

**Deliverable JIP1-3.2 - Status report on OH Harmonisation Infrastructure Hub**

**Workpackage 3**

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Data integration, interpretation and interoperability in one-health surveillance

WP3 in ORION had been planned to tackle infrastructural resources related to data harmonization in One-Health surveillance (OHS). During the requirement analysis carried in year 1 (and reported in the deliverable JIP1-3.1), it became clear that to support collaborative data analysis across health sectors this WP should focus on the goal of semantic interoperability. This would allow us to add value to the integratory activities already performed by EFSA and ECDC, and to develop tools for data integration that can be implemented in any scenario of data sharing barriers – a knowledge model is available to interpret data, across sectors, when data sharing or re-use is possible, but data sharing is not a requirement for the development and implementation of the infra-structure to handle interoperability.

As stated in the deliverable JIP1-3.1, reporting this WP’s activities in the first year (requirement analysis),

**Semantic interoperability** is concerned with ensuring the integrity and *meaning* of the data across systems. Semantic interoperability is particularly important in OH in order to allow *data reuse across sectors*, and even reuse of data for research and knowledge discovery.

That reported concluded that two main goals should guide the work on year 2:

1. Build an ontological framework for one-health surveillance (OHS) that allows computers to understand and reason with current data terminologies in the same way that humans do, maximising the benefit to cost ratio of the effort put into producing surveillance data;
2. Improve usability of data inside the institutions who own and/or use the data, as well as the potential for reuse by external stakeholders and for research and discovery.

We also reported that, to achieve these goals, this WP would work in 3 parallel working groups (WG)

1. **The knowledge modelling WG,** which advised by ontology experts from the computer science field, and supported by expert elicitation from ORION partners, will develop an ontology to support OHS data annotation and analysis.
2. **The technical development WG,** responsible for the development of the necessary tools to support data annotation using the ontology, as well as storage and access to linked data.
3. **The surveillance practice WG**, directly responsible for the Swedish “One-Health pilot” (described below), which will work to improve the “One-Healthness” of the cross-agency activity of publishing the annual report of surveillance against infectious diseases of animals and humans in Sweden, and support the use of this report as a user-case for implementation of workflows that produce interoperable data.

This report is a detailed account of the activities of these 3 working groups in the second year of the ORION project, and a guide to the resources developed.

# Knowledge modeling – developing the *Health Surveillance Ontology*

Semantic interoperability is achieved by marking up data and metadata using an explicit knowledge model that can be understood by humans and by machines, therefore complying with the FAIR data principles (findable, accessible, interoperable and reusable)[[1]](#footnote-1) .

“*An ontology defines a common vocabulary for researchers who need to share information in a domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them*”.

In order to attend the need for a human- and machine-readable knowledge model for surveillance, ORION has developed the ***Health Surveillance Ontology*** reusing knowledge from existing ontologies, as well as reusing terminologies already commonly used in practice, such as those adopted by EFSA and ECDC. Identification of concepts and their specialization was informed by data examples from the various “OH pilots” carried out in ORION.

The ontology is publicly available at a globally unique and eternally persistent identifier: [***https://w3id.org/hso***](https://w3id.org/hso). Content management is used - humans accessing this link via browser will be referred to a page listing all ontology documentation and additional resources, such training materials. Software agents pointed to the same address will find the machine-readable codes for the knowledge model (written using the Web Ontology Language - OWL).

The Health Surveillance Ontology is a full FAIR resource.

## Ontology content – concepts covered by the ontology

The development of the ontology was initially planned to be based 1) primarily on the various data models currently used by EFSA for foodborne zoonoses reporting, as these apply to both animal health (AH) and food safety (FS); with the intention of then 2) expanding the concepts modelled by the ontology to include public health (PH) concepts, informed by the data models for zoonotic diseases reporting used by the ECDC. Focusing on the EFSA models for reporting surveillance results at the surveillance system level (as opposed to case-based reporting) also had the advantage of providing a structure for the reporting of surveillance activities, which was directly related to the work carried out in ORION-WP1 to develop a “Consensus Reporting Annotation Checklist” (CRAC). During the first phase of this work, we worked in close contact with the CRAC development team, and maped several data models for description of surveillance systems.

When attempting to expand the knowledge model to include concepts from PH surveillance, however, it became clear that the ontology would have to accomodate not only differences in knowledge across sectors, but also differences in the structure of data, in particular to accommodate the differences between case-based and prevalence reporting, and the differences between systems of active data collection (such as AH surveillance activities which are planned) versus notification-based systems. The WP members then decided that ontology development should be informed by data examples, rather than data models, and focus on the specific data workflows requirements of each of the national OH-pilots to be carried out within ORION.

Below, we report the achievements in terms of content modeling during the first phase of development (year 2), and then summarize our plan to move forward in cycles of development that are data-driven in the next year (year 3).

### Development informed by data models

Table 1 lists all concepts currently linked in the ontology, and their source. The list of concepts was derived from the yearly prevalence reports from member states to EFSA (*Campylobacter spp* reports served as the main working example). For each concept identified, we searched and reused concepts from existing ontologies whenever available. When the concepts were available in resources other than ontologies – for instance terminology catalogues from EFSA, which are not machine readable, but are used to provided harmonisation among member states – we mirrored the existing content and linked to the original resource. The original resources are all listed in Table 1.

***Table 1.*** Concepts added to HSO and pending issues.

|  |  |  |
| --- | --- | --- |
| Concept | Linked sources1 | Notes and issues |
| Surveillance activity | EFSA, RISKSUR | A surveillance activity is, in the ontology, any group of surveillance observations, corresponding therefore to both a “surveillance component” and a “surveillance system” in the definitions set by Hoinville et al., 20132). Modelling is needed to establish links and hierarchy – for instance several surveillance activities can be a part of a bigger “surveillance system”, some activities may be carried out sing the same sampling scheme, etc. |
| Organism | NCBI taxonomy3, EFSA catalogue **PARAM**, OBI4, GenEpiO5 | The concept of an “organism” serves to identify both pathogens and hosts. So far we have added only 3 bacteria: *Campylobacter spp* (and the many subspecies), *Escherichia coli* and *Samonella spp;* as well as humans, cattle, pigs and chickens. For those few organisms, however, we have established all mappings among all the sources listed, so that data can be translated between any of them.  Work is needed to model relationships such as being a “host”, an “infectious agent”, a “susceptible species”, etc. |
| Starting date and end date |  | Rather than assigning a surveillance year, we chose to set a start (and optionally also ending) date. This because the activities aren’t always restricted to one year, and year for activities doesn’t always agree with the Gregorian calendar. |
| Livestock farming system | EOL6, EFSA catalogue **MTX** (limited scope, see notes) | Here we reviewed many sources, including 3 previous ontologies from the French Public Research Institute (INRA) and all the ontologies listed in the Agroportal (<http://agroportal.lirmm.fr/>), but the modelling in many of them was problematic to reuse. Mapping the concepts in the EFSA catalogue **ZOO\_CAT\_MATRIX** was also difficult, as codes such as “*Gallus gallus (fowl) - breeding flocks for egg production line - adult*” are actually a combination of 3 concepts: the animal species, production type, and age. We have set links between concepts in the ontology and top level codes in the hierarchy of the catalogue **MTX** (such as for instance “*Gallus gallus (fowl) - broilers*”), by establishing that this code refers to organism: “*Gallus gallus”* AND farming type “meat production” but the number of concepts form the catalogue currently covered by the ontology is small. |
| Establishments | EFSA, OBI4 | The full EFSA catalogue **SAMPNT** was imported. |
| Country | EFSA | The full EFSA catalogue **COUNTRY** was imported. |
| Region | EFSA | The full EFSA catalogue **NUTS2013\_NUTSCODE** was imported. |
| Language | EFSA | The full EFSA catalogue **LANG** was imported. |
| Sample type | EFSA, OBI4, GenEpiO5, UBERON7 | This will require a lot of discussion to model, as existing ontologies seem to have dealt with this in difference ways. There is consensus on calling a sample for analyses a “specimen”, and that concept was added to the ontology. But there are different approaches to deal with different dimensions of information, for instance: whether a sample is from animals, humans or food; whether it is a swab or a directly portion of a material; etc. These are details that can be discussed in the dedicated webinars to come. For now, the following concepts related to a sample type have been added:   * The “matrix type” from the EFSA catalogue **MTXTYP** * The sample type as being a portion of an organism material – and there we linked to all anatomical concepts in the UBERON7 ontology. * Sample types that are swab or whole organisms * Specific sample types – we have mapped all of the EFSA catalogue **ZOO\_CAT\_SMPTYP**. |
| Surveillance context | EFSA | The full EFSA catalogue **PRGTYP** was imported. |
| Surveillance sampler type | EFSA | The full EFSA catalogue **SAMPLR** was imported. |
| Sampling strategy | EFSA | The full EFSA catalogue **SAMPSTR** was imported. |
| Sampling unit | EFSA | The full EFSA catalogue **SAMPUNTYP** was imported. |
| Mass measurement | EFSA, OBI4, GenEpiO5 | The concept of a mass measurement and the units allows (g, Kg, etc) were added to allow modelling the concept of a “sample weight”, and make numerical measurements, in general, compatible with other ontologies. Units were also mapped to the EFSA catalogue **UNIT**. |
| Integer measurements |  | To be able to process numerical information, we have followed the design patterns or other ontologies, and added the following “unitless” numerical measurements in the ontology:   * Calculated sample size (PSU, SSU) * Number of units tested (PSU, SSU) * Number of units positive (PSU, SSU) * Number of units negative (PSU, SSU) * Number of specimen tested * Number of specimen positive * Number of specimen negative |
| Laboratory analysis | EFSA, OBI4, GenEpiO5 | Work is ongoing to process all of EFSA catalogues **ANLYTYP** and **ANLYMD\_PRVAM**, while keeping compatibility with other ontologies. |

1-This means that the ontology is capable of recognizing and translating data from and among recognized sources.

2- Proposed terms and concepts for describing and evaluating animal-health surveillance systems, Prev Vet Med. 2013 Oct 1;112(1-2):1-12. <https://www.ncbi.nlm.nih.gov/pubmed/23906392>

3- <https://www.ncbi.nlm.nih.gov/taxonomy>

4- Ontology for Biomedical Investigations (<http://obi-ontology.org/>)

5-Genomic Epidemiology Ontology (<https://genepio.org/>)

6- Environment Ontology for Livestock (<http://agroportal.lirmm.fr/ontologies/EOL>)

7-Uber anatomical ontology (<https://uberon.github.io/about.html>)

Figure 1 shows the currently modelled relationships between the concepts available in HSO. HSO is being developed using the Basic Formal Ontology (BFO) as a top ontology, aiming for full compliance with the principles of the Open Biological and Biomedical Ontology (OBO) Foundry. The OBO Foundry “is a collective of ontology developers that are committed to collaboration and adherence to shared principles. The mission of the OBO Foundry is to develop a family of interoperable ontologies that are both logically well-formed and scientifically accurate[[2]](#footnote-2)”. In other words, the OBO Fundry provides guidelines to ensure that every ontology modeling initiative adds value to previous one, and as the collective knowledge model is expanded, those adopting the OBO ontologies to model their data can make their datasets interoperable with all the body of data annotated with ontologies within the Foundry.

Following BFO top-level structure, we have, in Figure 1, used the following color-code in the rectangular boxes representing the concepts modelled: green for “realizable qualities”; red for “processes; and blue for “information content entities”. Yellow ellipses represent data properties (numerical or categorical properties assigned to instances of a concept), arrows represent object properties (properties linking instances of different concepts). The green-shaded box in Figure 1 is meant to exemplify tyes of results provided for a surveillance activity. When reporting, for instance, the number of samples collected in a surveillance activity and the number of those that were positive, the ontology woud allow a user to provide further information for these samples according to the knowledge model depicted in Figure 1. All this information – as for instance the sampling design, the surveillance samples, the sampling unit – would be directly connected to the results, ensuring that results are always published with all the epidemiological context needed for their correct interpretation.

En bild som visar text, karta

Automatiskt genererad beskrivning

***Figure 1.*** Concepts added to HSO and the relationships modelled between them. Red dotted arrows are relationships not yet modelled.

### Development informed by data examples

As stated above, WP3 will support the development of FAIR data workflows in each of the OH-pilots carried out in ORION. After the group decided that the ontology development should be based on *data examples*, rather than data models (that is, concrete examples of data shared across agencies for OH decision making, rather than theoretical models of data organization), we decided that development next year should be based on one data example form each pilot.

We will connect with each ORION pilot to support data annotation of one data example, and investigate the use of the interoperability tools developed in WP3 to facilitate cross-sector collaboration and/or add value to the data available. This will give us a chance to tackle data interoperability under different scenarios of data exchange – some pilots deal with case-based data (or even isolate-based) while others deal with data aggregated at the country level; some pilots have sensitive data, while other public data; etc.

## Resources available

Besides the public ontology codes in OWL (<http://w3id.org/hso>), users can also browse the ontology using the user-friendly ontology browser provided in BioPortal: [**http://bioportal.bioontology.org/ontologies/HSO**](http://bioportal.bioontology.org/ontologies/HSO)**.**

The ORION Knowledge Hub (<https://foodrisklabs.bfr.bund.de/oh-data/>) has links to all ontology resources, which include ontology documentation, mapping of ontology concepts to other existing terminologies, and instructional videos.

## Interoperability with other ontologies

As mentioned above, we strive for HSO to abide to the principles of the OBO Foundry, making it an ontology interoperable with a larhe body of other interoperable and complementary ontologies in the biomedical field. This means that data annotated with the ontology would also be interoperable with daa annotated using other OBO ontologies.

From these ontologies, we highlight two with high relevance to surveillance: the Ontology of Biomedical Investigations (OBI) and the Genetic Epidemiology Ontology (GenEpiO). The former, which models the structure of investigations, can serve as a guideline for modeling the structure of surveillance activities, such as the planning, execution and publication of results. The latter, is highly complementray to HSO, as it is focused on modeling meta-data associaltes with isolates submitted to whole-genome-sequencing (WGS) during outbreak investigations We are further highly connected to GenEpiO because they are meant to be the ontology of choice in the WGS analysis platform IRIDA (<https://www.irida.ca/>), which is being tested as one of the ORION OH-pilots. The GenEpiO development team is *also* involved in the OBI development team.

In order to draw a plan to work collaboratively with GenEpiO and OBI, in September 2019 the ORION-WP3, supported by ORION-WP2-NGS and OHEJP-WP4, organized the “***WGS-based surveillance: a cog-wheel workshop to detect links and promote collaboration among OHEJP projects and external initiatives***”. The WP3 leader also took advantage of this opportunity to organize a working meeting with GenEpiO and OBI developers during a whole day before the cog-wheel workshop, ans a follow-up discussion after the workshop.

WP3 and GenEpiO/OBI development teams have now bi-weekly meetings to discuss ontology development and cooperation.

# Tools for data annotation in practice

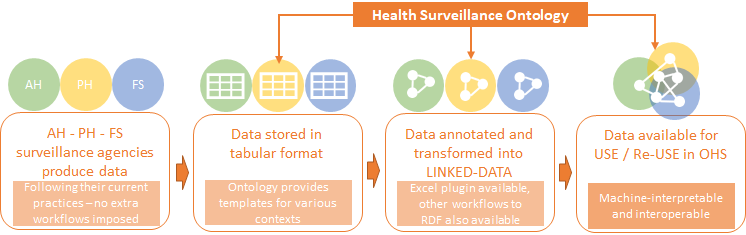
As HSO is, on itself, FAIR, it provides the required data annotation model for any data source to attend the FAIR principle of interoperability, as stated in the data principle I2 (“To be interoperable: I2 (meta)data use vocabularies that follow FAIR principles”)[[3]](#footnote-3).

The data annotation process is highly dependent on the data management tools used at each institution. In ORION we have identified that epidemiologists most frequently manipulate and exchange in flat formats, in “.xls”, “.xlsx” or “.csv” formats. For that reason, we have, in collaboration with other projects, developed a tool for semantic annotation of data in Excel, and subsequent export of the data in Resource Description Framework (RDF) format, a standard model for data interchange on the Web. The Excel plug-in, **ExcelRDF**, is **free and open source**. Codes for developers, as well as a guide to install the plug-in for users are available at **https://karlhammar.com/ExcelRDF/**. ExcelRDF is a Visual Studio Tools for Office (VSTO) plugin, which provides light-weight translation from OWL to XLS, and from XLS to RDF, to enable linked data generation from existing Excel-based tools and workflows.

Tools to annotate tabular data keeping the tabular format also exist, as well as tools to incorporate data annotation into SQL databases. Those were not developed in ORION, but WP3 will work to support the development of FAIR data workflows in each of the OH-pilots carried out in ORION, identifying which technical resources are most appropriate for the specific data workflow involved in each initiative.

Establishing a workflow of data annotation that is sustainable in practice must take into account the current practices within the agencies involved in OHS. While the adoption of data annotation practices can increase the value of data - potentially minimizing efforts in other steps of the continuum of data production and consumption - it can also be perceived as an “extra-burden”. It is important to help institutions understand how to establish effective data workflows, incorporating the adoption of the knowledge model into their existing practices.

Next year (year 3) data workflows within each ORION OH-pilot will be evaluated to propose improvement in FAIRness and incorporation of data annotation with minimum change of current practices. These workflows, as well as annotated data in various formats, will be made available in the ORION Knowledge Hub (<https://foodrisklabs.bfr.bund.de/oh-data/>) to serve as inspiration and support to agencies wanting to follow this principle. The workflows will exemplify how agencies can improve semantic interoperability of their data (in support to OHS) in particular, and their data FAIRness in general.



# The surveillance practice WG and the Swedish OH pilot

# Improving the one health work in the Swedish national surveillance report of infectious diseases in animals and humans

## Background

Every year since 2009 a national report on the outcome of surveillance activities of infectious diseases in animals and humans is produced in Sweden. The report is produced with contributions from the animal health-, public health- and food safety sector. The Swedish National Veterinary Institute (SVA) coordinates the production of the report. Authors from the different sectors are every year asked to review their chapters and update the numbers and change the text accordingly. This work has been completed by the authors without having to interact much with the other sectors. A common analysis between sectors of the outcome of the surveillance has not regularly been performed before writing the report. The validated data from the three sectors are published in a pdf-report but are not made available in any other format.

A need for improved One-Health (OH) collaboration in conjunction with the production of the report had previously been identified. This need was fed into WP3 of ORION by the Public Health Authority and it was decided to focus on the Swedish surveillance report in the pilot of WP3. The purpose of the pilot is to strengthen the OH-focus of the report and to create and implement a work-process supporting the collaboration between sectors that will persist after the project ends. Moreover, the agencies will through the process gain a better understanding of each other’s activities, data sources and results.

## Initial Workshop in 2018

To start a discussion on how to change the way of working within sectors into a more one-health oriented approach across sectors, and also discuss how the data in the report can be made available and easily accessible, a workshop was arranged in December 2018.

We decided initially to focus on three important chapters of foodborne zoonotic agents; *Salmonella*, *Campylobacter* and VTEC/STEC. Representatives from the public health, animal health and food safety in Sweden that have been responsible for producing the report and/or contributing to one of these chapters were invited to the workshop.

During the workshop the three sectors got the opportunity to present and discuss the data that are used today to produce the report. Potential sources of data that have not been used in the report previously were brought up for discussion as well as the lack of data that are not collected today. Furthermore, the actual process of working together in new ways between sectors when preparing the report was discussed as well as how the report itself could be improved in different ways.

Following this discussion, the participants were given a presentation about the possibilities of data interoperability through the ontology and technology work in ORION-WP3.

It was concluded that there is a need to increase the collaboration between sectors in the production of the report. It was a good opportunity for representatives from all three sectors to come together to present and discuss their surveillance data. By working more closely together it will be possible to improve the overall understanding of the results of all ongoing surveillance activities and hence enable a common interpretation of these results.

All participants were willing to meet and discuss surveillance results from 2018 in a workshop as a preparation for the work with the coming issue of the report. To be able to focus on the outcome of the surveillance, and also on how to improve the presentation of the results, it was decided to have separate workshops for each chapter. Workshops were scheduled to take place after data were collated and preliminary results ready to be shared.

## Pre-pilot workshops in 2019

Pathogen specific workshops were organized for *Salmonella, Campylobacter* and VTEC/STEC in the spring, 2019. During the workshops the texts from the previous surveillance report were scrutinized and discussed in detail to identify how the information can be presented in the best way. Tables and visualizations were also examined to see how they can be improved or if it is possible to produce visualizations with data from more than one sector. Data that had previously not been used for the surveillance report were discussed and sometimes introduced in the text or in a new table after agreement.

The workshops were followed up by skype or telephone meetings to discuss the tables and visualizations in more detail and finalize the text. The surveillance report of 2018 was printed in August 2019.

## Achievements of the pre-pilot

During 2019 we tested the concept of working together across sectors during the production of the report. Workshops were arranged to facilitate the collaboration and resulted in a joint effort and the production of three OH-chapters with partly new layout, changes in texts, tables and graphs.

A new section “In focus” was introduced in the OH-chapters. This highlighted section provides the possibility to describe (more in detail) some interesting or unusual finding from the previous year with a OH-focus. A slightly new structure to the text was also decided upon for the OH-chapters; the results section (of the previous year’s surveillance) was moved to the beginning of the chapter and the section about legislation was moved to the end of the chapter. The changes were made to emphasize the results, and also to improve the general readability.

## New Process

The new process that was introduced in the pre-pilot will be tested and evaluated in the real pilot 2020. The process itself will be documented and made available to other countries and institutions that are interested in this way of working. So far, the process can briefly be described as follows:

1. Preparation of instructions to authors involved in producing the report. Specific instructions should be prepared for main responsible authors of each chapter/disease.
2. Identification of relevant participants from each sector including appointing main responsibility for each chapter/disease (main responsible authors).
3. An initial meeting is recommended where the involved parties are invited to share and explain their surveillance process and available data.
4. A telco-meeting is held to plan the work and schedule times for workshops (separate meetings for each chapter/disease).
5. Workshops are held with a predefined agenda.

Some examples of questions to discuss:

* Major findings in the surveillance of each sector
* Outbreaks
* Unusual findings
* Suggestions of topics to highlight in the “In focus” section
* Improvements of last year’s report, new figures or graphs to include, new available data

1. Skype-meetings to finalise the text, tables and visualizations for each chapter.
2. Main author submits the chapter/disease to the editor team.
3. Evaluation of the process by sending out a questionnaire.
4. Adjust the process according to result of evaluation.

Examples of what should be provided by an editor-team:

* Instructions to authors and main authors
* Agendas for meetings and a checklist of what to prepare for meetings
* Shared platform between sectors to facilitate cooperative work on documents

## Lessons learned

The evaluation of the pre-pilot concluded a few things to continue with or to improve for the next year:

* Good experience with the “In focus” sections. We will continue with them.
* Good feedback overall on the OH-collaboration.
* Separate pdf-reports of each chapter will be produced next year. In that way the chapters can be used for more purposes than the surveillance report (e.g. on the institutions web sides next to disease information for a specific disease).
* A better solution for how to share and work together in documents between authorities is needed. The solution that was used did not enable all authors to use the track changes feature.
* It was not always clear who was responsible for what during the process. This uncertainty delayed the work sometimes and made it difficult to make decisions for a specific chapter.
* When more people are involved in the process of writing and deciding on layout of figures and graphs it is very important that there is someone that fully takes the responsibility of leading the work and communicating with the whole group and delivering text and data as expected.
* Experiences of shortage of time. It was difficult to manage all the new ideas and agree on all changes within the time limit for the report. Important to remember that
* Sometimes difficult to agree on what data to present and how to present data from different sectors together in a good way.
* Important to remember that it takes time to cooperate. The expectations need to be at the right level for the first year.

## Preparations for the real pilot 2020

To prepare for the pilot in 2020 new instructions were produced to clarify the role of the main responsible author of each chapter. It was also decided that all zoonotic chapters/diseases that are produced by authors from more than one sector should follow new guidelines in order to make all the zoonotic chapters more alike. To improve the OH work in all zoonotic chapters it will be mandatory for the main authors to contact the other authors for a meeting to discuss the results of the previous year’s surveillance and what to highlight in the report.

The process for the next surveillance report started already in December 2019 with meetings to plan for the real pilot. Workshops were scheduled in January for the *Salmonella*, *Campylobacter* and VTEC/STEC chapters. Possible topics for the “In focus” sections were discussed at the meetings.

A list of authors to all the chapters in the report were sent out in December to everyone involved to verify that it is correct. Along with it the new instructions to the main responsible authors were sent out.

The process of the real pilot will start in January, the texts and tables will be available for editing and more detailed instructions on how to edit the texts and data will be sent out by then.

# Conclusions and the way forward

Year 2 has been spent developing the ontology and preparing the Swedish pilot. On year 3, we will be able to “pull all strings together”, improving data workflows in OHS initiatives and providing these workflow examples in our public Knowledge Hub.

For the Swedish pilot, in particular, the practice track has improved the “One-Healthness” of the collaboration process across agencies in general, and the results published in the report in particular, working more or less independently form the technical and ontology working groups. In year 3, however, we will apply the tools for data annotation and aim to publish, alongside the PDF report, a Linked-Open-Data version of the zoonotic chapters in the report. That is, a version of the report that is not only findable and reusable, but also accessible (by humans and machines) and interoperable.

WP3 will also support the other OH pilots, developing bespoken data workflows to improve data FAIRness. However, it is clear that there doesn’t exist a “one fits all” solution. Rather than producing “a” tool of data interoperability, ORION-WP3 will make available the ontology and links to different tools for data annotation, including but not restricted to the one developed in ORION.

Adopting these tools in practice will depend on careful evaluation of current practices and adaptation of current workflows in ways that improve FAIRness, but also fit with legacy practices and infrastructure of the host organizations. ORION aims to leave a number of examples and guidelines for how institutions can do so in the future.

1. Findable, Accessible, Interoperable, Reusable. https://www.force11.org/group/fairgroup/fairprinciples [↑](#footnote-ref-1)
2. <http://obofoundry.org/> [↑](#footnote-ref-2)
3. https://www.force11.org/group/fairgroup/fairprinciples [↑](#footnote-ref-3)