



D2.8 Report on scientific developments and opportunities for innovation

WP 2 SRA

Responsible Partner: RIVM

Contributing partners: UCM



GENERAL INFORMATION

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Introduction

The growth of One Health-oriented research initiatives has led to a progressive erosion of traditional monodisciplinary “silos of knowledge”, with a measurable increase in multidisciplinary collaborations to improve human, animal, and environmental health.¹ Yet, the three main branches of knowledge of One Health (i.e. medical, veterinary, and environmental sciences) and the individual disciplines in each of them (e.g. microbiology, epidemiology, ecology, etc.) are still very much needed. Moreover, their relative importance to the overall goal is expected to vary, depending on the specific topic (e.g. foodborne zoonoses, antimicrobial resistance, emerging threats, etc.), the importance they ascribe to the objectives, and the specific (geographical and temporal) context they find themselves in.²

The continuous endeavor to integrate knowledge from different domains and disciplines, while giving the necessary importance to all relevant viewpoints in the collective work of OHEJP, is crucial to improve our ability to prevent and respond to zoonotic threats and antimicrobial resistance. In recent years, One Health-oriented research has developed rapidly in different directions, even within the OHEJP consortium itself. As new trends in One Health research emerge and others evolve, it is important for OHEJP to monitor the scientific developments to understand where the One Health community is mainly focusing on (i.e. the research hotspots or “hot topics”). Probably most importantly, this is also relevant to identify the potential gaps that are present in the current SRA, as well as the changing (national) research priorities of the OHEJP partners, as to identify new opportunities for innovation in One Health research for whatever will come after OHEJP. In this Deliverable 2.8, we present the results of the activities undertaken by WP2 (SRA) in order to address these goals. These activities can be summarized as follows.

1. **Gap analysis of the second round priority topics** → to identify what is still left to do within OHEJP based on the activities that have been prioritized and funded.
2. **Analysis of current One Health research hotspots** → to identify what are now the ‘hot topics’ in One health research, both within and outside the consortium.
3. **Rapid consultation of the partners** → to identify new/different (national) priorities in the consortium.

1. Gap analysis of the second round priority topics

Objectives

This gap analysis was meant to:

- identify potential gaps between the objectives of the selected priority research and integrative topics, and the objectives of the research and integrative projects that were granted in the second round of proposals;
- identify gaps in One Health research and/or integrative areas that have not been (sufficiently) covered by the OHEJP;
- identify key outputs/unique selling points of OHEJP (e.g. scientific approaches and innovations, guidelines, databases developed, etc.) that would benefit future partnerships.

Procedure

¹ Manlove, K. R., Walker, J. G., Craft, M. E., Huyvaert, K. P., Joseph, M. B., Miller, R. S., ... & Cross, P. C. (2016). “One Health” or three? Publication silos among the One Health disciplines. *PLoS biology*, 14(4), e1002448.

² Xie, T., Liu, W., Anderson, B. D., Liu, X., & Gray, G. C. (2017). A system dynamics approach to understanding the One Health concept. *PLoS One*, 12(9), e0184430.



The gap analysis was performed by the WP2 team based on the SRA/second call for project proposals and the project descriptions. Moreover, input from the project leaders themselves was asked, as they had the best knowledge to assess the extent to which the specific objectives of their projects are going to be met and what is still to be done compared to what was considered originally (i.e. additional objectives).

In total, 9 priority research topics and 3 priority integrative topics were assessed. These were the topics selected for the second OHEJP call for project proposals. Within these topics, a total of 13 joint research projects and 3 joint integrative projects were granted, as follows:

Foodborne zoonoses

- **Topic FBZSH3:** *Source attribution of bacterial foodborne zoonoses and antimicrobial resistance considering also the environment and non-livestock reservoirs (e.g. pets and wildlife) as sources.*
 - **Project DiSCoVer:** Discovering the sources of *Salmonella*, *Campylobacter*, VTEC and antimicrobial resistance.
- **Topic FBZ3.1:** Benchmarking biosecurity practices for pig farming across Europe using national surveillance data and management standards for identifying best practice to prevent biological hazards, particularly *Salmonella* and hepatitis E virus, from entering the food supply chain.
 - **Project BIOPIGEE:** Biosecurity practices for pig farming across Europe.
- **Topic FBZ4.1:** Source attribution and transmission routes of foodborne pathogens other than bacteria, with emphasis on *Toxoplasma gondii*.
 - **Project TOXOSOURCES:** *Toxoplasma gondii* sources quantified.
- **Topic FBZSH5:** Determinants of the reversal of the decreasing trend in *Salmonella* incidence in humans and poultry in the EU.
 - **Project ADONIS:** Assessing Determinants of the Non-Decreasing Incidence of *Salmonella*.
- **Topic FBZSH9:** Better tools for detection and investigation of foodborne outbreaks, including antimicrobial resistant pathogens, as well as economic assessments of potentially increased cluster detection through whole genome sequencing.
 - **Project BeOne:** Building Integrative Tools for One Health Surveillance.

Antimicrobial resistance

- **Topic AMRSH5:** Development of new tools for early (real-time) detection of resistant pathogens in humans and animals, as well as new diagnostic tools, in particular on-site tests for humans and animals.
 - **Project FARMED:** Fast Antimicrobial Resistance and Mobile-Element Detection using metagenomics for animal and human on-site tests.
 - **Project WORLDCOM:** Development of new tools for real-time detection of zoonotic bacteria and antimicrobial resistance in veterinary, human and environmental sources.
- **Topic AMR2.1:** Dynamics of AMR selection, clonal spread and horizontal gene transfer in humans, animals and the environment, including epidemiology of resistant microorganisms and antimicrobials in the environment and their (environment-mediated) spread.
 - **Project FULL-FORCE:** Full-length sequencing for an enhanced EFFORT to map and understand drivers and reservoirs of antimicrobial resistance.



- **Project FED-AMR:** The role of free extracellular DNA in dissemination of antimicrobial resistance over ecosystem boundaries along the food/feed chain.

Emerging threats

- **Topic ET2.1:** Development of a toolkit to characterize emerging threats by combining genomic and phenotypic information.
 - **Project TELE-Vir:** Point-of-incidence toolbox for emerging virus threats.
 - **Project IDEMBRU:** Identification of emerging *Brucella* species: new threats for human and animals.
- **Topic ET1.1:** Development and harmonization of NGS and non-NGS methods for the detection of foodborne parasites.
 - **Project MEmE:** Multi-centre study on *Echinococcus multilocularis* and *Echinococcus granulosus* s.l. in Europe: development and harmonisation of diagnostic methods in the food chain.
 - **Project PARADISE:** Parasite Detection, Isolation and Evaluation.

Integrative topics

- **Topic IA-3: Joint databases of reference materials and data, incl. metadata**
 - **Project CARE:** Cross-sectoral framework for quality Assurance Resources for countries in the European Union.
- **Topic IA-2: Laboratory methods - harmonised protocols and common best practice**
 - **Project OH-HARMONY-CAP:** One Health Harmonisation of Protocols for the Detection of Foodborne Pathogens and AMR Determinants.
- **Topic IA-1: Common frameworks for designing and implementing surveillance and control activities**
 - **Project MATRIX:** Connecting dimensions in One-Health surveillance.

The concept of the assessment procedure was the same as that used in the gap analysis of the first round topics (see OHEJP Deliverable 2.5). In brief, the assessment procedure consisted of three steps:

- **Comparison between the topic and project objectives.** The topic objectives formed the “desired future state”, i.e. where that specific priority topic is intended to go to. Indeed, these objectives indicate what we want to have from the projects granted within a given priority topic. The project objectives formed the “current situation” instead, i.e. what we expect to obtain from that specific project.
- **Assess the coverage of the topic objectives by the project objectives.** Having compared what the priority topics aim to obtain from the projects and what the granted projects are on due course to provide, the overall level of coverage of the topic objectives was scored based on the expected input from the granted projects. The scoring system was based on the following criteria:



Poor (P)	Substantial essential information/data is still required to fully address most topic objectives, and this information/data will not be provided by the granted projects
Fair (F)	Granted projects are generally able to address most topic objectives, with some major additional information/data still needed
Good (G)	Granted projects are fully able to address all or most topic objectives, with very minor additional information/data still needed
Excellent (E)	Granted projects will fully address all topic objectives (special mention)

NB: an overall assessment for all topic objectives was provided, i.e. the objectives were not scored separately, but only their global coverage was assessed. Once the level of coverage of a given topic was determined, a comment in support of the assessment was provided to indicate which input is still needed to fill the identified gaps, i.e. the inputs needed to fully address all topic objectives.

Each topic was assessed by two members of the WP2 team: one member had a leading role in assessing a given topic and the other one checked the assessments of the other member for corroboration purposes. The topic assessments were then summarized by coverage.

- **Ask the project leaders.** Having determined the level of coverage of a given topic, the project leaders were invited to provide feedback on:
 - The extent to which the specific objectives of their projects will be met, including what will be done besides what has been “promised” and what will be left out.
 - What remains to be done (gaps) in that specific field, independently of the project and topic objectives.
 - What are the main outcomes of their projects that may be of benefit (as the focus for additional work and "unique selling points" of the programme) in future partnerships beyond OHEJP.

Results

All topics could be assessed by the two assessors and a consensus score for the coverage was reached for all topics. None of the topics scored “Poor”, indicating that the granted projects were generally able to address the topic objectives. Only minor gaps were identified: an overview of the scores and input needed for each topic is showed in the table here below.

Topic	Score	Input needed
FBZSH3	Good	<ul style="list-style-type: none"> • Source attribution of bacterial zoonotic pathogens other than <i>Campylobacter</i>, <i>Salmonella</i> and VTEC.
FBZ3.1	Fair	<ul style="list-style-type: none"> • Benchmarking pre- and post-harvest interventions in pig farming other than biosecurity (e.g. surveillance/control programs, vaccination, cleaning and disinfection practices, farm management practices and feeding practices, including the impact of microbiota). • Develop new tools to evaluate the effectiveness and costs of pre- and post-harvest interventions, including biosecurity.
FBZ4.1	Good	<ul style="list-style-type: none"> • Source attribution and transmission routes of non-bacterial foodborne pathogens other than <i>Toxoplasma</i>.
FBZSH5	Excellent	None



FBZSH9	Fair	<ul style="list-style-type: none">Assess the potential direct and indirect economic impact of the improved surveillance and response systems at the national and EU level.
AMRSH5	Good	<ul style="list-style-type: none">Compatibility assessment of developed tools with EU organizations and in technology-limited countries.Detection of more specific resistance genes in given bacterial groups.
AMR2.1	Good	<ul style="list-style-type: none">Human data to be covered also in countries other than the Netherlands alone to have a broader OH perspective.
ET2.1	Good	<ul style="list-style-type: none">Feasibility assessment of the toolbox for EU organizations.Other emerging threats besides <i>Brucella</i>.
ET1.1	Good	<ul style="list-style-type: none">Investigate also other foodborne parasites besides <i>Echinococcus</i>.
IA-3	Excellent	None
IA-2	Excellent	None
IA-1	Excellent	None

For FBZ3.1, additional input was proposed by the project leaders. This concerned:

- Incorporation of information on endemic diseases within cost-benefit models, to provide much more realistic assessments of the benefits of biosecurity controls.
- Automation/technical development of identification of effective biosecurity measures with literature search and benchmarking, applicable to other zoonotic pathogens, livestock species and regions.

For FBZ4.1, input identified by the project leaders concerned:

- Having comparable data from the MSs.
- Work more across the pathogen silos, and include all pathogen groups where relevant.
- Understand how the changing diets and new dietary recommendations (of both humans and animals) affect the foodborne/feedborne pathogens.
- Focus more on the environment.
- Comparative (human-animal) approaches to study clinical disease (comparative pathology, improved diagnostics, treatment options, role of host aspects and parasite aspects on the outcome of the infections).

For IA-1, input identified by the project leaders concerned:

- Exchange data between surveillance activities across animal health, public health and food safety.
- Find common communication platforms for animal health, public health and food safety.
- Systematic strengthening of relationships and improved communication across animal health, public health and food safety (create a culture of cross-sectoral integration despite the siloed structure of the sectors).
- Data interoperability that does not rely solely on data harmonisation and adoption of standards. This priority area has been the focus of an EFSA working group, and the results of a recent report could serve as bases to guide goals of new integrative initiatives.
- Long-term maintenance and sustainability of all resources.

For IA-3, input identified by the project leaders concerned:

- Development of new diagnostic tests using whole genome sequencing where appropriate.
- Proficiency of testing is vital, as although whole genome sequencing offers significant advantages, there are big challenges particularly where pathogen levels might be low and confounded by host genome.



The main outcomes of EJP projects that may be beneficial for future partnerships, as proposed by the project leaders and summarized by the WP2 team, are:

- Harmonisation of biosecurity protocols, best practices, analytical methods and sampling procedures.
 - Harmonised biosecurity protocols and best practices at primary production to limit prevalence of specific pathogens of (public and animal health) importance.
 - Harmonised sampling and sample processing approaches at primary production for specific pathogens of (public and animal health) importance.
 - Updated information about prevalence of specific pathogens of (public and animal health) importance in their respective reservoirs in the EU.
 - Newly developed analytical methods that enable further studies.
 - Procedure for identification and evaluation of effective biosecurity measures related to specific pathogens that could be applied similarly for other pathogens and livestock production chains.
- OH surveillance infrastructure, knowledge-integration/exchange platforms, and creation of national and international expert networks inter-sectorial collaborations.
 - Knowledge-integration platforms that facilitate and enhance interaction/collaboration/information dissemination by linking users to a wide range of resources (e.g. guidelines and tools).
 - Strengthened country-level One Health surveillance, while allowing cross-country experiences to be shared and build on each other.
 - Increased use of a common language between animal health, public health and food safety.
 - Intra- and inter- national collaborations increasing the capacity of member states to more rapidly respond to situations, such as pandemics, which affect all sectors.
 - A roadmap template that can be utilized by any country to develop and implement national One Health surveillance.
 - National and international expert networks that promote actively the OH paradigm (One Health community resources), OH knowledgebase and inspiration catalogue of OH success stories.

Conclusions

Based on the results of the gap analysis, none of the selected topics were considered as being insufficiently covered. Only minor gaps were identified. These concerned mainly the range of pathogens, AMR types and livestock sectors included as focus of the project activities, as well as compatibility/feasibility assessments of the developed tools for wider use in different EU organizations and a holistic perspective including all OH components.

A number of 'unique selling points' of OHEJP were also identified. These concerned mainly the harmonisation of biosecurity protocols, best practices, analytical methods and sampling procedures, OH surveillance infrastructure, knowledge-integration/exchange platforms, and creation of national and international expert networks inter-sectorial collaborations.

2. Analysis of current One Health research hotspots

Objectives

The objective of this analysis was to summarize the research hotspots in One Health in Europe and globally through text-mining techniques applied to the proceedings of major One Health-themed conferences held in the past two years, focusing on foodborne zoonoses, antimicrobial resistance, emerging threats and



integrative activities. We hypothesized that conference proceedings will be better able to describe these hotspots than traditional journal publications, as conferences often showcase initial research findings before former publication in (peer-reviewed) scientific journals, which usually takes longer to achieve, or *vice versa* they spotlight important articles that have recently been published. Moreover, conferences usually offer broader selections of papers at a glance, covering a wide spectrum of disciplines, which have been selected by committees based on pre-defined quality and relevance criteria, meaning that it is possible to capitalize on this screening work further. Moreover, this allows the literature search to be more manageable in the end, as the number of items to screen is more limited.

Procedure

Conference proceedings

A selection of 668 papers related to zoonoses and antimicrobial resistance, as well as integrative activities related to detection, prevention and response to (re-)emerging zoonotic threats, were obtained from four major One Health conferences held in both 2019 and 2020: the Annual Scientific Meeting (ASM) of the OHEJP, the European Scientific Conference on Applied Infectious Disease Epidemiology (ESCAIDE), the European Congress of Clinical Microbiology & Infectious Diseases (ECCMID), and the World One Health Congress (WOHC).

The aforementioned conferences were divided into two groups. The first group included the ASM conferences, as these are attended mostly by the partners of the OHEJP and therefore mostly include studies conducted by European researchers that are more likely to capture the specific research hotspots for One Health in Europe. The other three conferences ESCAIDE, ECCMID and WOHC belonged to the other group, which was more likely to include studies from all over the world and therefore better reflect the research hotspots globally.

Data extraction and analysis

The full titles of all contributions presented in the aforementioned conferences, including abstracts, oral presentations, poster presentations, keynote lectures and satellite workshops were extracted from the conference proceedings and saved into an Excel file to build a database. Then, according to the content of the contribution, the titles were categorized into different fields, as follows. The ASM contributions were categorized into four sub-groups: antimicrobial resistance (AMR), food-borne zoonosis (FBZ), emerging threats (ET) and integrative activities (IA), whereas the ESCAIDE, ECCMID and WOHC contributions were categorized into three sub-groups AMR, FBZ and ET, as no specific contributions were present for the IA subgroup.

For the analysis, we used Orange (<https://orangedatamining.com/>), a component-based visual programming software package for data visualization, machine learning, data mining, and data analysis. Different algorithms were used to process the contributions, create word clouds and word networks. The analytical workflow used is shown in Figure 1. A pre-processing step was used to filter out uninformative words (e.g. articles, prepositions, verbs, etc.), including words that were implicit for the field in question (e.g. the word “resistance” for the AMR contributions). The frequency of occurrence of words in the processed text were then visualized in word clouds to identify those words that indicated the most frequent topics addressed in the contributions. Subsequently, the words were linked to one another to build a network, so that their inter-connections could be visualized at once. The analysis was performed

for the ASM and the other conferences separately, and per subgroup as well. The resulting pictures were then described qualitatively.

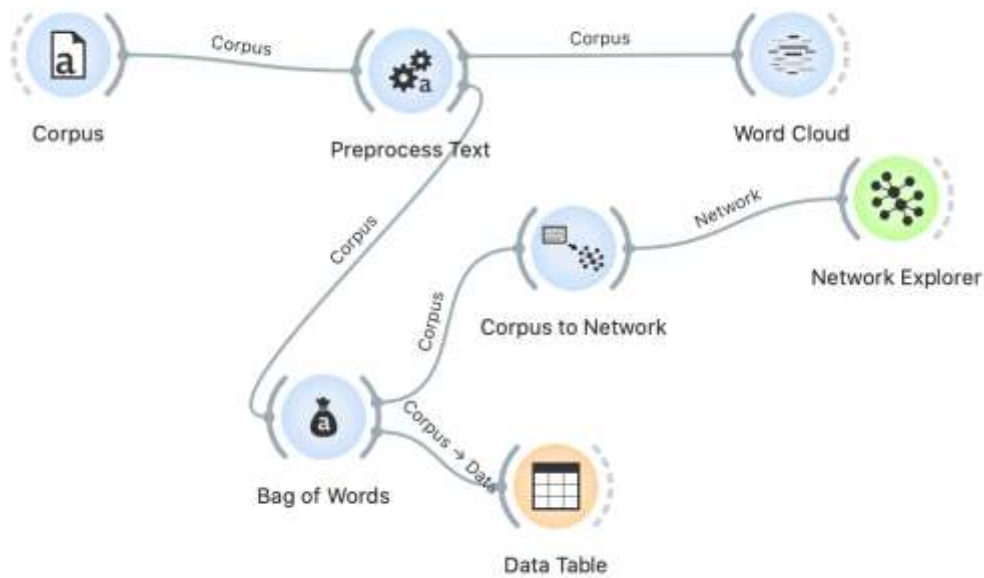


Figure 1. Workflow of the Orange software used for the analysis of the text of conference proceedings

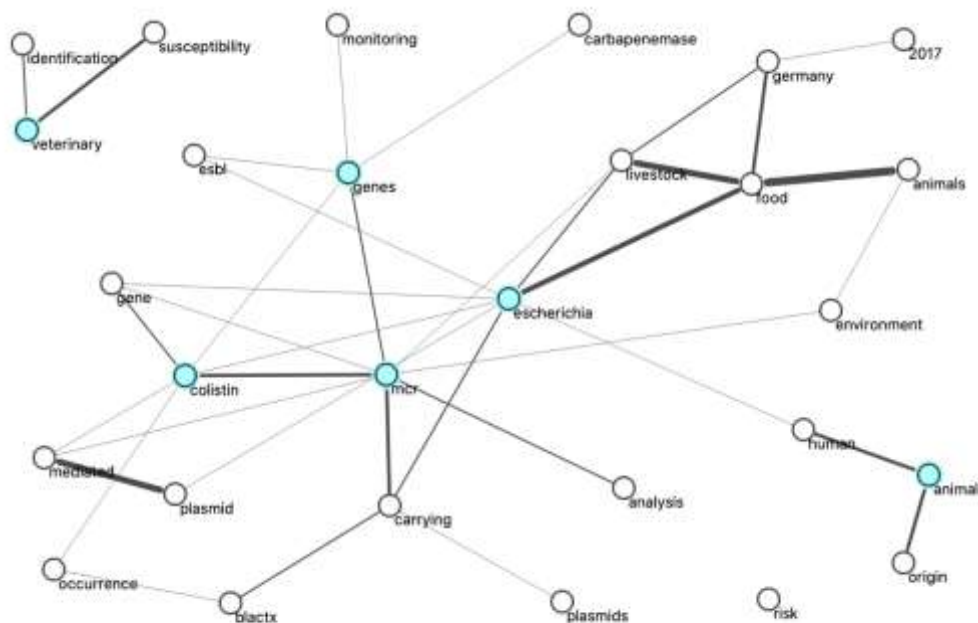
Findings

European research hotspots for antimicrobial resistance

The word cloud and word network for the AMR topics in the ASM of the One Health European Joint Programme, which mainly reflected the research hotspots in Europe, are reported in Figures 2 and 3, respectively (111 papers).



Scientific Meeting



Annual Scientific Meeting

In the Figures 2 and 3, it can be observed that One Health research on AMR in Europe focuses mainly on:

- food and livestock, followed by the environment and humans;
- *E. coli* as bacterial species under investigation;



- carbapenemase- and ESBL-producing bacteria and on the colistin resistance gene *mcr*;
- identification and occurrence (prevalence) of resistance, and somewhat less on transmission and surveillance.

Moreover, it appears that:

- research on *E. coli* is mostly related to food and livestock/animals, and less to humans, and it also seems to be mostly conducted in Germany;
- molecular studies are mostly related to *mcr*, plasmid-mediated resistance, carbapenemase and ESBL genes;
- research related to resistance in humans is mostly related to the animal origin of the resistance;
- research related to resistance in environment is related to animals and the colistin resistance gene *mcr*.

European research hotspots for foodborne zoonoses

The word cloud and word network for the FBZ topics in the ASM of the One Health European Joint Programme are reported in Figures 4 and 5, respectively (130 papers).



Figure 4. Word cloud for the research topics on foodborne zoonoses in the One Health EJP Annual Scientific Meeting

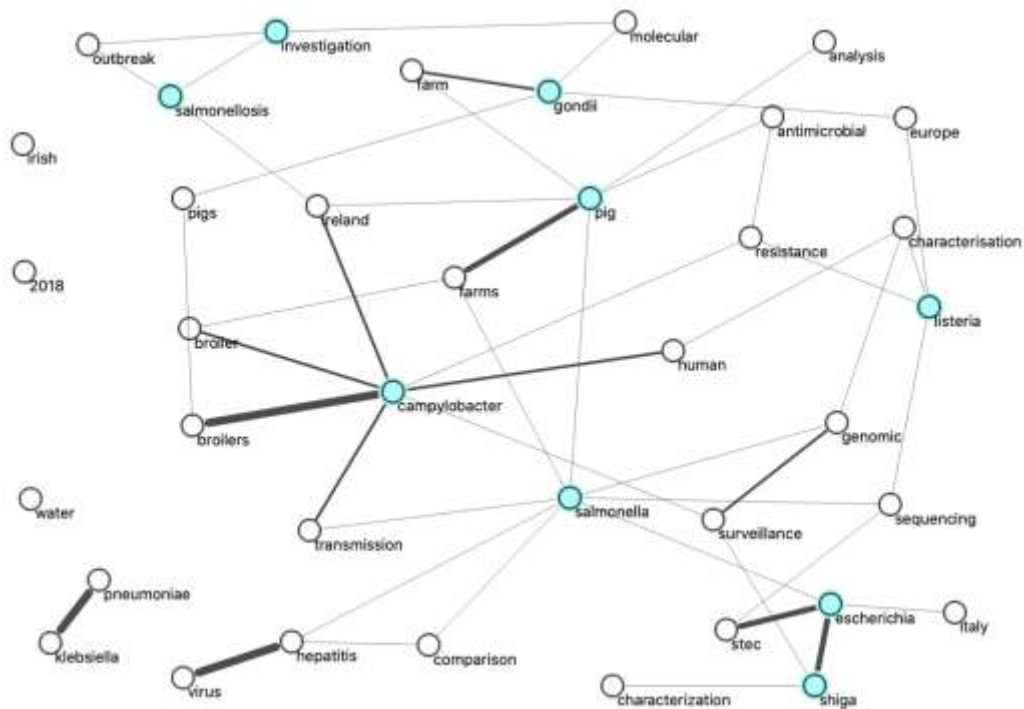


Figure 5. Word networks for the research topics on foodborne zoonoses in the One Health EJP Annual Scientific Meeting

In the Figures 4 and 5, it can be observed that One Health research on FBZ in Europe focuses mainly on:

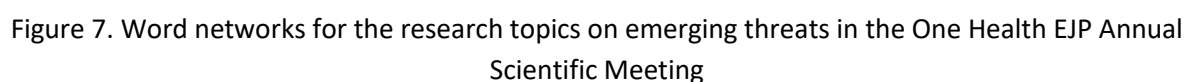
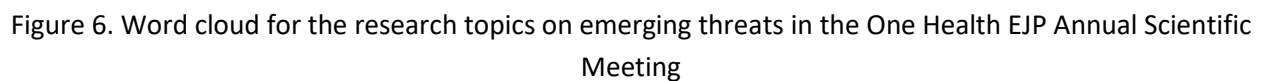
- *Campylobacter*, *Shiga*-toxin producing *E. coli* (STEC), *Salmonella*, *Listeria* and *Toxoplasma gondii*;
- transmission, surveillance, sequencing and characterization of the pathogens;
- pigs, broilers and water;
- Ireland and Italy (both particularly represented overall).

Moreover, it appears that:

- research on *Salmonella* is mostly related to pigs, and so is research on *T. gondii*.
- *Campylobacter* research is mostly focused on broilers and humans, and is often conducted in Ireland.
- research on STEC is often linked to Italy.
- sequencing/genomic characterization mainly involves *Listeria* and *Salmonella*, and AMR of *Listeria*.

European research hotspots for emerging threats

The word cloud and word network for the ET topics in the ASM of the One Health European Joint Programme are reported in Figures 6 and 7, respectively (43 papers).



- zoonotic diseases on humans and wildlife;
- hepatitis viruses, especially hepatitis E viruses, less on *Leishmania*, *Mycobacterium bovis* and *Klebsiella pneumoniae*;
- molecular analyses, including electrophoresis and PCR.

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- ### European research hotspots for integrative activities

A word cloud visualization of terms related to food safety and surveillance. The most prominent words are "surveillance", "framework", "exchange", "zoonoses", "resources", "generic", "human", "resistance", "transdisciplinary", "tuberculosis", "cohesive", "metadata", "collaboration", "systems", "communication", "klebsiella", "guidelines", "cross", "community", "sweden", "emerging", "supporting", "european", "orion", "intersectoral", "animal", "harmonized", "development", "antimicrobial", "sectoral", "models", "control", "new", "netherlands", "investigations", "employment", "pneumoniae", "network", "generic", "resistance", "transdisciplinary", "tuberculosis".

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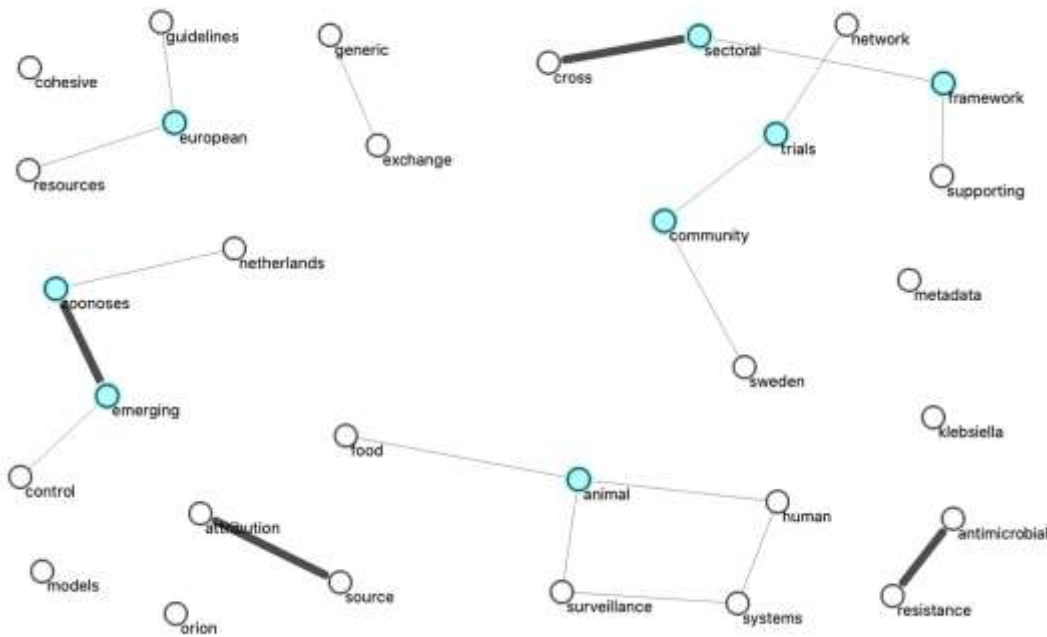


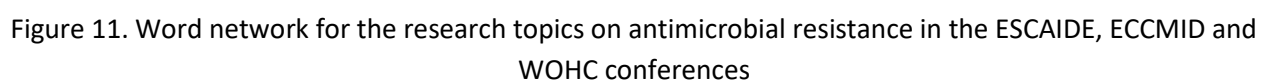
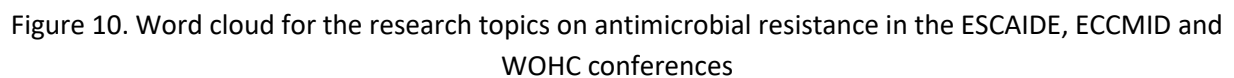
Figure 9. Word networks for the research topics on integrative activities in the One Health EJP Annual Scientific Meeting

In the Figures 8 and 9, it can be observed that One Health research on ET in Europe focuses mainly on:

- surveillance activities, data exchange, and building frameworks for facilitating the former two, and source attribution;
- food and zoonoses, and somewhat less on resistance.

Global research hotspots for antimicrobial resistance

The word cloud and word network for the AMR topics in the ESCAIDE, ECCMID and WOHC conferences, which reflected the global research hotspots more than the ASM conferences, are reported in Figures 10 and 11, respectively (132 papers).



- animals, food, and humans, followed by the environment, water and poultry farms;
- colistin resistance gene *mcr* and carbapenemase-producing bacteria;
- *E. coli*, *Staphylococcus aureus*, *Salmonella* and *Klebsiella pneumoniae*.

Moreover, it appears that:

- Research on *E. coli* is mostly related to ESBL resistance, followed by colistin and colistin resistance gene *mcr*;
- Research focuses mainly on antimicrobial resistance gene analysis, transmission risk, surveillance and epidemiology;
- Research related to resistance in animals is related to both food and companion animals;
- Research related to resistance in humans is directly related to *E. coli*, food and animals (including livestock and poultry) and indirectly related to companion animals;
- Research related to resistance in environment is mainly related to poultry, followed by water and animals.

Global research hotspots for foodborne zoonoses

The word cloud and word network for the FBZ topics in the ESCAIDE, ECCMID and WOHC conferences are reported in Figures 12 and 13, respectively (98 papers).



Figure 11. Word cloud for the research topics on foodborne zoonoses in the ESCAIDE, ECCMID and WOHC conferences

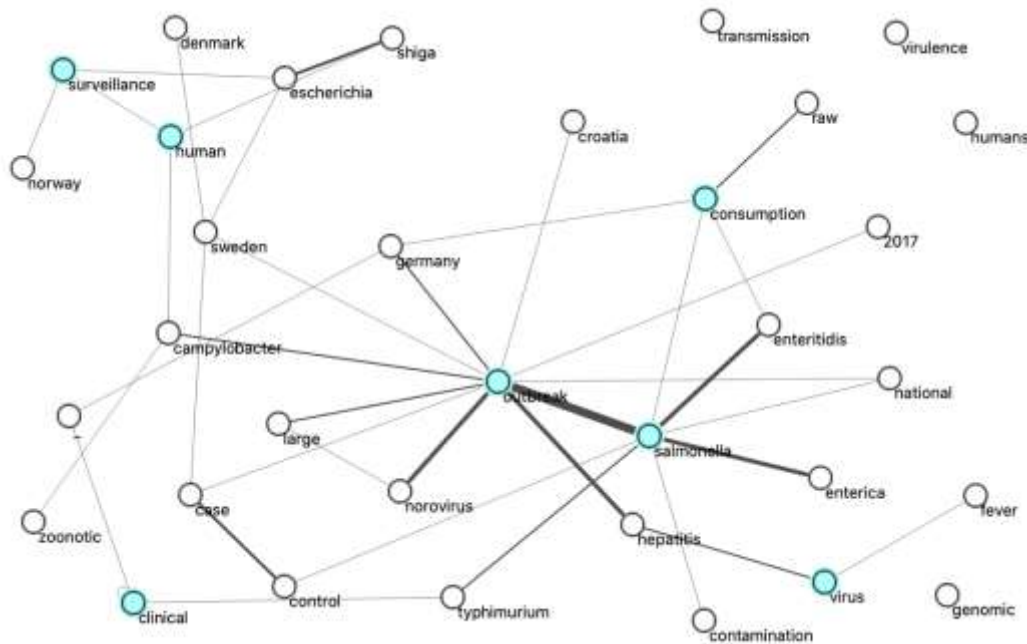


Figure 12.

Word network for the research topics on foodborne zoonoses in the ESCAIDE, ECCMID and WOHC conferences

In the Figures 11 and 12, it can be observed that One Health research on FBZ globally mainly focuses on:

- *Salmonella*, Shiga-toxin producing *Escherichia coli*, hepatitis virus, followed by *Campylobacter* and norovirus;
- outbreaks of *Salmonella* and norovirus, mostly in Germany;
- consumption of raw foods (as risk factor for infection);
- disease surveillance (for *Campylobacter* and STEC in particular) and case-control studies (for STEC and *Salmonella* in particular) in humans, mostly in Scandinavian countries.

Global research hotspots for emerging threats

The word cloud and word network for the ET topics in the ESCAIDE, ECCMID and WOHC conferences, which reflected the global research hotspots more than the ASM conferences, are reported in Figures 13 and 14, respectively (119 papers).



Figure 13. Word cloud for the research topics on emerging threats in the ESCAIDE, ECCMID and WOHC conferences

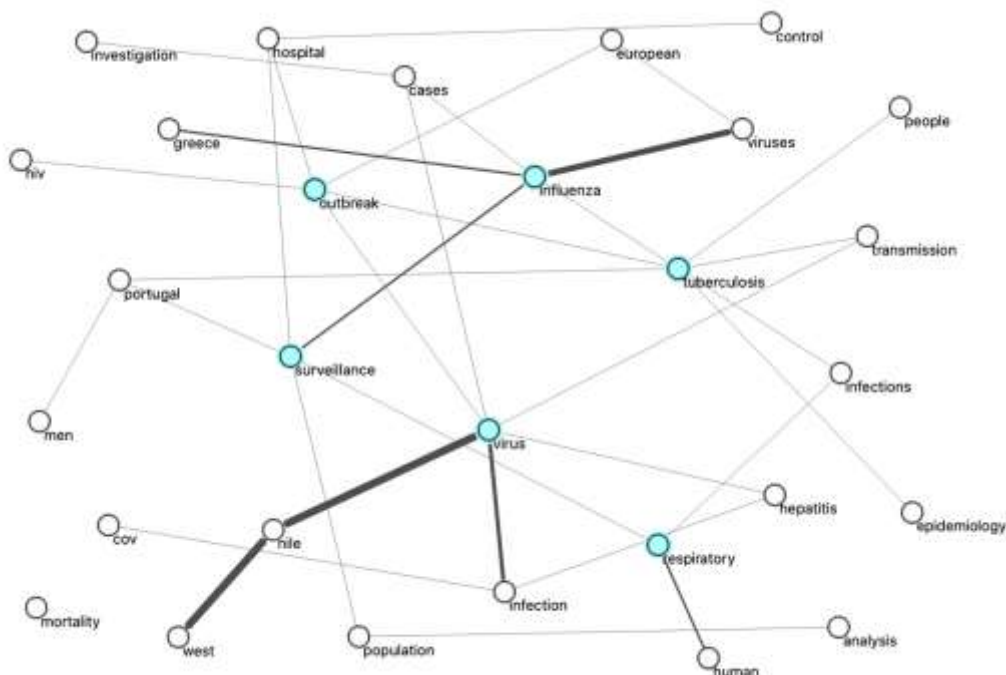


Figure 13. Word network for the research topics on emerging threats in the ESCAIDE, ECCMID and WOHC conferences

In the Figures 12 and 13, it can be observed that One Health research on ET globally mainly focuses on:

- influenza virus, followed by tuberculosis and West Nile virus;
- surveillance and outbreaks, and somewhat less on transmission and control;
- respiratory symptoms associated with humans;



- hospital outbreak control;
- influenza in Greece and tuberculosis in Portugal.

Conclusions

Most of the current hotspots in One Health research concern (microbiological and epidemiological) investigations of recent foodborne outbreaks. Studies mainly focused on the transmission, source attribution, surveillance, and prevention of the pathogens causing these outbreaks through molecular epidemiology. Humans, animals and the environment are the three components of One Health. However, most studies focused on humans and animals only, and far less on the environment. Furthermore, most of the animals involved in the research were farm animals, whereas companion and wild animals were less represented. In general, however, all major hotspots identified here were covered by the SRA.

3. Rapid consultation of the partners

Objectives

This rapid consultation was meant to identify novel priority research topics of highest interest within the OHEJP consortium in order to update/integrate the current list of priority research topics of the SRA with additional topics that the OHEJP partners might currently consider as a priority for their institute. Therefore, this elicitation aimed to provide possible additional priority research topics to be used as input for the strategic research and innovation agenda (SRIA), which is developed in WP7. As there will be no possibility within the existing OHEJP to fund research in these new topics, this consultation was performed only to identify priorities that are not included in the current SRA, but that the consortium considers relevant to work on together beyond the lifespan of OHEJP.

Procedure

The consultation was performed digitally (via e-mail) at the institutional level, meaning that the OHEJP scientific representatives of each institute were consulted. The invitation to participate to the consultation was sent on the 7th of April 2021 and a reminder was sent the day before the indicated deadline for response, on the 30th of April 2021.

The prioritized topics can be found in the SRA, and the OHEJP scientific representatives were reminded to refer to the SRA for an overview of these topics.

As the SRA is structured around three domains (i.e. foodborne zoonoses - FBZ, antimicrobial resistance - AMR, and emerging threats - ET), participants were asked to propose one topic for each domain, so three topics in total for each partner. A standardized table format to report the topics was provided for. Moreover, the proposed topic could cover different aspects of a specific subject (such as a pathogen, a livestock sector, a methodological approach, etc.) but it was advised not to provide a mix of different subjects merged together (for example: a topic like *“New diagnostic methods and on-farm interventions for disease*



X in livestock sector Y” was considered to be generally OK, but a topic like “*New diagnostic methods for disease X in livestock sector Y, assessment of on-farm interventions for disease Z in animal species Y and Q, and harmonization and sharing of data sources for livestock and human patients*” was not). It was asked to identify a clear priority. However, considering the three main components of One Health (i.e. humans, animals, environment) in the same topic was advised.

The consultation was not performed on a country basis, meaning that every partner institute was meant to indicate what their priorities for One Health research were (in addition to those already included in the SRA). These priorities could have had either a national or international perspective. The choice of what was more important was left entirely to the partners themselves. All partners were consulted; thus, multiple institutes participating in OHEJP in the same country were also consulted. Yet, within-country coordination to agree on the topics was not necessary (i.e. between OHEJP partners of the same country), as the consultation was meant to capture diversity in topics among the institutes and not among the countries. However, some consensus on the newly identified priority topics within the institute was necessary. To that end, it was asked to involve the relevant institute’s experts in the identification of the topics.

Given the widespread awareness of the impact and high priority character of the current COVID-19 situation, the partners were asked to indicate topics that did not include COVID-19. We therefore asked to propose priority topics besides COVID-19. To provide a response was not mandatory: in case no response was received from the partner, it was assumed that the partner had identified no additional priorities compared to those already included in the SRA.

Results

In total, 23 topics were received from 8 partners (RIVM, WBVR, APHA, NMVRVI, INIA, INRAE, FFA and NVI) in 7 countries (the Netherlands, UK, Lithuania, Spain, France, Finland and Norway). The partners NMVRVI (Lithuania) and FFA (Finland) were not part of OHEJP when the SRA was defined. An overview of the topics received is reported in Table 1.

Table 1. Overview of the priority research topics received.

Partner	FBZ	AMR	ET
The Netherlands			
RIVM	Intervention studies for emerging foodborne zoonoses in animal reservoirs using modelling and risk assessment approaches.	Identification and/or molecular characterization of (novel) AMR determinants and vectors (Mobile Genetic Elements) for attribution studies.	Syndromic surveillance in (livestock, companion and wildlife) animals and humans.
WBVR	Usage of in vitro models for the assessment of interventions of foodborne zoonoses	Implementation of long-read sequencing to improve WGS-based AMR monitoring in animals and food	Pandemic preparedness high risk pathogens (like hantavirus and henipavirus)
UK			
APHA	Assessment of impact of disinfection and water treatment on the control of <i>Campylobacter</i> in broiler farms	Impact of waste management on transfer of antimicrobial resistance on farm	Vector borne disease and climate change
Lithuania			



NMVRVI	Prevalence of the main infectious causes of abortion in dairy cattle in Lithuania (<i>Neospora</i> , <i>Leptospira</i> spp., <i>Chlamydia</i> , Q fever and other)	Analysis of plant toxins and mycotoxins	Prevalence of pathogens in wild boar in Lithuania and evaluation of the current risk to human and domestic animal health (Hepatitis E virus (HEV), <i>Toxoplasma gondii</i> , <i>Listeria monocytogenes</i> , Tick-borne encephalitis (TBE) and other)
Spain			
INIA	Early detection of new zoonotic infections in the human-animal interface (livestock, pets and synanthropic animals)	Target surveillance of antimicrobial residues and resistances in the environment	Surveillance of zoonotic potential evolution of viral respiratory diseases: real time alert systems
France			
INRAE	Integrative strategies based on microbiomes to reduce foodborne zoonosis, reduce animal farming impact on environment, improve animal health and welfare	Tracing AMR in microbial ecosystems, from animals, the environment and humans - Impact of farming practices	Epidemiology and integrative surveillance of pathogenic <i>E. coli</i> , an "ever emerging" pathogen, from human, animals and food systems
Finland			
FFA		Ensuring food security, plant health and crop yields: risk assessment of AMR in plant production (plant pathogenic bacteria)	Food frauds in the food chain: development of analytics, monitoring tools and early detection
Norway			
NVI	Microbiome and pathogen diversity mapping	Animals and environmental as sentinel systems for AMR	Tools to monitor pathogens in the environment (e.g. eDNA, barcoding etc...)

Of the 23 additional topics, 7 referred to FBZ, 8 to AMR, and 8 to ET. The newly proposed topics were also placed in the OHEJP research strategy matrix (Table 2). However, some topics were cross-thematic, involving more than one of the five themes of the research strategy matrix (analytical methods, host-microbe interactions, epidemiology, risk assessment, and intervention). Therefore, they were placed in multiple cells of the matrix, resulting in 5 topics for the theme analytical methods, 3 for host-microbe interactions, 12 for epidemiology, 3 for risk assessment, and 7 for intervention.

Table 2. Research strategy matrix with the additional topics. Topics written in *italics* are topics that are inserted twice in the matrix (non-italics = first choice categorization; italics = second choice categorization).

	FBZ	AMR	ET
Analytical methods		<ul style="list-style-type: none"> Identification and/or molecular characterization of (novel) AMR determinants and vectors (Mobile Genetic Elements) for attribution studies (RIVM) Implementation of long-read sequencing to improve WGS-based AMR monitoring in animals and food (WBVR) 	<ul style="list-style-type: none"> Food frauds in the food chain: development of analytics, monitoring tools and early detection (FFA) Tools to monitor pathogens in the environment (e.g. eDNA, barcoding etc...) (NVI)



		<ul style="list-style-type: none"> Analysis of plant toxins and mycotoxins (NMVRVI) 	
Host-microbe interaction	<ul style="list-style-type: none"> Microbiome and pathogen diversity mapping (NVI) <i>Usage of in vitro models for the assessment of interventions of foodborne zoonoses (WBVR)</i> <i>Integrative strategies based on microbiomes to reduce foodborne zoonosis, reduce animal farming impact on environment, improve animal health and welfare (INRAE)</i> 		
Epidemiology	<ul style="list-style-type: none"> Prevalence of the main infectious causes of abortion in dairy cattle in Lithuania (Neospora, Leptospira spp., Chlamydia, Q fever and other) (NMVRVI) Early detection of new zoonotic Infections in the human-animal interface (livestock, pets and synanthropic animals) (INIA) 	<ul style="list-style-type: none"> Target surveillance of antimicrobial residues and resistances in the environment (INIA) Animals and environment as sentinel systems for AMR (NVI) Tracing AMR in microbial ecosystems, from animals, the environment and humans - Impact of farming practices (INRAE) 	<ul style="list-style-type: none"> Vector borne disease and climate change (APHA) Syndromic surveillance in (livestock, companion and wildlife) animals and humans (RIVM) Prevalence of pathogens in wild boar in Lithuania and evaluation of the current risk to human and domestic animal health (Hepatitis E virus (HEV), Toxoplasma gondii, Listeria monocytogenes, Tick-borne encephalitis (TBE) and other) (NMVRVI) Surveillance of zoonotic potential evolution of viral respiratory diseases: real time alert systems (INIA) Epidemiology and integrative surveillance of pathogenic <i>E. coli</i>, an "ever emerging" pathogen, from human, animals and food systems (INRAE) <i>Food frauds in the food chain: development of analytics, monitoring tools and early detection (FFA)</i>



			<ul style="list-style-type: none"> • <i>Early detection of new zoonotic Infections in the human-animal interface (livestock, pets and synanthropic animals) (INIA)</i>
Risk assessment	<ul style="list-style-type: none"> • <i>Intervention studies for emerging foodborne zoonoses in animal reservoirs using modelling and risk assessment approaches (RIVM)</i> 	<ul style="list-style-type: none"> • Impact of waste management on transfer of AMR on farms (APHA) • Ensuring food security, plant health and crop yields: risk assessment of AMR in plant production (plant pathogenic bacteria) (FFA) 	
Intervention	<ul style="list-style-type: none"> • Intervention studies for emerging foodborne zoonoses in animal reservoirs using modelling and risk assessment approaches (RIVM). • Usage of in vitro models for the assessment of interventions of foodborne zoonoses (WBVR) • Integrative strategies based on microbiomes to reduce foodborne zoonosis, reduce animal farming impact on environment, improve animal health and welfare (INRAE) • Assessment of impact of disinfection and water treatment on the control of Campylobacter in broiler farms (APHA) 	<ul style="list-style-type: none"> • <i>Impact of waste management on transfer of AMR on farms (APHA)</i> 	<ul style="list-style-type: none"> • Pandemic preparedness high risk pathogens (like hantavirus and henipavirus) (WBVR) • <i>Surveillance of zoonotic potential evolution of viral respiratory diseases: real time alert systems (INIA)</i>

For the FBZ domain, the following observations can be made:

- Most topics focussed on intervention (4 topics).
- Special attention was given to microbiome research (3 topics), and particularly microbiome manipulation, also for intervention purposes (along with the use of *in vitro* models and modelling).
- Both microbiome research and *in vitro* models have their base in the theme host-microbe interaction, which was not represented in the topics eligible for funding in both rounds of calls for project proposals within OHEJP.
- A new topic not included in the SRA is the impact of disinfection and water treatment on the control of Campylobacter in broiler farms.



- The FBZ topics proposed by NMVRVI and INIA did not appear to fit the FBZ domain well, but more the ET domain.

For the AMR domain, the following observations can be made:

- Most topics focussed on strengthening surveillance systems for antimicrobial residues and AMR in the environment (3 topics) and animals (2 topics).
- The use of molecular typing methods, including WGS, for AMR detection, characterization and monitoring, was also mentioned twice. These topics, however, are already included in the SRA.
- New topics were the assessment of the impact of waste management on transfer of AMR on farms and risk assessment of AMR in plant production (plant pathogenic bacteria).
- The AMR topic from NMVRVI did not fit the scopes of the domain.

For the ET domain, the following observations can be made:

- Most topics focussed on development of analytical methods and tools for early warning (2 topics), real-time surveillance (3 topics) and pandemic preparedness (1 topic). Except for the latter, these topics are already covered by the SRA.
- Epidemiological studies on emerging pathogens in wild life and livestock were also mentioned, although they are already included in the SRA.
- A new topic is vector-borne diseases and climate change.

Conclusions

Based on the few additional topics received, it can be concluded that the SRA largely covers the current research priorities of the OHEJP partners. The additional FBZ topics identified in this consultation focus on the themes “intervention” and “host-microbe interaction”, particularly microbiome research in terms of microbiome modulation and disinfection/treatment practices. For AMR, strengthening surveillance systems, particularly those systems targeting the environment, as well as waste management and AMR in plant production, are identified as new topics. For ET, pandemic preparedness, as well as vector-borne diseases and climate change, are newly identified topics. This consultation also reinforces the importance (for the OHEJP partners) of other topics that are already covered by the SRA, such as the use of molecular typing methods, including WGS, for AMR surveillance and the development of analytical methods and tools for early warning in emerging pathogens in wild life and livestock.

4. Overall conclusions

This report aimed at summarizing the main hotspots in One Health research based on recent research outputs (within and outside the OHEJP consortium) and potential (additional) research priorities identified by the OHEJP partners themselves, as well as potential gaps that might still be present in the current SRA. Monitoring these “hot topics” and “missed chances” provides a basis for identifying opportunities for innovation in One Health research for whatever will come after OHEJP. Indeed, the information of this report will be used by WP7 (sustainability) in the development of the SRIA.

Overall, it was concluded that:

- The current SRA does not display major gaps and all selected topics have been sufficiently covered by the funded projects. Moreover, the SRA largely covers the current research priorities of the OHEJP partners.



- The few minor gaps identified in the SRA concerned mainly the spectrum of pathogens, AMR types and livestock sectors included as the focus of the research, which could be broader than now. Moreover, for a wider use in different EU organizations, the different tools developed by the projects should undergo a throughout compatibility/feasibility assessment. On the other hand, the harmonisation of biosecurity protocols, best practices, analytical methods and sampling procedures, integrated surveillance infrastructure, knowledge-integration/exchange platforms, and creation of national and international expert networks for inter-sectorial collaborations, are clearly recognized “selling points” of the OHEJP consortium.
- The holistic perspective of One Health could be better reflected in the SRA by including more research on the environment. An underrepresentation of the environmental component is also evident in the research hotspots, as these tend to focus mainly on humans and animals, and far less on the environment. This is particularly evident for AMR, for which the strengthening of surveillance systems, particularly those systems targeting the environment, as well as waste management, is a clear hot topic.
- Most research outputs seem to focus on studies dealing with microbiological and epidemiological investigations of foodborne outbreaks, particularly their transmission routes and sources, as well as surveillance and prevention activities, using molecular epidemiology. This reinforces the relevance (for the OHEJP partners) of the content of the SRA, as these topics are covered by the SRA, particularly the focus on molecular typing methods in surveillance and the development of analytical methods and tools for early warning.
- The animals involved in research are mainly farm animals, whereas companion and wild animals were less represented.
- For FBZ, topics dealing with interventions and host-microbe interactions, particularly microbiome research in terms of microbiome modulation and disinfection/treatment practices, are “hot”, albeit underrepresented in the SRA. The same can be said for pandemic preparedness of emerging threats, accordingly to the needs highlighted by the current COVID-19 pandemic situation, as well as vector-borne diseases and climate change, which are not covered by the SRA.