D2.1 Provisional Research Strategic Agenda

WP2 Integrative Strategic research Agenda

Responsible Partner: RIVM

Contributing partners: UCM, SSI, PIWet, ISS, NVI, DTU, Anses, BfR, APHA, NIPH, SVA, UoS, ISCIII, CODA-CERVA, WBVR

GENERAL INFORMATION

European Joint Programme full title	Promoting One Health in Europe through joint actions on foodborne zoonoses, antimicrobial resistance and emerging microbiological hazards
European Joint Programme acronym	One Health EJP
Funding	This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.
Grant Agreement	Grant agreement n° 773830
Starting Date	01/01/2018
Duration	60 Months

DOCUMENT MANAGEMENT

Deliverable	D2.1 Provisional strategic research agenda
WP and Task	WP2; Task 2.1
Leader	RIVM
Other contributors	UCM, SSI, PIWet, ISS, NVI, DTU, Anses, BfR, APHA, NIPH, SVA, UoS, ISCIII, CODA-CERVA, WBVR
Due month of the deliverable	M1
Actual submission month	M1
Type *R: Document, report* *DEC: Websites, patent fillings, videos, etc.* *OTHER*	R
Dissemination level *PU: Public* *CO: confidential, only for members of the consortium (including the Commission Services)*	PU

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Chapter 1: Introduction

The One Health European Joint Programme (EJP) is an European network of research institutes, mainly reference laboratories, integrating medical, veterinary and food scientists in the field of food and feed safety in order to improve research on the prevention and control of mainly foodborne zoonoses by joint programming, stimulating coherence of Research, while taking into account the public health concerns of consumers and other stakeholders throughout the food chain. At the stage of proposal submission, the consortium consists of 40 partner institutes from 19 countries and 1 association (Med-Vet-Net Association).

The One Health EJP is structured in seven WPs (figure 1)

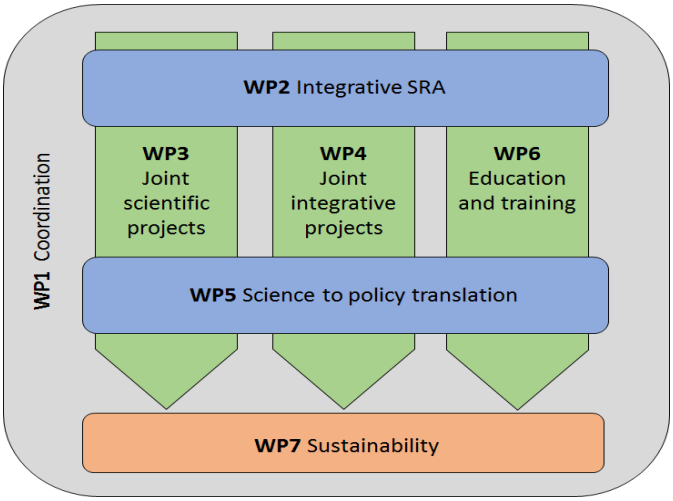


Figure 1: Structure of One Health EJP

In the preparatory phase of the One Health EJP, a provisional Strategic Research Agenda (SRA) was developed. The process of creation and the outcome are described in this document. By the start of this process, not all partner organisations – countries were identified and included in the consortium. This provisional SRA will be updated in the first year of the One Health EJP in order to prepare the second internal call. In that update all new partners will be involved.

Chapter 2: Summary of the prioritisation process

This provisional Strategic Research Agenda is the outcome of a carefully organised prioritisation process, developed by the Programme Management Team of the One Health European Joint Programme (EJP) in the preparatory phase of the project. Purpose was to identify priority topics for a first internal call for Joint Research Projects and Joint Integration Projects to start immediately after the formal start of the EJP. This in order to optimally make use of the full 5-year project period of the foreseen EJP for conducting joint research, integrating activities and PhD projects

In order to provide a basis for the strategic research agenda (SRA), a **strategy matrix** was developed in 2016 consisting of three domains, i.e. foodborne zoonoses, antimicrobial resistance and emerging threats, and five thematic research areas, i.e. analytical methods, host-microbe interaction, epidemiology, risk assessment and intervention, resulting in 15 research areas. These themes correspond to the major items as described in the call Work Programme (specific challenge & scope). The scope description of each of the 15 research areas is represented in table 1 and a further detailed thematic description is given in chapter 4.

The MSs participating in OneHealth EJP were invited to nominate **national experts** based on the strategy matrix, i.e. one expert per research area (15 experts per MS in total). Subsequently, these national experts were asked to suggest a top 3 research topics for each of the 15 research areas of the strategy matrix as well as 3 integrative activities. This resulted in a list of (up to) 48 research topics per research area and a list of 48 integration activities.

Then, similar raw research topics were grouped into summary topics, resulting in a list of a maximum of five summary research topics per research area (a maximum of 25 topics per domain). Furthermore, the integration activities of interest suggested by the experts were categorized into seven integrative topics.

Subsequently, an **experts meeting** was organized in May 2016 involving approximately 60 experts who had been selected based on nomination by the partner organizations and based on their expertise covering the strategy matrix. Based on the list of research topics and the list of integrative topics, **priority research topics and priority integrative topics** were identified by the experts following an established procedure including a Multi Criteria Decision Analysis (MCDA) procedure. Also, cross-domain priority research topics were identified.

This procedure finally resulted in nine ranked priority research topics in the domain of foodborne zoonoses, six ranked priority research topics in the domain of antimicrobial resistance, five ranked priority research topics in the domain of emerging threats and seven ranked priority integrative topics. For each of these priority topics, detailed descriptions were made by national experts coordinated by the so-called domain and theme secretaries (see Addendum 3). Final ranking and selection of priority topics for the first internal call was done by the OneHealth EJP **Scientific Steering Board** (SSB) in June 2016.

For the first round of projects, the four highest ranked research topics in the domain of foodborne zoonoses, the three highest ranked research topics in the domain of antimicrobial resistance, the first ranked research topics in the domain of emerging threats and the two highest ranked integrative topics were selected (see chapter 5; page 13). The detailed descriptions of the selected priority topics were used as a basis for launching the first internal call for letters of intent for Joint Research Projects (JRP) and Joint Integrative Projects (JIP) in June 2016 (see chapter 6). For each priority topic,

the volume of needed resources was assessed and thereafter budgets were pre-allocated for each topic.

The prioritization results provide the basis for the development of this **provisional integrative SRA**, to be finalized during the OneHealth EJP.

The 1st internal call for proposals for **Joint Research Projects (JRP) and Joint Integrative Projects (JIP)** was launched in June 2016 as a 2-step procedure; first an expression of interest (letter of intent) followed by final project descriptions. The JRPs and JIPs with the highest excellence were identified through assessment of the project proposals by external scientific experts. The final selection of JRP's and JIP's was a task of the Scientific Steering Board in its meeting at November 24th 2016. After the start of the EJP, this provisional SRA will be updated with all new partner organisations involved followed by a second internal call. A summary of this process is given in figure 2.

Figure 2: time line of prioritisation process

Table 1: Strategy matrix – scope description

Domains Themes	Foodborne zoonoses - bacterial, viral, prionic, fungal and parasitic pathogens - toxins produced by foodborne pathogens - foodborne transmission including drinking water - including the environment as so far as linked to foodborne transmission	Antimicrobial resistance - related to pathogenic and commensal bacteria	Emerging threats - Related to foodborne and non-foodborne zoonoses
Analytical methods	- analytical methods for detection, identification and typing including omics methods (e.g. NGS) - innovative methods for evaluation of virulence - quality assurance, harmonization, protocol and data sharing	- analytical methods for detection and typing, including omics methods (e.g. NGS) - innovative methods for AMR measurement - quality assurance, harmonization, protocol and data sharing	- analytical methods for detection and typing, including omics methods (e.g. NGS) - quality assurance, harmonization, protocol and data sharing
Host-microbe interaction	- determinants of virulence - microbial ecology (including phages, plasmids) - host-food-pathogen interactions - dose-response relationship - pathogenesis and host response	- mechanism of resistance - ecology of mobile genetic elements - dose-response relationship - carriage-disease relationship - fitness trade-off and AMR	- determinants of virulence - microbial ecology (including phages, plasmids) - host-(food)-pathogen interactions - dose-response relationship - pathogenesis and host response
Epidemiology	- design and evaluation of integrated surveillance programs - risk factor identification - reservoirs and routes of transmission - modelling of transmission dynamics - source attribution - drivers of change, including socio-economic drivers - storing and sharing of data, definition of metadata	- design and evaluation of integrated surveillance programs - risk factor identification - reservoirs and routes of transmission, resistance gene dissemination - modelling of transmission dynamics - source attribution - interaction between ecosystems - drivers of change, including socio-economic drivers - storage and sharing of data, definition of metadata	- harmonized systems for signalling / early warning of emerging zoonoses - design and evaluation of integrated surveillance programs - risk factor identification - source tracking methods - reservoirs and routes of transmission - modelling of transmission dynamics - horizon scanning, drivers of change including socio-economic drivers - storage and sharing of data

Risk assessment and socio-economic impact	- risk modelling - exposure assessment - hazard characterization - risk characterization - risk ranking / disease burden estimation - predictive microbiology - cost-benefit analysis - socio-economic impact, legal and policy aspects - development of methods for decision support	- risk modelling - exposure assessment - hazard characterization - risk characterization - risk ranking / disease burden estimation - cost-benefit analysis - socio-economic impact, legal and policy aspects - development of methods for decision support	- scenario studies - risk modelling - exposure assessment - hazard characterization - risk characterization - risk ranking / disease burden estimation - cost-benefit analysis - socio-economic impact, legal and policy aspects - development of methods for decision support
Intervention	- tools for intervention including biosecurity, vaccination, treatment options, etc. - strategies for communication, prevention and control - behavioural intervention approaches, e.g. nudging - cost-effectiveness of interventions	- tools for intervention - strategies for communication, prevention and control - behavioural intervention approaches, e.g. nudging - cost-effectiveness of interventions	- tools for preparedness - tools for intervention - strategies for communication, prevention and control - cost-effectiveness of interventions

Chapter 3: Prioritised research and integrative topics

Research topics domain Foodborne Zoonoses (FBZ)

1. Improved surveillance system and harmonized data analyses
2. Development and harmonisation of NGS-based methods for detection and tracing of FBZ agents, emerging threats and AMR determinants
3. Biosecurity and other interventions
4. Source attribution and transmission routes
5. Epidemiological studies: risk factors and dynamics
6. Risk communication and consumer targeted intervention strategies
7. Optimizing options for risk management and enforcement in feed and food production and processing
8. Model Systems (in vitro and in vivo) to study host/food – microbe interactions
9. Frameworks and systems for sharing tools and data for risk assessment and effective decision making

Research topics domain Antimicrobial Resistance (AMR)

1. Development and harmonisation of phenotypic methods
2. Epidemiological studies into the dynamics of AMR in human and animal populations and the environment including horizontal gene transfer and selection of AMR
3. Risk Assessment AMR
4. Communication and stewardship AMR
5. Disease burden, socio-economic consequences and risk ranking
6. Metagenomics and bioinformatics for detection and surveillance of AMR pathogens and determinants

Research topics domain Emerging Threats (ET)

1. Development and harmonisation of non-NGS-based methods for detection of FBZ agents and emerging threats
2. Improving preparedness and response
3. Applying risk assessment/modelling methodologies to support decisions for the control of emerging threats, foodborne zoonoses and antimicrobial resistance
4. Host factors associated with colonization, persistence and disease
5. Ecology of emerging pathogens

Integrative topics

1. Interpretation of surveillance data - Standardised data formats and ontologies, common tools and procedures for data analyses, including interpretation of sequence data
2. Common reporting and signalling procedures, joint platform for sharing surveillance data and their interpretation, incl. risk assessments
3. Joint databases of reference materials and data, incl. metadata
4. Harmonised protocols and common best practice
5. Mentoring (twinning) system for sharing of best intervention practice
6. Common frameworks for design and methods to assess equivalence between surveillance and control activities
7. Aligned use of experimental facilities and models (of transmission, ecology, risk assessment etc)

Chapter 4: Description of the research themes

4.a Theme Analytical methods

Within the theme **analytical methods**, 4 topics are identified and prioritised: 1) Development and harmonization of phenotypic methods 2) Development and harmonisation of non-NGS-based methods for detection of FBZ agents and emerging threats 3) Development and harmonisation of NGS-based methods for detection and tracing of FBZ agents, emerging threats and AMR determinants and 4) Metagenomics and bioinformatics for detection and surveillance of AMR pathogens and determinants.

Even in the area of NGS techniques**, phenotypic methods** are of utmost importance in daily routine practice, both in veterinary and human medicine. The objective of this topic is to stimulate the development of new quick diagnostic phenotypic tests for the detection and/or identification of AMR bacteria in humans, animals, feed, food and the environment. There will be a strong link with integration activities around data management.

Development and harmonisation of non-NGS-based methods for detection of FBZ agents and emerging threats will fill the gaps in the knowledge of the methodologies alternative to standard PCR or cultural isolation applicable to food-borne zoonoses and emerging threats. Technology increasingly allows developing or re-directing analytical methodologies for the detection of pathogens, which are more rapid and reliable than the standard approaches based on cultural strategies and potentially can cover pathogens that are currently not identifiable or misdiagnosed. For example, by use of highly specific antibodies (mabs), recombinant proteins, and/or genetic probes novel methods can be developed. Such technologies have the potential to deliver rapid assays on platforms applicable to field use such as bed/farm/pen-side tests, as well as in the food production chain. It is the goal to validate the methods to be used in EU and seek to develop automated systems with electronic data collection.

Development and harmonisation of NGS-based methods for detection and tracing of FBZ agents, emerging threats and AMR determinants should resolve delayed responses to crises which negatively affect management of human infections, trade, food chain sustainability and food security. The rapid growth of the sequencing technologies potentially allows delivering analytical tools for rapid identification of pathogens and AMR determinants based on characterisation of the agents and their genomes, not only on isolates but also following culture-independent strategies. One of the foreseen outcomes is the establishment of standardized and validated pipelines to extract information from raw NGS data on the detection and typing of specific pathogens, and genomic traits in genomes including virulence genes and AMR determinants.

The topic **Metagenomics and bioinformatics for detection and surveillance of AMR pathogens and determinants** will enforce WGS metagenomics approaches in the monitoring of AMR development in complex microbiota recovered from relevant sites under selective pressure with antibiotics. This would include specific expected hotspots of AMR selection such as at hospital or farm level, or in the environment. Foreseen outcome is the production of quantitative WGS metagenomic data in geographical sites of human or veterinary (or combined) relevance as well as the correlation of metagenomic data with antibiotic usages and other risk factors

4.b Theme Epidemiology

Within the theme **EPIDEMIOLOGY,** 5 topics are prioritised: risk factors and dynamics, ecology of emerging pathogens, the dynamics of AMR in human and animal populations and the environment including horizontal gene transfer and selection of AMR, source attribution and transmission routes and improved surveillance system and harmonized data analyses.

Identification of **risk factors and infection dynamics** will serve to improve the effectiveness of surveillance systems and optimize the use of time and resources, both for foodborne zoonoses surveillance systems as well as for recognizing emerging threats. Verification of identified risk factors and optimal control points for foodborne and emerging threats will facilitate the development of models to predict pathogen transmission and dynamics related to the identified risk factors.

More insight in the **ecology of emerging pathogens** that are zoonotic and foodborne is needed for the prevention and control, including knowledge about pathogen transmission between human and animal populations and the environment. E.g. molecular epidemiology is needed to study host dynamics and to reconstruct high resolution transmission trees. An expected outcome is the identification of host-pathogen-ecology-combinations that constitute a higher risk if pathogens are introduced.

The **dynamics of Antimicrobial Resistance** attracts a lot of attention in recent times. Although multiple efforts have been undertaken, there are still knowledge gaps and inconsistencies in understanding of the epidemiology of antimicrobial resistance, i.e. its selection and spread under antimicrobial usage pressure in different ecological settings. Geographical differences, temporal trends, variable farming, environmental reservoirs, wildlife, farm and companion animals as well as human colonization, anthropogenic impact on the abundance of resistance in the environment, and factors promoting or mitigating resistance transmission need systematic studies. Foreseen outcome includes a better description of reservoirs and vectors of resistance as well as increased knowledge on environmental, geographical and demographic risk factors, drivers and catalysers of selection and trends in resistance.

The topic **Improved surveillance system and harmonized data analyses** is based on the observation that current EU surveillance systems on foodborne zoonoses, antimicrobial resistance and emerging threats are focused on selected threats and areas. Globalization however, requires broader and flexible actions to detect hazards, reservoirs, vectors, trends and routes of transmission as well as common approach and timely analysis and data sharing. For research in this area a strong interaction is foreseen with the integration activities in WP4.

Finally, **source attribution and transmission route** studies will improve knowledge on sources and transmission routes of pathogens and AMR determinants within ecosystems, including the food chain. Furthermore, it will provide sound methods and baseline information to guide risk assessment and management, including platforms for sharing new approaches to attribute cases of FBZ and AMR to their sources.

4.c Theme Host-microbe interactions

Within the theme **Host Microbe interactions**, 2 topics are identified and prioritised: 1) Host factors associated with colonization, persistence and disease and 2) Model Systems (in vitro and in vivo) to study host/food – microbe interactions.

The topic **Host factors associated with colonization, persistence and disease** will cover both foodborne zoonoses as well as emerging threats. The elements defining host specificity of microbes is poorly understood. Crossing of the species barriers represents a crucial event in emergence of

known and novel diseases. Recent evidence suggests that the microbiota in combination with the host immune response and host tissue type, may be involved in host specificity. One of the objectives is to better understand humoral/cellular immune response and its implementation to control microbial infections and its role in latency/sub-clinical infections. A link with integration activities is foreseen as multi-microbial experts will share knowledge to create a multi-microbial hub to share and disseminate knowledge and techniques to study host specificity.

Model systems are crucial to understand the pathogenesis, emergence and spread of infectious diseases. One of the objectives is to develop novel in vivo models (both animal models and alternatives such as cellular systems) that reflect infection in the natural host, that opens the door to understand the pathogenesis of infectious diseases. Since exposure does always lead to disease, studying the immune response by seroprevalence studies will reveal the burden of disease and exposure to microbes in each region. Also new mathematical approaches to dissect the behaviour of microbes within a host or their geographical dissemination will be developed. These mathematical models might describe and predict emergence and spread of food-borne pathogens from host, to food and in the food chain.

4.d Theme Risk Assessment

Within the theme **Risk Assessment**, 4 topics are identified and prioritised: 1) Frameworks and systems for sharing tools and data for risk assessment and effective decision making; 2) Disease burden, socio-economic consequences and risk ranking; 3) Applying risk assessment/modelling methodologies to support decisions for the control of emerging threats, foodborne zoonoses and antimicrobial resistance and 4) Risk Assessment AMR.

Rationale for the topic **Frameworks and systems for sharing tools and data for risk assessment and effective decision making within and outside Europe** is the fact that large number of predictive modelling and risk assessment models, software tools and databases have been developed in the past decades, but their maintenance is not always guaranteed and exchange of information between these resources is currently difficult and time consuming, which limits their application. An obvious next step is to combine the data and software tools that are available in Europe and facilitate the communication between them and the networks hosted by EFSA. Core results of the project are joint use of harmonized standards by EJP partner organisations and the joint infrastructure that provides resources that will be of immediate and future practical use when performing risk assessment to support decision making in Europe.

Disease burden is increasingly studied, particularly to inform risk management strategies. The recent publications on the global disease burden of foodborne disease have shown the relevance and potential of quantitative disease burden estimation, among others as a basis for risk prioritization. These latest developments also highlighted current challenges in estimating the burden of some foodborne diseases, particularly associated with AMR and other emerging threats. The need to extend current burden of disease estimations by incorporating **socio economic consequences** is widely recognized. By integrating health, economic and social impact assessments (applying e.g. multi-criteria decision analysis), and develop a method that can be applied in different countries, comparative **risk rankings** can be performed across the EU.

In the past decades, **risk assessment modelling** has been developed and applied in a number of European countries, mainly for microbial hazards like *Salmonella, Campylobacter* and *Listeria*. As a next step, it is important to further develop and apply risk assessment methods in the area of foodborne zoonoses and for a broader range of hazards, including emerging threats, antimicrobial resistant bacteria, viruses and parasites. These risk assessments should be aimed at **decision support**, including cost benefit analyses, cross- border animal movement and trade with feed and

food. Expected outcomes are a.o. novel risk assessment methods that allow the inclusion of NGS and metagenomic data and novel risk assessment tools for specific microbial hazards (e.g. Toxoplasma), emerging threats (e.g. models for their introduction and spread, and the impact of reactions to early detection) and the spread of antimicrobial resistance.

Risk Assessment of AMR is a dedicated topic due to constantly evolving nature of AMR. Therefore, risk assessments need to be regularly updated and adapted to new potential hazards. Projects in this field will address the relative and absolute contribution of animal and environmental sources to the public health burden of AMR, including variability between bacterial species, by using risk assessment. Expected results include increased understanding of the role of the environment in dissemination of antimicrobial resistance and human exposure.

4.e Theme Intervention

Within the theme **Intervention**, 5 topics are identified and prioritised: 1) Improving preparedness and response; 2) Communication and Stewardship AMR strategies 3) Risk communication and consumer targeted intervention 4) Biosecurity and other interventions, and 5) Optimizing options for risk management and enforcement in feed and food production and processing.

Natural disasters and microbiological threats are often unpredictable, nevertheless we want to try to reduce the effects they can cause by trying to detect and identify them and as much as possible eliminate or prevent them. Topic **Improving preparedness and response** aims at building an integrated capacity for European public health and veterinary laboratories to detect, control and prevent emerging diseases in Europe. Central point is the development of methods and tools to early identify, detect and control emerging threats, – including novel tools for data collection, analyses and data sharing - in cooperation with established networks like EMERGE, ENIVD, EWRS, IHR; focused on microbial, zoonotic, food-borne bacterial, viral and parasitic threats as well as on their emerging AMR mechanisms or virulence patterns.

Communication with stakeholders and **stewardship of antimicrobial usage** form an important component of the international strategy to combat antimicrobial resistance and preserve the effectiveness of antimicrobials in both man and animals. The impact of different prescribing practices in both animals and man on the development of antimicrobial resistance is a component of the evidence-base on which appropriate interventions may be recommended. As reduction of antibiotic usage might have side effects, one of the foreseen actions is to develop systems to monitor adverse consequences of adoption of antimicrobial stewardship guidelines including negative effects on animal productivity, welfare or costs of production.

Due to globalization and various selective pressures, pathogens on the European market are likely to have changed in recent years, and changing production systems create new challenges relating to pathogens in locally and globally produced food. The research focuses to give the European community (authorities, industry) a “toolbox” regarding **communication and consumer targeted interventions.**

Biosecurity (the sum of preventive measures to keep the unwanted microbes away from animals/humans/food/feed) is one of the key **interventions** as “prevention is better than cure”. Due to the large differences in production systems across Europe and changing husbandry and climate, the optimal solution in one area might not be optimal in another. It is important to validate promising practices in different countries and to perform robust, meaningful studies to provide sound evidence and avoid wasting funds on studies of insufficient power.

The international trade **in feed, foods** and breeding animals might constitute additional challenges when it comes to **risk management options.** In order to reduce the negative consequences of food borne pathogens, we aim at identification and evaluation of the cost benefit of various intervention methods, optimizing various processing steps, and evaluation of the efficacy of various communication strategies.

Chapter 5: Description of the integrative activities

The core mission of partners in the One Health EJP is to provide expertise and services to appropriately prevent, detect and respond to societal challenges, i.e. foodborne zoonoses, antimicrobial resistance and emerging threats. The chain of actions from prevention via detection to response defines a series of capacities that need to be maintained and kept up to date by the expert institutes. These pertain to their capacity to design and implement surveillance activities, develop high quality laboratory methods, access reference materials and data, to their ability to timely and appropriately interpret and communicate surveillance information as well as provide guidance to risk managers about relevant actions, both for prevention and response.

Current state of the art

More or less formalised collaborations and networks exist within the three domains of the EJP already today, both nationally and internationally, largely driven by the strong legislative framework on food safety and the corresponding dynamic policy environment that all institutes working within the field have to relate to. This includes, but is not limited to, networks set up by the European Commission, ECDC and EFSA such as the network of EU Reference Laboratories, the European Food- and Waterborne Diseases and Zoonoses Network, the European Antimicrobial Resistance Surveillance Network, the Emerging Viral Diseases-Expert Laboratory Network, VectorNet, the Animal Health and Welfare Network, and the networks for zoonoses monitoring data collection and analysis, as well as for BSE-TSE and microbiological risk assessment.

Although most of these networks are established within their respective sectors (public health vs vet-food) the strategies of both EFSA and ECDC aim towards an improved inter-sectoral integration (ECDC strategic multi-annual programme 2014-2020). Examples are AMR surveillance in food-borne pathogens where an integrated EU system will be jointly developed, and the rapid detection and investigation of food- and waterborne outbreaks through linkage of strains through molecular typing data, with cluster analyses on anonymised data performed in a joint database.

An ambition to link human data collection with baseline surveys in the food and animal sector with the aim to produce better public health risk assessments and broader scientific epidemiological overviews is also an area where the EU institutions can pave the way for an improved national integration of surveillance activities. Both EFSA and ECDC also have ambitions in the field of harmonised methodologies and in building capacity in scientific assessment, investigation and knowledge.

Another example of an international inter-institutional collaboration that serve integration across the public health-animal health interface is the Med-Vet-Net Association (www.medvetnet.org), an organisation established to maintain the collaborations developed as a result of the Med-Vet-Net network of excellence. There are also professional networks that are more tied to specific thematic expertise (microbiology, epidemiology, risk assessment), but even these tend to exist within sectors rather than across.

Nationally, the degree of methodological and operational integration between Med and Vet institutes across Europe varies, from formalised and well-established to informal and *ad hoc* (EU Workshop One Health Risk Analysis Structures, 2016, RIVM).

Challenge and progress beyond state of the art

The ambition of the integrative activities of the One Health EJP is to **develop structures, work processes and platforms that overcome any inter-sectoral division within the themes and domains defined by the EJP scope, resulting in ONE single European surveillance community**. This integrative development should be aligned with European priorities, accommodate and be adapted to existing EU initiatives and support long-term sustainment in the improved joint capacity.

Operational integration will be promoted by means of several different instruments, with the primary being the implementation of joint integrative projects. Seven topics have been defined, to reflect the challenges along the prevent-detect-respond chain of actions. These challenges include the access to joint frameworks for cost-efficient design of surveillance activities, harmonisation of laboratory approaches, including access to well defined and relevant reference materials for proficiency testing and test development, as well as joint approaches for interpretation and communication of surveillance information to decision makers. With regards to means to prevention and joint outbreak investigations, there are also varying degree of challenges nationally, creating an opportunity for sharing expertise between EU member states. Resources such as infrastructure and software, e.g. experimental facilities and simulation models (of transmission, ecology, risk assessment etc.) could also be used more efficiently across the sectors. A ranking reflecting the priorities of Programme Managers that contribute to the EJP has been made, initially highlighting two topics; **standardised data formats and ontologies, common tools and procedures for data analyses, including interpretation of sequence data**, as well as **common reporting and signalling procedures, with a joint platform for sharing surveillance data and their interpretation, incl. risk assessments**.

The remaining five areas for integration concern joint databases of reference materials and data, incl. metadata, harmonised protocols and common best practice for laboratory methods, development of mentoring (twinning) systems for sharing of best intervention practice, common frameworks for design and methods to assess equivalence between surveillance and control activities as well as the use of experimental facilities and models (of transmission, ecology, risk assessment etc.).

Clearly, since the joint EU capacity is a function of each member state's capacity, the EJP integrative activities will aim to make the joint development accessible to all partners, ensure there is transfer of skills and knowledge and promote harmonised approaches wherever it is relevant.

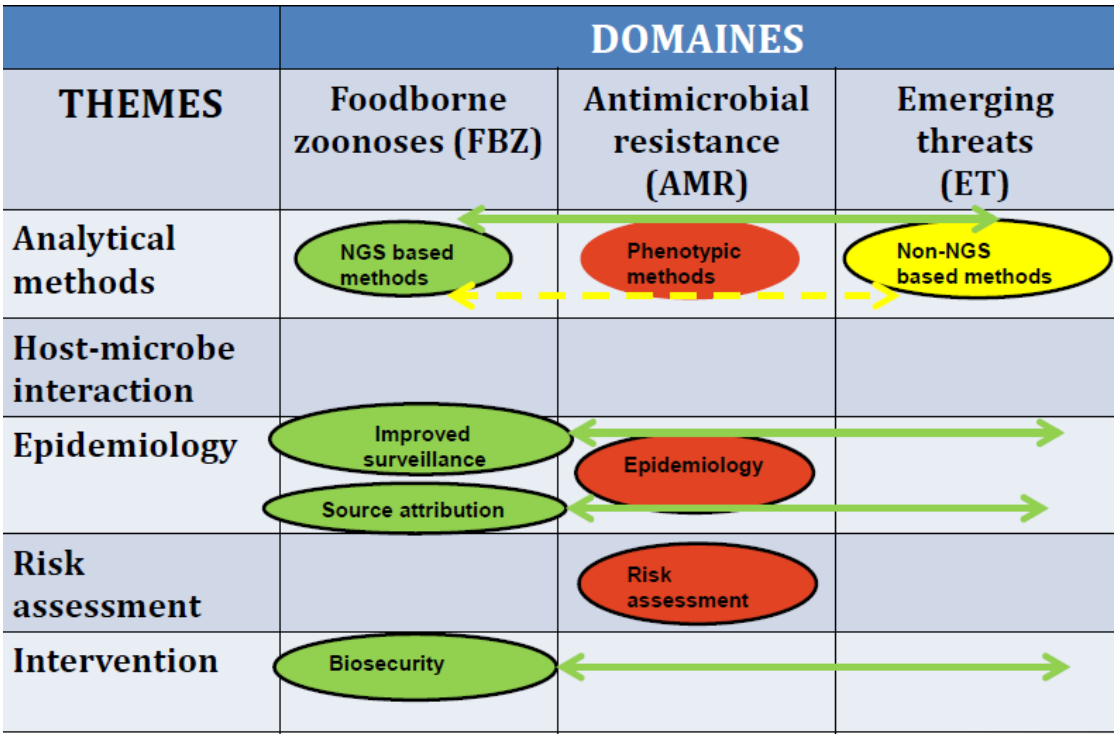
Chapter 6: Selected topics in the first internal call and outcome of this call

An overview of the topics selected by the SSB for the first internal call as well as the projects selected is presented in Table 2.

Table 2: Overview of prioritised topics and selected projects

Prioritised topics Joint research projects		**Nr LoI's**	**Project(s) selected**
FBZ-1	**Improved Surveillance**	**4**	**NOVA**
FBZ-2	**NGS-based methods**	**6**	**METASTAVA; LIST ADAPT**
FBZ-3	**Biosecurity, interventions**	**5**	**AIR SAMPLING; MoMIR-PPC**
FBZ-4	**Source attribution**	**6**	**MedVetKlebs**
FBZ-5	Risk Factors		
FBZ-6	Risk communication		
FBZ-7	Risk management options food production		
FBZ-8	Model systems		
FBZ-9	Frameworks for risk assessment		
AMR-1	**Phenotypic methods**	**1**	**IMPART**
AMR-2	**Epidemiology AMR**	**6**	**ARDig**
AMR-3	**Risk assessment AMR**	**1**	**RADAR**
AMR-4	Communication and stewardship AMR		
AMR-5	Disease burden		
AMR-6	Metagenomics		
ET-1	**Non-NGS-based methods**	**5**	**Tox-detect; MAD-VIR**
ET-2	Preparedness and response		
ET-3	Risk assessment for decision support		
ET-4	Host factors		
ET-5	Ecology of emerging pathogens.		
Prioritised topics Integration Activities		**Nr LoI's**	**Project(s) selected**
IA-1	**Surveillance data - Standardised data formats and ontologies**	**1**	**ORION**
IA- 2	**Joint platform for sharing surveillance data**	**2**	**COHESIVE**
IA-3	Joint databases of reference materials and data		
IA-4	Harmonised protocols and common best practice		
IA-5	System for sharing of best intervention practice		
IA-6	To assess equivalence between surveillance and control activities		
IA-7	Experimental facilities and models		

Figure 3: Distribution of selected priority research topics for the first call in relation to the strategy matrix.



Addendum 1: Topic descriptions

Topic FBZ-1: Improved surveillance system and harmonized data analyses

Context
Current EU surveillance systems on foodborne zoonoses, antimicrobial resistance, and emerging threats are focused on selected threats and areas. Globalization requires broader and flexible actions to detect hazards, reservoirs, vectors, trends, and routes of transmission as well as common approach and timely analysis and data sharing.

Objectives
The study should perform research that enables new surveillance approaches or facilitates evaluation and comparison of the cost-effectiveness of different surveillance systems.
This may include:

- assessments of the effects of focusing surveillance resources by using risk-based or consequence-based approaches
- assessments of potential benefit from targeted surveillance across the food chain and humans
- modelling of surveillance activities, based on existing or simulated population data, and exploration of potential new surveillance strategies
- development and evaluation of syndromic surveillance systems, and use of novel data sources
- estimation of the effect of applying harmonized pathogen/case nomenclature between countries, or animals and humans (e.g. in whole-genome sequencing for definition of cases), on surveillance design and performance

The project should also address the development of improved surveillance approaches (i.e. new types, approaches, novel methods). It should cover as much as possible specific aspects of the following issues in surveillance systems:

- propose new and/or improved types, approaches, and/or methods of surveillance
- selection and spread of antimicrobial resistance in relation to antimicrobial usage and residues (within One Health approach), and/or
- relate surveillance outcomes to public and animal health consequences (disease burden within One Health approach),
- facilitate communication (early-warning, common definitions) and timely sharing of surveillance data between partner laboratories. (link to integrative topic 5)

The research will focus on zoonotic agents of EU priority as supported by EU level prioritisation exercises, strategic research agendas or similar.

Expected results
The study should facilitate joint action of partner organizations. The project should:

- develop improved or novel approaches for surveillance (i.e. target or source orientated) schemes,
- develop and evaluate tools and methods (i.e. planning, optimal allocation of resources) for surveillance of new, neglected, or emerging threats and/or areas,
- provide improved methods to design and evaluate surveillance, and thereby ensure that surveillance capture disease occurrence in a cost-efficient way (link to integrative topic 1)

Topic FBZ-2: Development and harmonisation of NGS-based methods for detection and tracing of FBZ agents, emerging threats and AMR determinants

Context

Public health and veterinary systems are constantly burdened by potential epidemics caused by existing, new and emerging zoonoses and AMR threats. Delayed responses to crises negatively affect management of human infections, trade, food chain sustainability and food security.

The rapid growth of the sequencing technologies potentially allows delivering analytical tools for rapid identification of pathogens and AMR determinants based on characterisation of the agents and their genomes, not only on isolates but also following culture-independent strategies (ECDC: Expert Opinion on the introduction of next-generation typing methods for food- and waterborne diseases in the EU and EEA, 2015).

Objectives

The overall objectives will be to deploy a harmonized scheme, from sample preparation to results' analysis, for the use of the NGS technology for a more precise and rapid detection, characterization and tracing of FBZ agents with preference given to those considered a priority in the Zoonoses Directive, AMR determinants and emerging threats. The focus of this topic will be the detection and in silico characterisation of FBZ agents, identification and typing of AMR determinants and the study of the relationships between pathogens and the microbiota in clinical faecal/food/environment/human samples by using a metagenomics approach. All the aspects related with the strains' subtyping and comparison already included in other EC-funded initiatives are not covered by this topic. Research should be focussed on pathogens/AMR determinants of EU priority as supported by EU level prioritisation exercises, strategic research agendas or similar.

The specific goals include:

- Harmonized procedures for sample preparation, DNA-isolation, library preparation and sequencing, including the assessment of quality parameters achievable with the different platforms for NGS (research objective – link with integrative topic 2 and 3)
- The establishment of standardized and validated pipelines to extract information from raw NGS data on the detection and typing of specific pathogens, and genomic traits in genomes including virulence genes and AMR determinants (research objective - link with integrative topic 4)
- The identification of specific pathogens, potential emerging threats, in microbiota of complex specimens through culture-independent metagenomics (research objective – to be tuned with research topic AMR 10).

Expected results

- SOPs for the production and analysis of NGS data including whole genome sequencing and metagenomics (Deliverable - link with integrative topic 2).
- SOPs for identification of specific pathogens and AMR genes in complex microbial communities of e.g. clinical/faecal/food/environment samples (Deliverable - in link with integrative topic 2)
- European reference databases of markers for identification of FBZ agents, emerging threats and AMR determinants (Deliverable - in link with integrative topic 3 and 4)
- Proficiency Testing schemes on the production/analysis of NGS data (Impact on the collaboration between EJP partners - in link with integrative topic 2)

Topic FBZ-3 : Biosecurity and other interventions

Context

Introduction, transmission, development and accumulation of zoonotic pathogens, antimicrobial resistance and emerging threats in humans and animals must be detected and prevented as early as possible using suitable approaches, tools and interventions. Biosecurity (the sum of preventive measures to keep the unwanted microbes away from animals/humans/food/feed) is one of the key interventions as "prevention is better than cure".
Due to the large differences in production systems across the Med Vet sectors and countries, and taking into account the developing and changing husbandry and climate, routes of infection, different terrestric and aquatic ecosystems and niches, food production and behavioral patterns, the optimal solution in one area might not be optimal in another. It is important to validate promising practices in different countries and to perform robust, meaningful studies to provide sound evidence and avoid wasting funds on studies of insufficient power. It is also necessary to find the best ways to communicate such complex matters. As there are many microbes and problems of interest and relevance, it is important to have a broad perspective, including problems not much studied earlier.

Objectives
The overall aim is to enable authorities, the industry, veterinarians and medical doctors to take the best actions possible to prevent, or reduce as early and as much as possible, the negative consequences of food borne pathogens, emerging diseases and antimicrobial resistance. This will be achieved by providing the European community (authorities, industry) with better and more harmonized interventions and codes of best practices and a "toolbox" in case there is a need to take actions against various threats. The research will focus on pathogens of EU priority as supported by EU level prioritisation exercises, strategic research agendas or similar.

Specific aims:
- To identify and benchmark best practice systems for efficient and cost-effective biosecurity in farms, feed- and food processing units and hospitals. Other interventions to be considered can include surveillance and/or control programs, vaccination, phages, pro- or prebiotics, disinfectants, prevention of biofilm, interventions at microbial level, optimizing husbandry, food processing and medical care procedures, feeding practices and the impact on commensal microbiotas and their competitive exclusion of pathogenic agents both to reduce the burden of disease and minimizing the use of antimicrobials.
- Develop tools to evaluate cost effectiveness of interventions, and tools to evaluate the effectiveness of implemented interventions.
- To develop and evaluate novel tools for collecting and communicating data and information and for education of and communication with farmers, industry and health care workers.

Expected results
- Easily available best practice guides and scoring/evaluation systems for biosecurity measures for different production systems and stakeholders to be used as a decision support system (link to integrative topic 6).
- An easily accessible database of threats and possible interventions in different situations, including the cost effectiveness of such interventions (link to integrative topic 6).
- New intervention methods and systems for evaluation of the effectiveness of implemented interventions.

Topic FBZ-4: Source attribution and transmission routes

Context

EU foodborne zoonoses surveillance systems and antimicrobial resistance monitoring target specific threat/source combination. Having assumed zoonotic origin of relevant public health threats, systematic studies on source attribution and transmission routes have been focused on a few aspects. Improved evidence-based knowledge including zoonotic and/or anthropozoonotic transmission and human-to-human spread is needed.

Objectives
The study should:

- focus on food- and water-borne pathogens, either bacteria, viruses, fungi, parasites, as well as antimicrobial resistance and its transmissible elements, prioritized by EU level prioritisation exercises, strategic research agendas or similar
- aim at identification of reservoirs, sources, vehicles, and routes of pathogen transmission applying a One Health approach
- impose ecological approach, not limited to farm-to-fork concept, food of animal origin, or animal to human transmission. Instead, the role of environment, wildlife and non-food producing animals, globalisation (imports, travels, etc.), and/or human behaviour is anticipated,
- address human impact on ecology of pathogens and antimicrobial resistance,
- involve both conventional and novel (NGS-based) techniques,
- develop or improve pipelines or models for source attribution,
- to critically assess and improve existing models for source attribution
- facilitate an integrated approach between source and outcome by data sharing. (link to integrative topic 5)

Expected results
The project will

- improve knowledge on sources and transmission routes of pathogens and AMR determinants within ecosystems, including food chain,
- provide sound methods and baseline information to guide risk assessment and management, including platforms for sharing new approaches to attribute cases of FBZ and AMR to their sources (link to integrative topic 5)

Topic FBZ-5: Epidemiological studies: risk factors and dynamics

Context
EU foodborne zoonoses surveillance systems target specific threat/source combinations, whereas emerging threats require identification of agent and possible route of infection. In both scenarios identification of risk factors and infection dynamics might serve to improve the effectiveness of surveillance systems and optimize the use of time and resources.

Objectives
The study should focus on infectious agents included in current zoonoses and emerging threats surveillance. The project should:

- collect epidemiological metadata and metagenomic data from representative clinical cases to identify threats relevant for human or animal populations,
- determine the impact of dissemination of hazards due to movements of humans and animals, trade of goods (including feed and food), geographical and seasonal distribution, climate and demographic changes, alimentation patterns and habits on the dynamics and risks posed by foodborne and emerging threats,
- verify or identify risk factors and optimal control points for foodborne and emerging threats,
- develop models to predict pathogen transmission and dynamics related to the identified risk factors.

Expected results
The study should facilitate joint action of partner organizations. The project will

- identify risk factors for a range of foodborne and emerging threats for future prioritisation, ranking and intervention,
- assess dynamics of foodborne and emerging threats,
- demonstrate the added value through linkage with the European monitoring and surveillance managed by EFSA and ECDC
- identify optimal control points to reduce public health consequences of foodborne and emerging threats.

Topic FBZ-6: Risk communication and consumer targeted intervention strategies

Context
Foodborne zoonotic pathogens constitute an important European problem, and prevention of such diseases would lead to improvement of human health and economic benefits. Due to globalization and various selective pressures, pathogens on the European market are likely to have changed in recent years, and changing production systems create new challenges relating to pathogens in locally and globally produced food. Not all relevant pathogens can be removed before they reach the consumers, making it a necessity to look for possible interventions at consumer level and to educate consumers about possible risks.

Objectives
The overall aim is to enable consumers, authorities, the industry and the health care systems to take the best actions and interventions possible to prevent or reduce the negative consequences of food borne pathogens. Give the European community (authorities, industry) a "toolbox" regarding communication and consumer targeted interventions. The research should be focussed on pathogens of EU priority as supported by EU level prioritisation exercises, strategic research agendas or similar.

Specific aims:

- To identify the knowledge gaps, both internationally and nationally, to identify the most optimal consumer targeted interventions, and to evaluate the efficacy of the intervention strategies regarding effect on the consumers as well as barriers to their acceptance. (link to integrative topic 6)
- To investigate how to eliminate/reduce food borne pathogens in hosts/environments including possibilities to modify or change the human gut flora or immunity, e.g. by dietary strategies, prebiotics etc
- To study the most effective strategies for knowledge transfer and risk communication to the consumers, including the motivation and maintenance of awareness and compliance.

Expected results

- Increased capacity in the field of Risk communication in the participating institutions and countries. (link to integrative topic 6)
- Increased knowledge on national/regional differences in regards to communication with consumers regarding food borne risks and how to deal with such differences. (link to integrative topic 6)

Topic FBZ-7: Optimizing options for risk management and enforcement in feed and food production and processing

Context
Foodborne zoonotic pathogens constitute an important European problem, and prevention of such diseases would lead to improvement of human health and economic benefits.
In addition to various aspects linked to managing prevalence and growth of food-borne pathogens, the international trade in feed, foods and breeding animals might constitute additional challenges when it comes to risk management options.

Objectives
The overall aim is to provide European authorities and the feed and food industries with effective risk management options for prevention and/or reduction of the negative consequences of food borne pathogens.

Specific aims:
- To identify, assess and quantify risks, and to evaluate the cost benefit of various intervention methods.
- To optimize various processing steps.
- To evaluate the efficacy of various communication strategies.

Expected results
- Guidelines and/or regulations regarding consumption, trade, usage of feed and feed materials and interventions (control measures and/or treatment strategies) in the food chain for optimal risk management. (link to integrative topic 6)
- Cost benefit analyses relating to routine analysis and decisions on actions in commercial production.
- Improved ability to interpret results obtained with molecular detection methods with respect to quantifying risk and possible false positives/negatives, pathogenic/non-pathogenic, viable/non-viable strains.
- Easily accessible blueprints for improved HACCP plans in food processing.

Topic FBZ-8: Model Systems (in vitro and in vivo) to study host/food – microbe interactions

Context
- Model systems are crucial to understand the pathogenesis, emergence and spread of infectious diseases.
- The use of animal and cellular systems elicits the understanding of the outcome of a given disease and results in novel approaches to fight against diseases.
- The use of models involving interaction of microbes with food or spread in the food chain, remain an important tool to ensure consumer safety.
- Mathematical models increase our ability to understand, and ultimately predict, the behaviour of pathogens in their hosts as well as the spread of the contamination throughout the food chain and the geographic distribution of spread of disease.
- The genetic content of microbes is dynamic, and gives rise to new emerging pathogens, representing a threat to consumers and animal populations.
- The identification of virulence factors can lead to the construction of avirulent mutants and their use as new vaccines, like the novel European TB vaccine (e.g. http://www.tbvi.eu/).
- The development of alternatives to animal models is a priority in the EU and world-wide http://publications.jrc.ec.europa.eu/repository/bitstream/JRC97811/lbna27474enn.pdf

Objectives

- To develop novel in vivo models (both animal models and alternatives such as cellular systems) that reflect infection in the natural host, that opens the door to understand the pathogenesis of infectious diseases. To use these models to study the pathogenesis of microbial diseases.
- To develop models to study interaction, survival and spread of microbes in food or the food production chain.
- To develop new mathematical approaches to dissect the behaviour of microbes within a host or their geographical dissemination
- Identification of viral/bacteria/parasitic markers that characterize microbial threats for animal and/or human populations
- Identify and tackle potential pathogens in the environment.
- To characterize the interaction of microbes with their host.

Expected results
- New animal/cellular models to study infectious diseases.
- Mathematical models that describe and predict emergence and spread of food-borne pathogens from host, to food and in the food chain.
- Increase animal welfare by optimizing animal models or developing alternative approaches.
- Recognition of Virulence/Resistance markers that play an important role in fast identification of microbial threats in the food chain.
- Identification of new virulence factors or new combinations of existing factors that can lead to new drug targets against microbial pathogens.

Topic FBZ-9: Frameworks and systems for sharing tools and data for risk assessment and effective decision making

Context
Within and outside Europe, a large number of predictive modelling and risk assessment models, software tools and databases have been developed in the past decades. However, their maintenance is not always guaranteed and exchange of information between these resources is currently difficult and time consuming, which limits their application. An obvious next step is to combine the data and software tools that are available in Europe and facilitate the communication between them and the networks hosted by EFSA.

Objectives
The overall objective is to facilitate the shared use of existing risk assessment tools and knowledge bases in Europe, to allow harmonised, fast and effective decision support in Europe.
- to create a cross domain inventory of existing risk assessment and data resources; (link to integrative topics 4 and 5
- to create and apply a shared language that allows communication between these tools; (link to integrative topic 4)
- to extend and improve shared infrastructures (data standards, controlled vocabularies/ domain-specific ontologies, open source software code) that support the bridging of existing risk assessment and data resources of the EJP partners; (link to integrative topic 4)
- to enhance existing tools / database/ resources, to facilitate the seamless exchange of information between these tools; (link to integrative topic 5 and 7)
- to establish a pan European harmonised data collection and freely accessible data; (link to integrative topic 5)
- to perform demonstration and dissemination activities to showcase the successful proof-of-concept implementation;

Expected results

- Established shared infrastructure to integrate and exchange risk assessment models facilitating easy access and optimum use of existing decision support tools and newly created knowledge bases. (link to integrative topic 5 and 7)
- Evidence for added value of the common infrastructure by proof-of-concept applications in the form of prototypic examples of the implementation of an EJP knowledge base created through between-partner sharing of existing tools and models.
- Core results of the project are joint use of harmonized standards by EJP partner organisations and the joint infrastructure that provides resources that will be of immediate and future practical use when performing risk assessment to support decision making in Europe. (link to integrative topics 4, 5 and 7)

Topic AMR-1: Development and harmonization of phenotypic methods

Context
Although NGS technology has provided considerable advances in the detection and characterization of AMR determinants, phenotypic methods are still of utmost importance in routine practice, both in veterinary and human medicine. Selective media have proved to be of major interest in detecting ESBL and carbapenemase-producing bacteria but many others are lacking. Numerous emerging phenotypic technologies are proposed to physicians and vets without robust validation. Finally, rapid reliable tests for antimicrobial susceptibility testing or pathogen identification would be of help in saving antibiotics in all sectors.

Objectives
The overall objective is to stimulate the development of new diagnostic phenotypic tests for the detection or identification of AMR bacteria in humans, animals, feed, food and the environment, and to provide approved schemes and data for the validation of antimicrobial susceptibility testing methods in clinical practice, in human and veterinary medicine. All aspects related with antimicrobial susceptibility testing already included in other EC-funded initiatives (e.g. EUCAST) are not covered by this topic.

Expected results
- Rapid and cheap, high-performing, harmonized diagnostic solutions for targeted antimicrobial treatment in humans and animals. New antibiotic-enriched selective culture media which allow rapid screening of emergent resistant phenotypes and that are not covered by the existing market (colistin, aminoglycosides, …) are developed.
- Validated data on new and existing antimicrobial susceptibility testing methods brought to clinical practice in human or veterinary medicine, or to laboratories analysing food samples.
- Epidemiological cut-off values and clinical breakpoints for selected antimicrobial/pathogen combinations are determined
- Link to integrative topic 2: Harmonized methods for generating comparable data of AMR in humans, animals, feed, food and the environment are available.

Topic AMR-2: Epidemiological studies into the dynamics of AMR in human and animals populations and the environment including horizontal gene transfer and selection of AMR

Context
Although multiple efforts have been undertaken there are still knowledge gaps and inconsistencies in understanding of the epidemiology of antimicrobial resistance, i.e. its selection and spread under antimicrobial usage pressure in different ecological settings. Geographical differences, temporal trends, variable farming, environmental reservoirs, wildlife, farm and companion animals as well as

human colonization, anthropogenic impact on the abundance of resistance in the environment, and factors promoting or mitigating resistance transmission need systematic studies.

Objectives
The study should add to, but not replicate, current knowledge. Multidisciplinary approach including microbiology, genomics (i.e. WGS), epidemiology should address several of the below areas:

- Investigate geographical differences and trends in antimicrobial usage and resistance in the environment, human (including exposure groups) and animal populations, based on current, available monitoring programmes in the EU.
- Study the influence of animal management (including antimicrobial usage) on the occurrence and spread of resistance,
- Clarify associations between consequences of antimicrobial usage and levels and spread of resistance; develop appropriate methodologies.
- Study associations between antimicrobial usage and resistance in bacteria from food animals, companion animals and humans
- Study associations between resistance mechanisms in bacteria of environmental, animal and human origin,
- Special attention should be payed to multidrug and emerging resistances, as well as resistance to critically important antimicrobials for human and animal treatment,
- Study the origin and transmission dynamics of resistant bacteria (i.e. import versus local selection, zoonotic versus anthropogenic versus environmental)
- Study clonal spread of resistant bacteria versus horizontal gene transfer in the dissemination of resistance within One Health approach. These might include fitness cost studies.

Expected results
The results are expected to provide evidence on the epidemiology of resistance, namely:

- a better description of reservoirs and vectors of resistance,
- increased knowledge on environmental, geographical and demographic risk factors, drivers and catalysers of selection and trends in resistance,
- more awareness of the ecological consequences of antimicrobial usage,
- increased knowledge on the dynamics and transmission routes of AMR for future prioritisation and interventions.
- Models, instructions or guidelines are developed that enable to study the link between antimicrobial usage and resistance.

Topic AMR-3: Risk Assessment AMR

Context
It is the nature of AMR that it is constantly evolving. Therefore, risk assessments need to be regularly updated and adapted to new potential hazards. However, AMR is not only evolving in animal husbandry and the food chain but likewise in the human population. One major challenge is therefore to determine the contribution of the livestock sector and the environment to the overall burden of AMR. This necessitates the analysis of the drivers of AMR in animal populations and the environment, transmission in the microbial community and along the food chain. Furthermore, means to evaluate interventions to mitigate the risk are needed, so the impact on AMR in the human population can be assessed.

Objectives
Projects in this field will address the relative and absolute contribution of animal and environmental sources to the public health burden of AMR, including variability between bacterial species, by using risk assessment. They will link data on antimicrobial consumption and the effects of different kinds of

antimicrobial use on AMR in animal husbandry. They will model the spread of resistance determinants in microbial communities, the environment and along the food chain and their effect on exposure of humans. Projects will include the development of generic models of spread that may be adapted to various bacterial species and resistance determinants. They will also make use of knowledge gained in the framework of other projects such as EFFORT or ESCAPE

Expected results

- Improved understanding of the association between antimicrobial use and resistance
- Tools to predict microbial development (survival and transmission) through the food chain, including the effect of processing steps
- Generic RA-models applicable and adaptable to various AMR determinants
- Increased understanding of the role of the environment in dissemination of antimicrobial resistance and human exposure

Topic AMR-4: Communication and Stewardship AMR

Context

Communication with stakeholders and stewardship of antimicrobial usage form an important component of the strategy to combat antimicrobial resistance and preserve the effectiveness of antimicrobials in both man and animals. The responsible use of antimicrobials in animals is promoted at the national level in European countries, as well at the European level, for example by the European Medicines Agency (EMA) and European Platform for Responsible Use of Medicines in Animals (EPRUMA). The development of robust, evidence-based guidelines in animals is not however as advanced as in man. Interventions to improve prescribing practices and develop optimal communication strategies in animals are required, as well as the development of interventions (guidelines and advice) based on a robust evidence-base, which consider the principles developed in human medicine and those issues specific to animals. The impact of different prescribing practices in both animals and man on the development of antimicrobial resistance is a component of the evidence-base on which appropriate interventions may be recommended.

Objectives

- Development of robust, evidence-based, antimicrobial stewardship guidelines for animals.
- Provision of detailed case or scenario studies, providing examples of successful or beneficial outcomes in relation to selected animal disease conditions.
- Collaboration between medical and veterinary sectors to assimilate best practice developed in human medicine into veterinary medicine (link to integrative topic 6).
- Determining the most effective routes of communication with stakeholders, and influencing stakeholder behavior to promote responsible use.
- Development of systems to monitor adverse consequences of adoption of antimicrobial stewardship guidelines including negative effects on animal productivity, welfare or costs of production.

Expected results

- Development of evidence-based antimicrobial stewardship guidelines for animals.
- Cross-collaboration between medical and veterinary specialists to optimize stewardship guidelines (link to integrative topic 6).
- A repository of case / scenario studies providing practical examples of beneficial outcomes.
- Identification of the optimal routes of communication with stakeholders.
- Clear identification of adverse consequences.

Topic AMR-5: Disease burden, socio-economic consequences and risk ranking

Context
Disease burden is increasingly studied, particularly to inform risk management strategies. The recent publications on the global disease burden of foodborne disease have shown the relevance and potential of quantitative disease burden estimation, among others as a basis for risk prioritization. These latest developments also highlighted current challenges in estimating the burden of some foodborne diseases, particularly associated with AMR and other emerging threats. Due to the complex transmission and health consequences, these require further method development, for which for example new generation sequencing typing offers new opportunities. Furthermore, the need to extend current burden of disease estimations by incorporating socio economic consequences is widely recognized. By integrating health, economic and social impact assessments (applying e.g. multi-criteria decision analysis), and develop a method that can be applied in different countries, comparative risk rankings can be performed across the EU.

Objectives
- Develop models to estimate the burden of disease associated with AMR determinants and pathogens, for example by making use of available NGS data.
- Develop a general multi-criteria framework for decision making that can take into account different factors like human and animal health burden, environmental impact, as well as socio-economic factors and allows for a harmonised risk ranking approach across Europe.
- Develop risk ranking methods and perform risk ranking for foodborne diseases, including pathogens, viruses, parasites, AMR determinants and bacteria, as well as emerging threats, applying this general multi-criteria decision framework.

Expected results
- Development of models to estimate the burden of disease of AMR determinants and zoonotic pathogens of relevance in the EU in animal and human populations.
- Development of harmonised risk ranking methods for FBZ, AMR and ET;
- Disease burden estimates and risk ranking of foodborne diseases, including AMR determinants and bacteria and other pathogens in different European countries;
- Multi-criteria risk ranking applied in several case studies for FBZ, AMR and ET.

Topic AMR 6: Metagenomics and bioinformatics for detection and surveillance of AMR pathogens and determinants

Context
The development of the NGS technology has given access to a deep characterization of genomes of isolated AMR bacteria and allowed new insights in deciphering the spread of AMR determinants among pathogens and/or commensals in humans and animals. On the other hand, culture-independent strategies referred to as metagenomics provide new and global approaches to investigate the distribution and features of AMR determinants from complex microbiota and are promising (ECDC: Expert Opinion on the introduction of next-generation typing methods for food- and waterborne diseases in the EU and EEA, 2015).

Objectives
The overall objective is to enforce WGS metagenomics approaches in the monitoring of AMR development in complex microbiota recovered from relevant sites under selective pressure with antibiotics. This would include specific expected hotspots of AMR selection such as at hospital or farm level, or in the environment. The objectives should be tuned with FBZ-2, 'NGS-based methods'.

Expected results

- Production of quantitative WGS metagenomic data in geographical sites of human or veterinary (or combined) relevance
- Correlation of metagenomic data with antibiotic usages and other risk factors
- Tools for quantification of AMR determinants in metagenomic data
- Link to integrative topic 2: develop harmonized protocols for metagenomic analysis in various matrices.

Topic ET-1: **Development and harmonisation of non-NGS-based methods for detection of FBZ agents and emerging threats**

Context
Public health and veterinary systems are constantly burdened by potential epidemics caused by new and emerging zoonoses, either food-borne or not. The methods used to detect zoonotic agents are often long and cumbersome and do not cover the entire spectrum of threats. The lack of rapid and comprehensive analytical approaches negatively affect management of human infections, trade, food chain sustainability and food security.
Technology increasingly allows developing or re-directing analytical methodologies for the detection of pathogens, which are more rapid and reliable than the standard approaches based on cultural strategies and potentially can cover pathogens that are currently not identifiable or misdiagnosed. Such technologies have the potential to deliver rapid assays on platforms applicable to field use such as bed/farm/pen-side tests, as well as in the food production chain.

Objectives
The overall objectives will be to fill the gaps in the knowledge of the methodologies alternative to standard PCR or cultural isolation applicable to food-borne zoonoses and emerging threats. The research will focus on zoonotic agents of EU priority as supported by EU level prioritisation exercises, strategic research agendas or similar. The setup of methods not based on NGS and harmonized scheme for their use will be the main focus of the call, with emphasis on the development innovative sampling or sample preparation techniques.

Specific aims:
- The development of approaches for the pheno/genotypic (non-NGS-based) detection of new zoonotic agents and emerging threats covering all the process from sampling to sample preparation and analysis of results (research objective)
- The development of rapid and reliable non-NGS-based tools for the detection of new zoonotic agents and emerging threats at bed/pen/farm-site or other locations in the food production chain (research objective)
- The optimisation and validation of existing and newly developed methods for the pheno/genotypic (non-NGS-based) detection of new zoonotic agents and emerging threats (research objective- in collaboration with integrative topic 3)

Expected results
- Harmonized procedures for pheno/genotypic detection of new zoonotic agents and emerging threats (Deliverable).
- Validated, rapid and reliable non-NGS-based methods for pheno/genotypic detection of new zoonotic agents and emerging threats (Deliverable).
- Proficiency Testing schemes for the assessment of the performance parameters of the optimised/developed methods for the pheno-genotypic (non-NGS) detection of new zoonotic agents and emerging threats (Impact on the collaboration between EJP partners- in collaboration with integrative topic 3)

Topic ET-2: Improving preparedness and response

Context

Natural disasters and microbiological threats are often unpredictable, nevertheless we want to try to reduce the effects they can cause by trying to detect and identify them and as much as possible eliminate or prevent them. In spite of implementation across Europe of networks (EWRS, EMERGE, ENIV, RASFF) for signaling of microbiological threats, including imported emerging pathogens, food-transmitted or zoonotic, and exchange information, there is still potential for improvement of preparedness and response to such threats. It should be pointed out that new microbiological threats may be a result of changes in human behavior, as well as implementation of new processing or preservation methods (food, water) but also differences in national regulations. There is a need to develop methods and tools suitable to early detection, identification and control of emerging threats but specially to fast and appropriate decision making and effective response.

Objectives

The main aim is to build integrated capacity for European public health and veterinary laboratories to detect, control and prevent emerging diseases in the Europe. The activities to be undertaken within the scope of this part of the EJP, focused on improving preparedness and response to emerging threats, might encompass the following actions:

- Development of methods and tools to early identify, detect and control emerging threats, – including novel tools for data collection, analyses and data sharing - in cooperation with established networks like EMERGE, ENIVD, EWRS, IHR; focused on microbial, zoonotic, food-borne bacterial, viral and parasitic threats as well as on their emerging AM mechanisms or virulence patterns. The main goal will be to develop tools that will be effective in spite of the well-known phenomenon of high variability and variety of microbial threats as well as different carriers or way of transmission.
- Development of modern methods/tools for decision making and intervention: evaluation of already established methods/tools including their compatibility to national regulations and systems across Europe as well as Europe networks; optimization and validation of developed methods/tools; training.

Expected results

Building of an integrated European - broad surveillance - response program, based on a MedVet EJP network, to detect, control and prevent emerging diseases appearing in Europe or potentially introduced in Europe will be the main goal of the project. The main goal of this part of project: improvement preparedness and response to emerging threats is expected by:

- developed modern and integrated tools / algorithms for early detection and control of emerging threats (animal-, feed-, food-, water- or environment transmitted), as well as for crisis communication, decision making and response across Europe (link to integrative topics 4 and 5);
- Evaluation of effectiveness of response to different emerging threats in Europe;
- Preparedness plan/plans to respond to potential emerging threats in Europe connected to animal-, food-, water- or environment transmission.

Topic ET-3: Applying risk assessment/modelling methodologies to support decisions for the control of emerging threats, foodborne zoonoses and antimicrobial resistance

Context

In the past decades, risk assessment modelling has been developed and applied in a number of European countries, mainly for microbial hazards like *Salmonella, Campylobacter* and *Listeria*. As a next step, it is important to further develop and apply risk assessment methods in the area of foodborne zoonoses and for a broader range of hazards, including emerging threats, antimicrobial

resistant bacteria, viruses and parasites. These risk assessments should be aimed at decision support, including cost benefit analyses, cross- border animal movement and trade with feed and food.

Objectives

- To develop a decision support framework for the different cases (foodborne zoonoses, emerging threats, AMR, animal disease, etc.) to inform what types of assessments are needed
- To further develop relevant novel risk assessment methods for adequate, rapid and fit for purpose decision support for the control of emerging threats, foodborne zoonoses and antimicrobial resistance, taking advantage of novel methods for identification and characterization of hazards.
- To perform international risk assessment case studies, including cross national animal movement and trade with feed and food.
- To strengthen the collaboration between EJP partners in the area of risk assessment, by building shared tools and harmonising data collection (link to integrative topics 4 and 5)

Expected results

- The project will provide novel risk assessment toolboxes for EJP partners, provide capacity building between them and strengthen the tools for rapid decision support. (link to integrative topics 4 and 5)
- Novel risk assessment methods that allow the inclusion of NGS and metagenomic data, as well as improved hazard characterisation.
- Novel risk assessment tools for specific microbial hazards (e.g. Toxoplasma), emerging threats (e.g. models for their introduction and spread, and the impact of reactions to early detection) and the spread of antimicrobial resistance
- Specific relevant pan-European risk assessments performed to support control of emerging threats, foodborne zoonoses and antimicrobial resistance.

Topic ET-4: Host factors associated with colonization, persistence and disease

Context

The elements defining host specificity of microbes is poorly understood. Crossing of the species barriers represents a crucial event in emergence of known and novel diseases. Understanding the host factors that determine the flow between carriage, persistence and disease represents a major challenge to develop effective control measures of given pathogens. Recent evident suggests that the microbiota may be involved in host specificity.
The project proposal should clearly indicate that the work has not been done in the context of other EU projects.

Objectives

- To help elucidate our knowledge on the host factors that determine host specificity.
- To better understand humoral/cellular immune response and its implementation to control microbial infections and its role in latency/sub-clinical infections.
- To increase our understanding of the relevance of the microbiome and the host specificity of microbes.
- To study pathogen virulence factors that are associated with colonization, persistence, latency and disease
- To unify efforts within the EU to tackle spread of microbes to new hosts.

Expected results

- Increased knowledge on host factors associated with colonization, persistence and disease

- Link to integrative topic 3: Multi-microbial experts will share knowledge to create a multi-microbial hub to share knowledge and techniques to study host specificity.

Topic ET-5: Ecology of emerging pathogens

Context
In order to prevent and control emerging pathogens that are zoonotic and foodborne, knowledge about pathogen transmission between human and animal populations and the environment is essential. This includes knowledge about disease dynamics within populations, and the interface between populations (human, livestock, or wildlife) and the environment.

Objectives
Studies may focus on both emerging and re-emerging pathogens, including currently unknown hazards, and should include as much as possible the following objectives:
- Identify determinants of spread and persistence of foodborne zoonoses in wildlife reservoirs or the environment
- Investigate factors (and links between these) that may favour the emergence of foodborne zoonoses, e.g. pathogen virulence, global trade with food and foodstuffs, high population densities and degree of contact between populations (animal-animal, food-human, human-animal)
- Develop, parameterise and use disease spread models that capture transmission within and between relevant parts of the ecological system (e.g. human-animal, domestic animals-wildlife, human or animals-environment, or pathogen-individual-herd-population)
- Understand the role of mobile genetic elements in the ecology and emergence of new pathogens
- Use molecular epidemiology to study host dynamics and to reconstruct high resolution transmission trees
- Assess the importance of transmission pathways across the ecological system
- Investigate transmission links and spatiotemporal trends of cases of emerging disease

Expected results
- Identification of transmission routes and potential interface of disease spread across parts of the ecological system
- Improved ability to optimise surveillance and disease control
- Identification of data requirements and knowledge gaps in the ecology of emerging pathogens
- Identification of host-pathogen-ecology-combinations that constitute a higher risk if pathogens are introduced

Integrative topic 1: Common frameworks for design and methods to assess equivalence between surveillance and control activities

Context
- Surveillance activities vary in nature between the Med-Vet sectors, where the former is usually passive in nature whereas the former often involves active surveillance activities. There is no joint framework for the integrated design and evaluation of cost-efficient surveillance along the food chain and across the Med-Vet interface.
- Such a framework would provide the necessary guidance and ensure that surveillance, incl. official controls, is more transparent, comparable, cost-efficient and meets societal needs.
- Certain animal health surveillance objectives (case finding, prevalence estimation, early detection) show many similarities with the objectives of official controls in the food chain, for example in the application of risk-based approaches. However, whereas the former has

increasingly moved towards output-based standards, such standards are still lacking for many areas of official controls, or are not being applied.

Objectives

- To conduct an inventory of existing frameworks for design and evaluation of surveillance, incl. official controls
    - To complement and adapt such frameworks for surveillance of food-borne zoonoses, antimicrobial resistance and emerging threats across the Med-Vet sectors
    - To apply the frameworks in selected partner countries, for prioritised hazards in all domains.
    - To evaluate drivers and constraints to adoption of the frameworks and adapt them accordingly.
- To apply frameworks for assessing equivalence between national control programmes, incl. programmes that are part of official controls, for prioritized hazards in all domains.

Expected results

- Existing frameworks for design and evaluation of cost-efficient surveillance are adapted for use across the Med-Vet sectors
- At least four inter-sectoral surveillance activities for prioritised hazards have been designed or redesigned using the frameworks, leading to increased cost-effectiveness.
- The frameworks are regularly applied in at least four MS and forms an integral part of the surveillance policy cycle, leading to higher quality surveillance output and better official controls at the EU level.

Integrative topic 2: Harmonized protocols and common best practice

Context

- For all relevant hazards in the chain from feed to food, European Union Reference Laboratories (EURLs) are established. Their function is to ensure MS have the national capacity to carry out relevant laboratory investigations for the hazards in question. No such structure exists on the public health side, and some pathogens of relevance do not have an EURL.
- There is a rapid transition to NGS methods for typing of foodborne pathogens, and for characterising resistance mechanisms.
- In order to increase the usefulness of NGS and non-NGS data nationally and internationally, there is a need for harmonisation by agreement on common strategies and protocols.

Objectives

- To conduct a needs assessment for identification of methodological fields in prioritised need of harmonisation across the Med-Vet interface.
- Based on the needs assessment, develop harmonised protocols for detection and typing of foodborne pathogens and AMR determinants.
- Implement harmonised protocols for detection and typing of foodborne pathogens and AMR determinants.

Expected results

- An action plan describing the state of the art with regard to harmonisation of laboratory methods across Europe, including a list of prioritised fields.
- Harmonised protocols for detection and typing of prioritised foodborne pathogens and AMR determinants are developed and implemented in all partner institutes.
- Mechanisms for ensuring prospective harmonisation in the implementation of new methods for detection and typing of foodborne pathogens and AMR determinants.

Integrative topic 3: Joint databases of reference materials and data, incl. metadata

Context

- Databases of reference materials as well as sequence databases exist nationally and in some cases also at the EU level.
- Such data are poorly accessible across the MedVet sectors, often due to issues with data sharing.
- Well defined reference materials or reference data are necessary for test development, for use in proficiency testing or for use in the tracing of outbreaks. These include strain collections as well as sequence collection of genomes, virulence, resistance genes and mobile genetic elements.

Objectives

- To conduct and inventory of national strain collections and associated sequence databases, for hazards in all domains.
- To define procedures for alignment and sharing of sequence data.
- To complement existing platform for storage of and access to sequence data, for hazards in all domains

Expected results

- An EU-wide overview of relevant national biological materials
- Common standards for recording of epidemiological data and metadata for biological materials
- Common standards for data sharing
- A joint platform for storage of and access to sequence data, for hazards in all domains

Integrative topic 4: Interpretation of surveillance data - Standardized data formats and ontologies, common tools and procedures for data analyses, including interpretation of sequence data.

Context

- There is a rapid transition to NGS methods for typing of pathogens, and for characterising resistance mechanisms. Still, there is, in practice, limited use of such data in routine surveillance or for outbreak investigations, due to challenges in interpretation of the data.
- The use of big data for early detection provides an opportunity. Such data are by nature heterogeneous and difficult to interpret. Semantic web techniques can be used to query such data, but the necessary ontologies are still under development.
- Code for analyzing surveillance data, including the development of algorithms for detection of aberrations are available in the public domain. A wider implementation of these methods can enhance joint surveillance capacity and facilitate reporting to stakeholders such as EFSA, ECDC and OIE.

Objectives

- To carry out an inventory of the current practice with regard to data collection and methods for interpretation of surveillance data (including epidemiological and microbiological data; also sequence data).
- To perform a terminology mapping to create a semantic network between the different systems. Creation of an initial map to link different terminologies/thresholds. Work with the stakeholders to resolve the ambiguous and unmapped items.
- To provide an overall architecture of a surveillance programme (guidelines) with the highest level of harmonization with either international standards, if available, or a uniform approach to collection, management and analysis of data that acknowledges the requirements for national reporting to relevant EU bodies.

Expected results

- An action plan describing the state of the art with regard to harmonisation of the interpretation of surveillance data.
- Initial map linking different terminologies/thresholds.
- Pilot study: implementation of the provided surveillance guidelines in those pairs of Med-Vet partners in order to extend to the rest of MVN partners after evaluation.

Integrative topic 5: Common reporting and signaling procedures, joint platform for sharing surveillance data and their interpretation, incl. risk assessments

Context

- The reporting of outputs from health surveillance systems should be done in a near real-time and interactive manner in order to provide decision makers with powerful means to identify, assess, and manage health hazards as early and efficiently as possible.
- Surveillance systems with an early warning function mainly serve to provide data that can be used to detect and respond to outbreaks or public health threats in a timely and appropriate manner.
- Reducing the lag between data collection and health action is not an easy task and requires a chain of events from the initial sampling procedure, to laboratory testing, database entry, data analysis, and information dissemination to achieve a dynamic process.
- Signals could be heterogeneous, i.e. not only based on passive and active surveillance, but also on information obtained on events and trends through horizon scanning.
- In order to support the function of reporting and feedback in any surveillance system, an appropriate and effective medium for communication at each level of surveillance should be defined, instituted and maintained. Evaluation could determine the emerging needs of communication facilities at different levels of surveillance are being met.

Objectives

- To conduct an inventory of existing joint platforms within partner institutes and at EU level, used for sharing and visualising surveillance data, including horizon scanning information, nationally and internationally, launching early warning and conducting risk assessments.
- To support alignment with existing EU initiatives (EFSA, ECDC) for communication of surveillance data.
- To facilitate transfer of experiences with early warning and risk assessment across MS and across the Med-Vet interface, by identifying context-specific best-practice.
- To analyse the existing systems to propose the best practice to define baselines, to detect signals, and to communicate to stakeholders and the public.

Expected results

- An EU overview of existing platforms to share surveillance data, common reporting, signalling procedures and performance of risk assessments.
- All partners have the necessary resources and competence to contribute timely to situation awareness regarding endemic and emerging pathogens at EU level

- To identify context-specific best-practice to share among MS by means of joint training activities.

Integrative topic 6: Mentoring (twinning) system for sharing of best intervention practice

Context

- Approaches to the control of transmission of foodborne zoonoses, antimicrobial resistance and emerging threats differ depending on biological, epidemiological, technical and socio-economic preconditions.
- The palette of control options available in the Med and Vet sectors, and geographically, also vary due to differences in policies, organizational structures and for financial reasons.
- As a result, the hazard situation varies across MS, and so does the national experiences with control of different pathogens at different stages along the food chain.

Objectives

- To carry out an inventory of the current practice with regard to interventions, for hazards in all domains.
- To facilitate transfer of experiences with interventions across MS by identifying context-specific best-practice.
- To build a mentoring/twinning network to allow active sharing of knowledge on best-practice interventions.

Expected results

- There is an overview of what interventions are in place across the Med-Vet sectors to prevent transmission of prioritised hazards in all domains
- Context-specific best-practice has been identified and is shared among MS by means of twinning activities.

Integrative topic 7: Aligned use of experimental facilities and models (of transmission, ecology, risk assessment etc.)

Context

- An FP7-funded project for organizing European animal infectiology centers to achieve economies of scale and modernize existing facilities (NADIR) was concluded in 2013, with many but not all EJP partners.
- Computer models are widely used to understand biological processes that subsequently inform approaches to prevention and control. The development of generic and/or common modeling frameworks can enhance transparency, communication and usefulness of model output in informing national and EU policies.
- Data abundancy allows for the development of data-driven modeling approaches; however, computational capacity is becoming a bottleneck which calls for more efficient code and algorithms.

Objectives

- To integrate additional EJP partners into the Network of Animal Disease Infectiology Research Facilities (NADIR).
- To conduct an inventory of modelling frameworks available within partner institutes, that are used to inform surveillance and control activities and for conducting risk assessments.
- To identify or develop modelling frameworks that meet prioritised needs of all EJP domains.
- To make such modelling frameworks available for research and routine work via a relevant platform format.

Expected results

- An active EU wide network of BSL-3 facilities for studies of animal infectious diseases.
- An action plan describing the state of the art with regard to availability of models of relevance to the EJP across Europe, including a list of prioritised fields for development.
- A joint platform where modelling frameworks for the design of surveillance and control activities, as well as for risk assessments, can be accessed and maintained.

Addendum 2: Experts workshop, ANSES, May 2016

Participating countries and partners in the experts workshop (40 organisations including 3 (Linked) Third Parties from 16 countries.

countries	partners			
Austria	AGES			
Belgium	CODA-CERVA	WIV-ISP		
Bulgaria	NCIPD	NDRVMI	SAIM-BAS	
Czech rep	NIPH	VRI		
Denmark	SSI	DTU		
France	Anses	InVS	INRA	IPP
Germany	BfR	RKI	FLI	
Hungary	VMRI	NCE		
Ireland	UCD	NUI Galway		
Italy	ISS	IZSAM	IZSLER	
Netherlands	RIVM	CVI (WUR)	NCOH	
Norway	NVI	FHI		
Poland	PIWet	NIZP-PZH		
Spain	ISCIII	VISAVET-UCM	INIA	
Sweden	SVA	NFA	PHA	
UK	APHA	PHE	Surrey	

Participants experts workshop:

Chirstian Kornschober, Klemens Fuchs, Nadine Botteldoorn, Iva Christova, Sarah Welby Steven van Borm, Ralista Popova-Ilinkina, Stayanka Stoitsova, Maarten Nauta, Barbora Macková, Renata Karpíšková, Karen Krogfelt, Henrik Hasman, Jeffrey Hoorfar, Didier Mazel, Jean-Yves Madec, Pascal Hendrikx, Philippe Velge, Karsten Nöckler, Bernd-Alois Tenhagen, Heinrich Neubauer, Ákos Tóth, Zoltán Zádori, Katarzyna Pancer, Dearbhaile Morris, Akke Vellinga, Lynda Gun, Stefano Morabito, Annalisa Pantosti, Paolo Calistri, Giovanni Alborali, Johan Bongers, Joke van der Giessen, Barry Rockx, Dik Mevius, Armin Elbers, Diana Leonhardt, Solveig Jore, Merete Hofshagen, Aleksander Masny, Dariusz Wasyl, Artur Rzezutka, Isabel Cuesta, Ana Alastruey, Bruno González-Zorn, Miguel Angel Jiménez, Jenny Frossling, Cecilia Jernberg, Jakob Ottoson, Marianne Elvander, Karl Ståhl, Roland Lindqvist, Dilys Morgan/Leslie Larkin**,** Rob Davies, Chris Teale, Dan Horton, Alex Cook, Arjen van de Giessen, Maria Perteger, Hein Imberechts, Ann Lindberg, Roest, Hendrik Jan, Silvia Herrera, Roberto Laragione, Wim van der Poel, Arvand Mardjan, Christian Herzog, Eniko Ban, Martijn Bouwknegt, Andre Jestin, Arnaud Callegari.

Contributions in drafting the descriptions of the research themes (chapter 4), integrative activities (chapter 5) and the topic descriptions (addendum 1): Karen Krogfelt, Dariusz Wasyl, Stefano Morabito, Merete Hofshagen, Bruno Gonzalez-Zorn, Maarten Nauta, Jean-Yves Madec, Bernd-Alois Tenhagen, Chris Teale, Katarzyna Pancer, Jenny Frössling, Dan Horton, Ann Lindberg, Maria Perteger, Hein Imberechts, Roest, Hendrik Jan, Silvia Herrera, Roberto Laragione, Wim van der Poel, Andre Jestin, Arjen van de Giessen, Johan Bongers.

Experts workshops (Multiple-criteria decision analysis meeting) has been funded by ANR grant:
"Montage de réseaux scientifiques européens ou internationaux MRSEI" Ref : Projet ANR-16-MRSE-0008-01

Addendum 3: Domain-theme-area secretaries

	Foodborne zoonoses Karen Krogfelt		**Antimicrobial resistance** Jean-Yves Madec		**Emerging Threats** Dan Horton	
Analytical methods Stefano Morabito	Stefano Morabito	ISS	Jean-Yves Madec	ANSES	Dan Horton	Surrey
Host-microbe interaction Bruno Gonzalez-Zorn	Karen Krogfelt	SSI	Bruno Gonzalez Zorn	VISAVET-UCM	Philippe Velge	INRA
Epidemiology Dariusz Wasyl	Paolo Calistri	IZSAM	Dariusz Wasyl	Piwet	Jenny Frössling	SVA
Risk Assessment Maarten Nauta	Maarten Nauta	DTU	Bernd-Alois Tenhagen	BfR	Pascal Hendrikx	Anses
Intervention Merete Hofshagen	Merete Hofshagen	NVI	Chris Teale	APHA	Katarzyna Pancer	NIZP-PZH

List of Abbreviations

AMR	AntiMicrobial Resistance
EJP	European Joint Programme
ET	Emerging Threats
FBZ	Food Borne Zoonoses
JIP	Joint Integration Projects
JRP	Joint Research Projects
NGS	Next Generation Sequencing
MCDA	Multi Criteria Decision Analysis
MS	Member States
RA	Risk Assessment
SSB	Scientific Steering Board
WGS	Whole Genome Sequencing