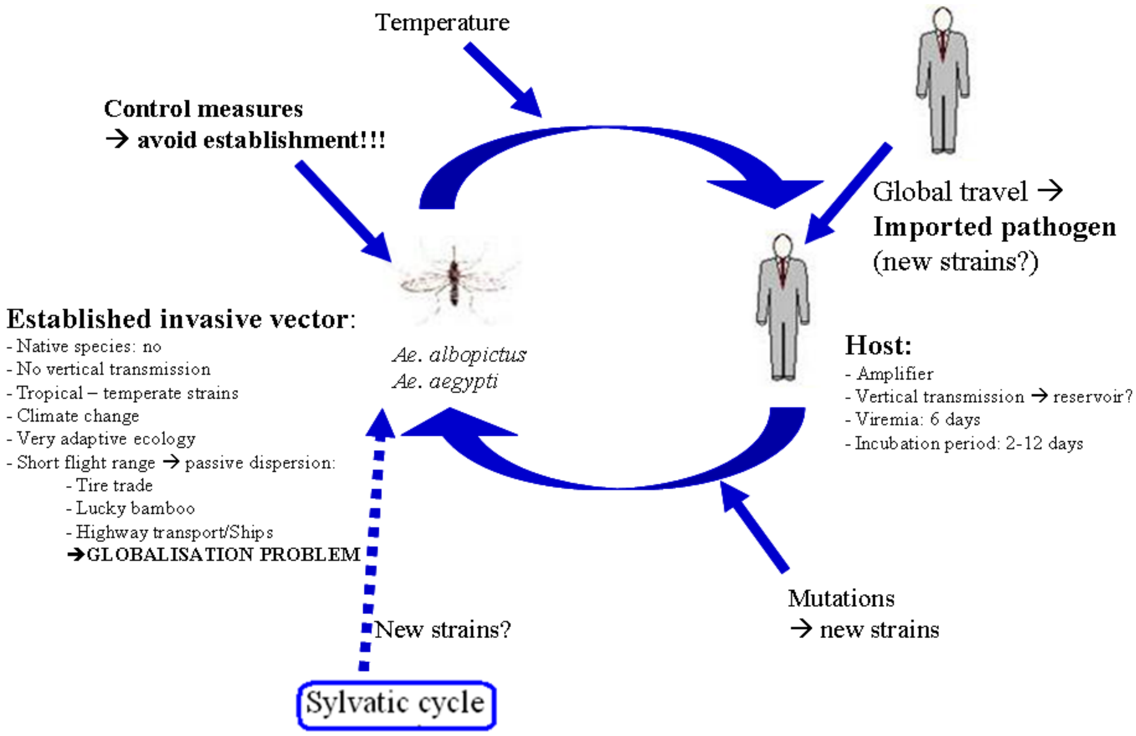

Fig. 5: The transmission cycle of Chikungunya virus in Europe, including some factors influencing the risk of an outbreak. Similar scenarios can occur for Dengue virus, Yellow Fever virus.

Case study 2: West Nile Virus (WNV)

In this case study the virus is transmitted in a natural cycle between birds and mosquitoes, while humans and other mammals are incidental and dead-end hosts (Fig. 6). As birds are the amplifying hosts, humans can only be infected by bridging vectors that are anthropophilic as well as ornithophilic. In Belgium, prime candidates as bridge vectors are the very common species *Culex pipiens* and *Coquillettidia richiardii*. WNV has been circulating in Europe for several decades and has caused outbreaks in several countries like Italy, France and Greece, causing a certain level of immunity among bird populations. However, new strains of the virus can always be imported by migratory birds and cause new outbreaks. Other arboviruses that have been detected in Europe and also circulate in between birds and mosquitoes with humans as dead-end hosts include Usutu virus and Sindbis virus.

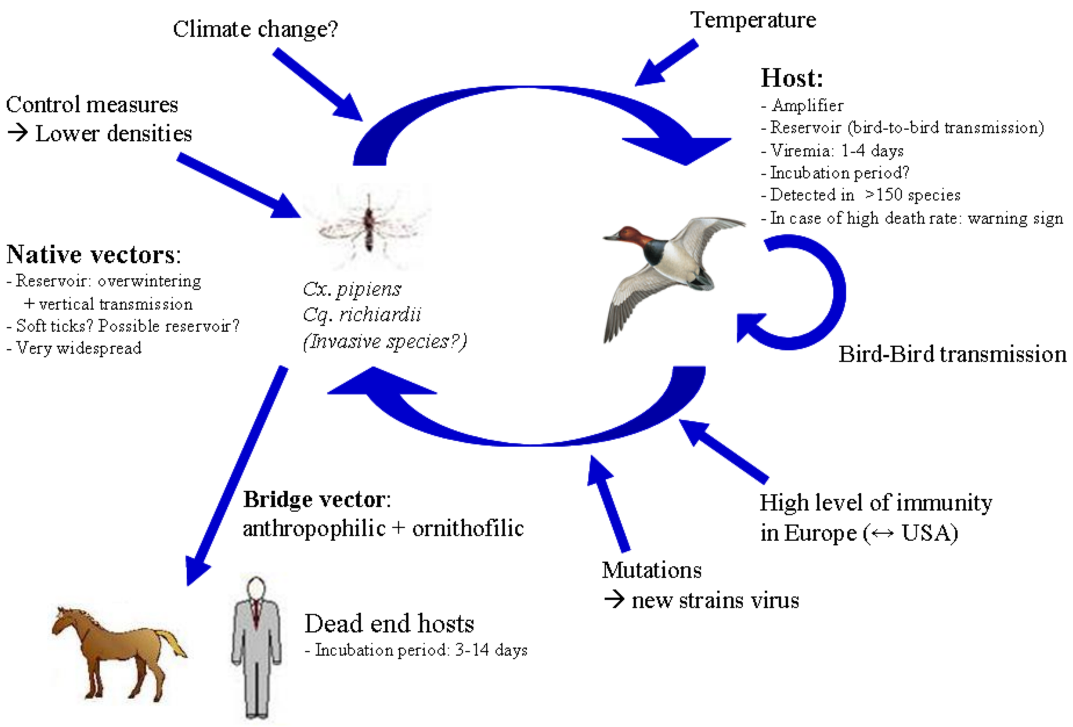

Fig. 6: The transmission cycle of West Nile Fever virus in Europe, including some factors influencing the risk of an outbreak. Similar scenarios: Sindbis virus, St. Louis Encephalitis virus, Usutu virus, Japanese Encephalitis virus

So far WNV has never been observed in Belgium. Given the re-emergence of this virus in Europe on a regular basis (ECDC, 2010), probably due to introductions by infected birds migrating from Africa, it seems unlikely that Belgium would be excluded since many of the same bird species migrate here. Moreover the most incriminated vector in European outbreaks is *Cx. pipiens*, the most common species in Belgium. Furthermore, in UK it was discovered that WNV, as well as Usutu antibodies are present in a wide range of migratory and resident birds even though the disease has never been observed either. So even if WNV might circulate amongst resident birds already and the necessary vectors are present, why have there been no outbreaks in Belgium or neighbouring countries (excluding southern France)? A plausible explanation is that a certain level of herd immunity exists against WNV among European birds. Birds become immune for life after an infection with WNV and the regular introduction of (low virulent?) strains of WNV can maintain this herd immunity, preventing major outbreaks. In the US on the other hand, WNV was introduced in a naïve bird population, which immediately lead to the start of a widespread epidemic.
As flaviviruses and especially the Japanese Encephalitis group to which WNV belongs, can show high cross immunity it might also be possible that this immunity is caused by other related flaviviruses circulating in Europe, like Usutu or other yet unidentified viruses. Recently, the overwintering of Usutu virus in indigenous mosquitoes has been reported in Germany (ProMED-mail post 20120425.1114006).

Case study 3: Bluetongue and Schmallenberg viruses

The final case study on arthropod-borne diseases focuses on Bluetongue (Fig. 7), a disease that does not affect humans but has unexpectedly caused massive outbreaks among livestock in Belgium. It is an interesting example on how the pathogen of an imported infected animal gets picked up by native vectors (*Culicoides*) and is quickly spread over several countries. The massive economic loss as a result of the epizootic shows how important it is to be prepared for potential arbovirus outbreaks. Other examples of epizootic arboviruses are African horse sickness virus (also spread by *Culicoides*), African swine fever virus (spread by ticks) and the viruses of the *Bunyaviridae* family, genus *Orthobunyavirus* (Akabane, Aino, Shamonda, Schmallenberg virus) (also spread by *Culicoides*).

The massive economic loss as a result of the BTV epizootic that unexpectedly arrived in Belgium and neighbouring countries shows how important it is to be prepared for potential arbovirus outbreaks. For BTV-8 a vaccine became available in a relatively short period. Since May 2008 until 2010 all sheep and cattle, including bisons and buffaloes, were obliged to be vaccinated against BTV-8 in Belgium. For goats, deer and other ruminants vaccination was voluntary. This vaccination plan was approved by the European Commission (EC) along with plans in Austria, Czech Republic, Denmark, Germany, Spain, France, Italy, Luxemburg, the Netherlands, Portugal and Sweden. The EC introduced the obligation for the Member States to carry out bluetongue monitoring programs in the restricted zones and surveillance programs outside the restricted zones. In Belgium AFSCA is responsible for the organization of the cross-sectional monitoring projects to evaluate the prevalence of BTV-8, the efficiency of the vaccination campaign and of the eradication program. However, livestock is not protected against other BTV serotypes that circulate in Europe, so risk of outbreaks due to new strains remains a possibility.

The emergence of Schmallenberg virus (SBV) in the winter of 2011, represents a major event in animal health and is a new challenge for European veterinarians and researchers. The main clinical signs in adult cattle are fever and a significant drop of milk yield for several days, in some cases also diarrhoea and abortions. A congenital arthrogyposis/ hydranencephaly syndrome is also described in lambs, kids and calves. The infection is considered as non contagious, most likely propagated among ruminants by biting midges of the genus *Culicoides*. Clinical cases were reported in adult cattle in Germany and the Netherlands since summer 2011, and congenital affections with SBV detection since December, first from Germany, the Netherlands and Belgium, then UK and France, and later from Italy, Luxembourg and Spain. It is remarkable that both SBV and BTV-8 emerged in the same geographic area in naives ruminants, and that they shared the main transmission pattern (vectors of the *Culicoides* genus). The BTV-8 emergence represented an example in terms of control measures to be applied in case of animal non-contagious diseases. Nevertheless, at present no vaccine is available against SBV, and no compulsory notification of the disease exists in Belgium and in Europe (due to the absent – very low zoonotic risk and the low morbidity and mortality rates in ruminants). EFSA in a recent scientific report (EFSA, 2012) encouraged to continue the surveillance of SBV in affected countries and regions neighbouring affected areas, within herd and animal level impact investigation, monitoring putative vector population, setting SBV host vector transmission parameters, investigating other routes of transmission, host susceptibility, virulence and vulnerable period during gestation. Furthermore, the possible origins of the virus should be investigated as more information becomes available on the virus characteristics and infection epidemiology.

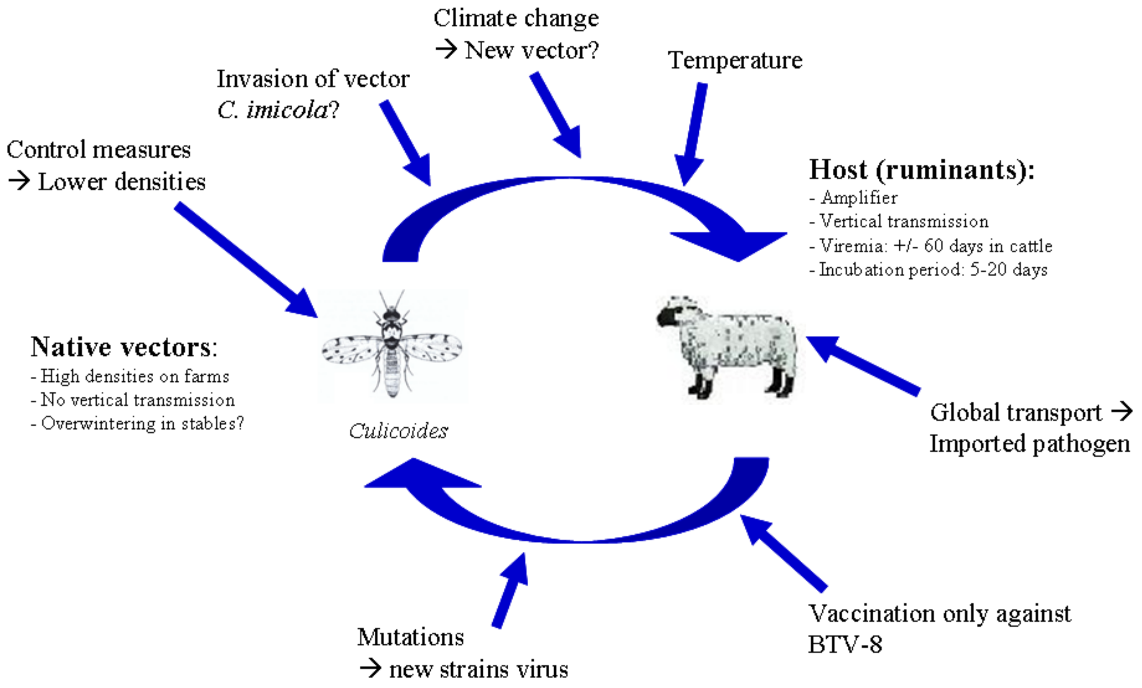

Fig. 7: The transmission cycle of Bluetongue virus in Belgium including some factors influencing the risk of an outbreak. Similar scenarios possible for African horse sickness virus, African swine fever virus (transmitted by ticks), Schmallenberg virus.

Mammalian-borne viruses

Hantaviruses are worldwide emerging haemorrhagic fever viruses. They belong to the family *Bunyaviridae* and at present 40 different serotypes have been identified. Their natural reservoir is represented by wild rodent and their transmission to human is mainly via aerosolized excreta of chronically infected rodents. Eurasian viruses cause hemorrhagic fever with renal syndrome (low mortality) (HFRS) (in Asia: Hantaan, Amur, Seoul, Thailand virus and in Europe: Puumala, Dobrava, Seoul, Tula virus). American viruses cause cardio-pulmonary syndrome (high mortality) (HPS) (Sin Nombre and Andes virus). The hantavirus distribution is influenced by rodent reservoirs distribution and the human hantavirus incidence is conditioned by multiple factors, such as climate and environmental conditions (conditioning the abundance of food for the rodents as well as the rodent geographic distribution), human activities (outdoor activities, hunting, intensity of human-wildlife contacts), season, virus virulence.

In Belgium: 2 serotypes (Puumala and Tula virus) have been identified with an increasing number of human cases per year since 2005. In Belgium the detection of human hantavirus is based on a collaboration between the Belgian Sentinel Laboratory Network (ISP) and the National Reference Laboratory (Queen Astrid Military Hospital, Brussels). A specific disease surveillance network exists in Europe (ECDC) and it is based on the collaboration of the different European Reference centers. The control measures include the control of the rodent population, information campaigns in endemic areas to reduce human activities at risk.

Directly transmitted viruses

Most influenza A viruses circulate naturally as constantly evolving RNA-based avian influenza viruses among flocks of wild birds, especially ducks and waders. Some of these viruses have crossed species barriers and have become established in mammals, notably in humans (human influenza viruses) and pigs (swine influenza viruses). Between the influenza pandemics in Europe there are annual epidemics, usually occurring each autumn/winter season, caused by a changing mix of influenza A and B viruses of varying severity depending on that year's strains. The human to human transmission of the seasonal influenza is influenced by the movements of infected persons, the public health measures of respiratory hygiene and handwashing. In Belgium a weekly surveillance of seasonal influenza exists and is based on a clinical surveillance (National Reference Laboratory, ISP) and a virological surveillance in patients with influenza-like symptoms (ISP). A European Influenza Surveillance Network (EISN) directed by ECDC ensures the exchange of information among the European member States during the epidemic period.

Avian influenza: H5N1

Factors influencing introduction of new avian influenza virus in Europe:

- migratory birds
- presence of natural reservoir for aquatic birds
- legal and illegal import of birds

Factors influencing avian influenza virus transmission:

- resistance in water
- resistance to UV
- resistance to temperature
- contact between infected wild birds and domestic birds

In 2003 the highly pathogenic avian influenza (HPAI) H5N1 in Asia showed striking features such as the cross-species transmission (wild feline, cats and dogs) and the zoonotic potential. The virus was first detected in Europe in 2005 and it was characterized by high mortality among wild waterfowl migratory birds, and some cases in domestic poultry holdings. In Belgium a surveillance system was established with the collaboration between the AFSCA, CERVA and ISP (starting in 2006 until now) and involved passive surveillance of dead birds, active wild birds surveillance and increased serological surveillance in poultry, exclusion diagnosis in poultry flocks with abnormal symptoms. Control measures were also defined, in order to reduce any contact between domestic and wild birds, strict regulation in case of bird expositions or markets, definition of high risk areas (close to natural birds reservoir).

Considering the zoonotic potential of the HPAI H5N1, and the WHO declaration of a pandemic alert phase 3, in Belgium since December 2005, an emergency procedure was applied:

- sampling kits and procedures sent to clinical biological laboratories
- informative letters to physicians
- severe acute respiratory illness and presence of risk situations (travel in endemic regions, contact with poultry or consumption of uncooked poultry product)

Influenza pandemic H1N1 2009

The virus resulted from a triple reassortment between a swine, an avian and a human virus. The virus became a human virus, with high transmission rate from human to human (direct contact).

Factors influencing the introduction in Europe of the pandemic (H1N1) 2009:

- frequent movements of persons to and from infected countries
- contact with infected persons
- high transmission rate

Surveillance in Belgium during the containment phase:

- sampling kits and procedures sent to clinical biological laboratories
- informative letters to physicians
- severe acute respiratory illness and presence of risk situations (travel in infected countries)

Surveillance in Belgium during the mitigation phase:

- no more systematic laboratory testing

- only hospitalized and high risk patients
- increased number of GP participating to the sentinel surveillance network

Control measures:

- EU countries recommended simple public health measures of respiratory hygiene, handwashing (no mask wearing recommendation)
- international movements to and from infected countries: informative documents
- antiviral treatment (differences among EU countries)
- monovalent vaccine:
- common EU policy for vaccination of categories at risk;
- each EU country adopted own strategies for the rest of the population

A. SWOT analysis (as applied to a public management structure)

The SWOT (pour *Strength*, *Weakness*, *Opportunity* and *Threat*) tool for analysis (Evans et al. 2003) is currently used for a strategic approach in management. It sheds light on the *Strengths* - *Weaknesses* internal to an organisation, which are strategically important when facing *Opportunities* and *Threats coming from the external environment.* It helps identify key factors for success, minimizing weaknesses and maximising strengths. Such a method can easily be applied with expert methods, using small groups dynamics (eg: Future Search conference, workshop scenario, Delphi…).

<table>
<tr><td colspan="6">SWOT – EUROPEAID (EUROPEAN COMMISSION)</td></tr>
<tr><td colspan="3" rowspan="3"></td><td colspan="3">INTERNAL APPROACH</td></tr>
<tr><td>Strengths</td><td>weaknesses</td><td rowspan="2">Strengths can master weaknesses</td></tr>
<tr><td>To maximise</td><td>To minimize</td></tr>
<tr><td rowspan="3">EXTERNAL APPROACH</td><td>Opportunities</td><td>How maximise?</td><td>Strengths can be used to use opportunities?</td><td>Opportunities can help counter weaknesses?</td><td></td></tr>
<tr><td>Threats</td><td>How minimize?</td><td>Use forces to reduce threats?</td><td>Minimizes weaknesses and threats?</td><td></td></tr>
<tr><td colspan="2">Opportunities can help minimize threats?</td><td></td><td></td><td></td></tr>
</table>

Answers for the « SWOT » analysis were collected with MESYDEL (www.Mesydel.com) - a Delphi on line (2 rows, with open questions, followed by a meeting face to face to discuss results and conclusions) during April - Mai 2011 (workshop on June 17 2011), with experts and public servants from both communities, which were somehow associated to the surveillance of animal or public health.

SWOT of the regulation system (public health)

	+	-
Internal approach	**Strengths** Openness to vigilance (all suspect pathologies can be reported)	**Weaknesses**
	Similar logic in all regional entities	But with specific lists in each of them
	In Flanders, GPs and public servants know the protocol	GPs do not know the protocol (in French community) or are less ready to report (Brussels)
	Administrative autonomy of the Flemish Agency of health care (Flanders)	
	Expert advice is asked to university labs or to reference labs	
	More attitude towards reporting in Flanders	
	Flexibility is possible	
External approach	**Opportunities** Legislation EU& OMS : to report diseases eg : Dutch report on FCO	**Threats** Increase in transports of goods, animals, persons Global change

SWOT of the regulation system (animal health & zoonoses)

	+	-
Internal approach	**Strengths** Federal competence With regional initiatives (limited) List of diseases Complex structures, with a networking on the whole territory (see AFSCA and its provincial network) working with stakeholders (Vets and farmers)	**Weaknesses** Regional initiatives are not coordinated No measure to avoid entry on the territory (no quarantine eg)
External approach	**Opportunities** Harmonization EU List of diseases at EU and international levels	**Threats** No measure to avoid entry on the territory (no quarantine eg) Global change

SWOT analysis from the MESYDEL (Delphi on line)

	+	-
Internal approach	**Strengths** Proposition of the French project on a national platform for epidemiological surveillance systems (what are the conditions of transposition?)	**Weaknesses** **Institutional organisation** Complex system with different elements, each with its own culture, means, tools and environment. Health system is different in Flanders / Wallonia / Brussels Complex distribution of responsibilities between policy levels, different for animal /public health. **Functioning of the system** Too few coordination between actions organised by sub-federal entities (human health) No transparency of the roles of each actor Reporting procedure is unclear Too few links and too few common practices between animal / human health (70% emerging human diseases will be zoonotic) Too few communication between human / animal health systems Too few top-down back information (from the institutions back to the gp, vets, farmers) Normative structure is too rigid and not adaptable (e.g changes in list of diseases to declare) A key actor (AFSCA) has a legitimacy problem (particularly towards the farmers). It is perceived as economic enemy, not as a help. **Important role of the political agenda :** The public policy agency is more reactive than proactive (let's consider the "monthly risk"); media pressure No integrative / comparative approach in risk management No political trade-off between different risks No prospective global vision Political decision makers are not informed enough **Financial resources** Budgets are not high enough to follow zoonoses All tests are not reimbursed (economic barriers to precautionary analysis) Means are not proportionate between animal / health systems **Information** Too few quantitative date are available Existing data are not used thoroughly Experts panels are not enough diversified towards interests (too few contradictory debates) **Human health** Some first line actors - GP's - lack training in infectious diseases **Methods** **List of viral diseases to be declared** Does not match current needs for zoonoses

		No regular reevaluation with taking in account epidemiological changes Different in the different regions. Administrative borders should be questioned : they are not pertinent for sanitary issues It is difficult for human - animal health professionals to work together, because they have different professional frames (eg. importance of impact of human health <> economic impact for animal health). Inclusion on the lists should start from possibility for actions and not from the risks alone **Reporting deficit** The whole system is based on the assumption that first line professionals are keen to report and to act as reliable public health actor. Under-reporting should be evaluated beforehand and causes of such behavior should be identified. GP's do not feel concerned as actors of "public health", they are not really trained for infectious diseases, not informed of new risks, ... They are already overworked and try to avoid extra administrative work load. Vet's have a conflict of interest: their customer relationship with the farmers can be affected by this reporting. Famers: are they really open to public health issues? AFSCA seems to have an image of "stick behind the door", which is not a good starting point to launch a learning process with their partners, the farmers. …
External approach	**Opportunities** A new model proposed by the administration, more integrated	**Threats** Mobility of goods, people, and animals rises the risk level to import new vectors or sick subjects. Climate change Small territory for the administration Complex institutional frame : multi level and multi actor Commercial and political stakes
	This opportunity is based on the concept of emerging diseases	Few control of animals at the borders New risks with wildlife (under the responsibility of regional authorities)
	A vigilance dynamic can also be considered as supporting an attitude of suspicion	Crisis management
	More active system based on voluntary inputs (MoSS)	MoSS[1] is redundant with the list of obligatory declaration ==> is risky as it can lead to more confusion
	Better communication between ISP (human health) and AFSCA (animal)	
	reporting organised by first line laboratories	

[1]MoSS : web application created to establish a voluntary communication between veterinarians and experts of the sanitary institutions (early detection and identification of emerging diseases)

Evaluating the performance level of the vigilance system

The concept of "vigilance" is based on a new articulation between administrative management and local competencies - the latter are mobilised by first line experts such as GPs, Vets, or farmers" (Fallon et al, 2012). One first line of research could be to refer to the **"Performance indicators"** defined by CDC in order to qualify a reporting system:

Simple: the network should be perceived as simple by the first line actors who feed it

Data quality– analyse the lacking or incomplete date (mistake in reporting by the first line actors)

Acceptability: what is the motivation of the first line actors to partake in the functioning of the network? Why are they reluctant to report?

Sensitivity: Can the network detect an emerging disease? This is often related to the level of training of the first line actors

Representativeness: the network can give a good image of the situation of the diseases there are strong bias, e.g. auto selection due to the voluntary reporting.

Rapidity: what is the time span between the different steps in the reporting process?

Stability: is the network reliable and operational?

Another issue which deserves attention is the **conditions of trust towards AFSCA**. Such condition seems to be lacking, particularly at the side of the farmers. This attitude must be linked to the difficulties to make them adopt reporting practices: this attitude can help to understand the reluctance of these actors to communicate through the reporting system.

Decentralization/Centralization: Decentralization in the epidemiological surveillance system (particularly in the human health system) is considered by many participants as a weakness. Animal health system seems to be more centralized.
There is also a reported lack of communication between the human / animal health sectors: this lack of communication is explained by the participants by the different frames of actions of the two networks: at the side of public health, the main issue is the gravity of the disease for humans; for the administration in charge of animal health, the prior criteria is first et foremost economical. These two weakly related systems can be questioned: what is the input of the public administration or of the political authorities in the prioritization? Are political authorities adequately informed in principles of risk management and prioritisation? Is there a transfer of expertise from the regional / community public authorities towards the federal - central bodies?

Another question from the analysis is related to the French example "**plateforme nationale française de la surveillance épidémiologique de la santé animale"**: is it a good example to follow? This model should develop new mechanisms supporting a better communication and a logic of "working together". The French experience should be monitored before trying to transpose it concretely in the Belgian environment. Another issue should be considered (ex ante evaluation): can this model help "co-working" for the actors of public and animal health?

Such a model could be supportive for a **"learning organisation"**: in such an organisation, the actors can test their ideas, confront them to their colleagues' views and to the evolving environment. Ideas are not to be piled up, but integrated. It means that new ideas or diverging way of thinking are to be promoted, with a diversified set of experts. Such a leaning organisation can only by launched with the reference to main principles:

- the **power structure should be adapted** in order to encourage the transfer of knowledge. This goes against the principles of bureaucratic management whose hierarchical structures and horizontal specialisation act as breaks for free flow of information. Networks and informal contact points are to be developed to counter the effect of bureaucratic division of power.

- Create conditions for an **"idea laboratory"** where participants can exchange and test ideas, out of the bureaucratic links. At the same time, such exchange of information over longer period time can lead to specialisation and differentiation: if not adequately monitored, exchanges of ideas can accentuate the differences between groups.
- Such an "idea laboratory" would work only if freedom of speech is guaranteed: it requires mutual trust, cooperative spirit, a ***problem solving*** **approach** between the partners (as opposed to a competitive approach).

3. POLICY SUPPORT

A plea for an analysis in terms of vulnerability:

Vulnerability, broadly defined as the potential for loss, is an important concept in hazards research, particularly concerning environmental hazards in the geographical research field (Burton 1997; Cutter 1996; Füssel and Klein 2006; Füssel 2007; Janssen et al. 2006). "Vulnerability concept is used to characterize a system's lack of robustness or [/and] resilience with respect to various threats, both within and outside the boundaries of the system" (Einarsson and Rausand 1998: 535). Following their definition, "vulnerability may be considered as the opposite of robustness and resilience".

Robustness is a static concept. It's a quality of any system related to its ability to sustain some damage without failure. **Robusteness has much to do with institutional resistance to change, change at the margin** (Handmer, Dover, and Downing 1999)**.** Resilience is a dynamic concept. It also refers to "a system's ability to accept and withstand unexpected applications and operational conditions", but "resilience means that the system may change and adapt to new situations"(Einarsson and Rausand 1998). **Resilience involves flexibility and adaptability** (Handmer 1999).

Following Einarsson and Rausand's perspective, vulnerability analysis should be scenario-based : "Scenario is defined as a sequence of potential events, where the events may be separated in time and space, and where barriers to prevent the sequence are a part of the scenario" (Einarsson and Rausand 1998: 541). Scenario-based approach might be very fruitful because vulnerability can be revealed by the use of scenario as well as the hazard does reveal vulnerability when it happens (Veyret and Reghezza 2006).

To do so, qualitative methods allows in-depth and contextualized analysis (Thouret and d'Ercole 1996). "To use or oversimplify the multidimensional vulnerability to a scalar quantity in representing risk could mask the underlying causes of risks and lead to results that are not useful" (Haimes 2006: 294). Moreover, "a particular strength of the use of place-based vulnerability approach is its potential for increased public involvement and collaborative assessment" (Turner et al. 2003: 8076). Indeed, a vulnerability approach may provide creative elements and could be particularly useful "in the face of irreducible uncertainty about risk situations" (Sarewitz et al. 2003: 808), particularly as it may invite to reconcile and integrate lay and expert knowledge, (Callon et al. 2002; Turner et al. 2003). "The participation of existing or potentially vulnerable population in the evaluation of their vulnerability is recognized as essential if assessments are to be useful for policy makers" (Eakin and Luers 2006: 378).

To properly build and describe those scenarios, it seems consistent to use Füssel's four dimensions that allow specifying the vulnerable situations considered (Füssel 2007). The first is the "system" considered: a population group, an economic sector, a Seveso plant and the area's population... The second is the "attribute of concern" which are the valued attributes of the vulnerable system that are threatened by its exposure to hazard (*e.g.* human health, biodiversity, facilities, market shares …). The third is the "hazard" considered, as a specific potentially damaging influence on the system of analysis regarding its vulnerability. The fourth is the "temporal reference", the point in time or time period of interest. In this perspective, we only consider discrete events or "scenarios" (Einarsson and Rausand 1998) which must be thus regularly re-evaluated.

Benefits and problems of a vulnerability approach

The vulnerability approach which we proposed here for the systems of public health / zoonose surveillance, is based on the development and use of prospective scenarios in order to unveil the internal and external factors which decrease / increase the vulnerability. The way of working is not anymore to provide *a posteriori* a list of isolated risk factors - see the SWOT analysis - but rather to systematically explore these factors within a constructed prospective scenario.

Vulnerability allows exploring beyond phenomena's for which "understanding the uncertainty of the uncertainty estimates is impossible" (Sarewitz et al. 2003: 806). This approach also put forward the importance of context: "extreme events are created by context", they are determined not only by some set of characteristics inherent in the physical phenomena, but by the interaction of those characteristics with other systems, which are taken into account with vulnerability analysis (Sarewitz et al. 2003). Third, vulnerability approach could open new research perspectives based on the questioning of a strongly dominant positivist safety paradigm" (Gilbert et al. 2007: 960-1). Fourth, some authors argue that vulnerability reduction is a value-based issue while classical cost/benefice risk reduction is not (Dow et al. 2006; Sarewitz et al. 2003). "In a human rights context, issues of cost-benefit and debate over uncertainty not only lose their centrality, but are rendered inappropriate. […] By privileging risk management over vulnerability management, quantification becomes a value in itself that constricts […] policy options" (Sarewitz et al. 2003: 810). In another way, vulnerability management could provide a great basis for value-based and broader political approach (Sarewitz et al. 2003).

<u>Risk analysis and vulnerability analysis</u>

The main focus of risk analysis is the accidental event causes and the possible event chains following the accidental event. The focus is on barriers and safety functions and potential effects of the event (outcome risk). The focal point of vulnerability analysis is the characteristics of the system that contribute to its survivability (the boundaries of the system and the level of consequences to be defined). Here again the concept of barrier is relevant but is broader than for a risk analysis (Einarsson 1998). It may for instance include public information on risk and behaviours in case of an emergent exotic disease (for instance avoiding staying in a garden at night (Chikungunya virus).

Hence, the scopes of VA and RA are partially different: there is an overlap.

Vulnerability analysis can be performed without a causal analysis of the event in a context of great uncertainty or ignorance for instance. At the difference of risk analysis, it also includes emergency preparedness.

In so far as its implementation includes cross-sectorial lessons learnt from previous incidents/accidents/crises (see Crichton et al. 2009), it contributes to enhance its resilience. Resilience can be interpreted as the uncertainty about the severity of the consequences of the activity given the occurrence of any type of event. Of course, in practice, we always have to define some boundaries for which events to be included (Aven, 2011, 518). We may get ill due to different types of virus attacks. Vulnerability management may address different types of (unknown) virus attacks (for instance), to different (unexpected) events by promoting the resilience of the system.

The objective of vulnerability analysis is to increase the awareness of potential disturbances and accidental events that may threaten the survivability of the system. Vulnerability ignorance contributes in itself to outcomes we observe, but seek to avoid, and should be investigated in addition to risk analysis. A myopic focus on risk to the exclusion of vulnerability can easily enhance rather than reduce the prospects for negative outcomes (Einarsson et al, 2003, 810).

<u>Recommendations</u>

List of viral diseases and prioritization

The identification of the hazards through the realization of a list of viral diseases ended in a closed list which could not be exhaustive and especially did not take in consideration the possibility of emergence of unknown and uncharacterized viruses. Furthermore in the context of a qualitative risk analysis, the hazards should be identified and prioritized in order to accomplish the risk assessment and to give useful information to the decision makers.

Surveillance systems

Some points of contrasts were pointed out between the two main surveillance systems, the one concerning human health and the other one related to animal health and food chain security issues

The human health networks are open to observe emerging health issues, even under uncertainty, as long as there is a probability of large epidemic hazard. It means that the list of diseases to be declared is not closed in the legal frame.

As far as animal health is concerned, there is less space for open or uncertain "emerging" issues in the legal frame: all lists are closed and only in the frame of "exotic diseases" does the legal frame provide some space to organize epidemiological research in order to search for vectors of the disease.

Risk factors

An open list of risk factors has been described.

Vector-borne viruses are emerging pathogens, and several factors are increasing the risk of their emergence in Belgium and in Europe: climate change (migration patterns of birds and wildlife, vector population, landscape), human activities (landscape, human international movements), trade, virus genetic mutations.

For mammalian-borne viruses the following risk factors can influence their emergence, re-emergence and increased incidence: climate change (migration patterns of birds and wildlife, landscape), human activities (landscape, human international movements, human habits, occupational risks), trade, virus genetic mutations.

For directly transmitted viruses, their increased incidence can be influenced by the following factors: climate change (resistance of the virus in the environment, migration patterns of birds and wildlife, human activities), human activities (human habits, occupational risks), human demography, trade, virus genetic mutations.

Risk management

The control measures against viral diseases are mainly organized by the Scientific Institute of Public Health in coordination with other institutions such as the CERVA and the AFSCA in case of zoonotic pathogens, or the Institute of Tropical Medicine for tropical infectious diseases. They are mainly dependent on already known viruses and are less adapted to a quick reaction in face of an emerging disease.

Regarding vector-borne viral infections, a list of current possible control measures against arthropod vectors was drawn in this report. As a major outcome of this analysis, it was pointed out that, in Belgium, despite a recent intervention in Natoye (province of Namur), a vector surveillance system is lacking and once a problem does occur, the decision-making process is not straightforward, especially regarding the responsibility and skills for implementing the control, and the kind of intervention that should be applied in case of epidemics, prevention of epidemics, invasive species or outbreaks of nuisance.

Institutional organisation

In human health, the federalization of the health prevention responsibilities led to the development of a fragmented system with a complex distribution of responsibilities between policy levels, and which is different for animal and public health. The three regions kept the same logic of notification (via general practitioners or laboratories) but the Region of Bruxelles-Capital and the Vlaamse Gemeenschap developed a new specific legal frame. However, considering human health, the coordination between actions organised by sub-federal entities should be improved. Animal health is organized at a federal level and does not suffer from the same issue, except for matters in relation with wildlife that are regions-dependent.

A major pitfall was identified in the communication between human and animal health systems in Belgium, especially taking into account the fact that 70% of emerging human diseases are zoonotic. The creation of structural links between these human and animal health systems needs a profound reorganization of the federal, regional and community institutions.

4. DISSEMINATION AND VALORISATION

Participation of E. Thiry, V. Versteirt at the Belgian Biodiversity – Public Health Conference, 30th November 2011, Belspo;

5. PUBLICATIONS

1) Dal Pozzo F., Martinelle L., Gallina L., Mast J., Sarradin P., Thiry E., Scagliarini A., Büttner M., Saegerman C. Original findings associated to a case of bovine papular stomatitis in two housed calves. *Journal of Clinical Microbiology*, 2011, 49, 4397-4400.
2) Dal Pozzo F., Thiry E. Antiviral chemotherapy in veterinary medicine: current applications and perspectives. *OIE Scientific and Technical Review*, submitted for publication.
3) Fallon C., Piet G., Thiry E., Dal Pozzo F., Zwetkoff C. Renouveler la gestion du risque par l'ouverture à un système de vigilance ? Le cas de la fièvre catarrhale ovine. *VertigO-revue electronique en sciences de l'environnement*, accepted for publication.
4) Fallon C., Rossignol N., and C. Zwetkoff. "Vulnerability and risk: some reflections for a new form of safety governance." Paper presented at *International Workshop on Safety and Security Risk Assessment and Organizational Cultures*. Antwerp, Belgium, January 2012.

6. ACKNOWLEDGMENTS

VIRORISK partners would like to thank all the participants of the Delphi questionnaire performed in the course of the project: their contributions have been essential.

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