Deliverable D-WP2.1

OHEJP JIP MATRIX – WP2

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MAPPING OF THE SURVEILLANCE CHAIN FOR ALL HAZARD TRACKS, AND CROSS-SECTORIAL LINKAGES

Summary

Introduction

JIP05-MATRIX (here below MATRIX) is an EU-co-funded project within the framework of the One Health European Joint Programme (OHEJP). MATRIX plans to build a framework that addresses cross-sectorial collaboration along the whole surveillance pathway, with particular focus on surveillance design, data collection, and data analysis. MATRIX operates with a focus on specific pathogens/hazards (hazard-tracks, HT), which were chosen based on the operational priorities of the 19 MATRIX partner institutes across 12 European countries and their One Health (OH) relevance.

The aim of MATRIX Work Package 2, tasks 1 and 2 (here below WP2-T1 and WP2-T2, respectively) was to provide a mapping of the surveillance chain across all sectors for each hazard-track covered by MATRIX, for at least one country per hazard-track, and to identify chain linkages between sectors.

In order to provide a full map of the surveillance chain for the four MATRIX hazard tracks (*Campylobacter, Listeria, Salmonella* and Emerging threats) for at least one country per hazard-track **(WP2-T1)**, WP2 reviewed the available information coming from the first round of OHEJP joint integrative projects (JIP), in particular JIP ORION and JIP COHESIVE, and joint research projects (JRP), as JRP NOVA) [1]-[3]. Subsequently WP2 developed an online questionnaire to gather the additional information needed for the mapping.

For **WP2-T2,** chain linkages were identified on the basis of the full map of the surveillance chain for each sector. The mapping was the substrate for exploring how information sharing can be operationalised, and with which timelines and mode of operation.

In the present deliverable, we describe the results of WP2-T1 and WP2-T2, presenting the mapping of different surveillance chains for the hazard-tracks and identifying possible linkages and outputs to be shared. The results of WP2-T1 and WP2-T2, and their interpretation, will be used also in the following deliverables of the WP2 namely, D-WP2.2 Suggested best-practices for multi-sectorial collaboration in order to achieve OHS, hazard-specific (hazard tracks) and D-WP2.3 Common framework of OHS surveillance.

WP2-T1: Mapping of the surveillance chain across all sectors for each hazard-track

Online questionnaires implementation

As the objective of WP2-T1 was the mapping of surveillance systems along the food chain for specific pathogens, we decided to gather the needed information by means of online questionnaires.

The results from previous OHEJP projects were the inspiration to conceptualise the mapping. The main references taken into consideration were:

- OHEJP JRP NOVA (Novel approaches for design and evaluation of cost-effective surveillance across the food chain), which aimed to develop new surveillance tools and methods, and to harmonise and optimise the use of existing surveillance system data. Although with a different purpose from ours (i.e. implementing syndromic surveillance systems), NOVA D3.1 "Full mapping of the chain process for three main productions in EU'' provided a detailed mapping of the food chain, and represented the groundwork to conceptualise the questionnaires [4].

- OHEJP JIP ORION (One health suRveillance Initiative on harmOnization of data collection and interpretatioN) created a One Health Glossary [5] to harmonise terminology across different sectors. Definitions from the Glossary were used to implement the questionnaires.

Additional insights on surveillance systems in place were provided by the European Food Safety Agency (EFSA), not only regarding official surveillance programmes but also in terms of activities carried out and data collected [6].

Hazard-tracks and coupled food chains

MATRIX project grounds on four hazard-tracks, namely *Campylobacter*, *Listeria, Salmonella*, and Emerging threats. One emerging threat had to be selected to initiate work in the emerging hazard-track: Norovirus was originally considered as an option, but was later excluded because of the lack of involvement of the animal health sector in the food chain; Hepatitis E virus (HEV) was then suggested and selected. Public health risks associated with HEV as a food-borne pathogen [6] helped to shape HEV questionnaires.

For each hazard-track, a specific food chain was selected to explore in as much detail as possible the surveillance in place in each country. Combinations were chosen to extend on previous projects [4], [5]:

- *Salmonella* was investigated in humans and pork meat food chain;
- *Listeria* in humans and dairy products;
- *Campylobacter* in humans and poultry meat;
- Hepatitis E in humans and wild boar meat.

Twelve different questionnaires were implemented, based on the "Farm-to-Patient" approach for the three sectors (animal health - AH, food safety - FS, and public health - PH) and each hazard-food chain combination. Drafts circulated for improvement and feedback amongst WP2 members; one contact

person per hazard-track brought together the feedback. The consolidated questionnaires were implemented in an online survey platform and made available for completion.

Questionnaires collection

Partners in MATRIX were asked to suggest possible contact persons with expertise in the specific field of interest, between MATRIX partners and non-partners. The identified contact persons were individually contacted to verify their interest in taking part in the survey. The questionnaires were distributed to different institutions of each sector, reaching the expert/contact person, starting in late November 2020. When requested, a PDF version of the questionnaires was provided to collect information from more than one expert (see Annex I - Questionnaires). Answers were collected over a two-month period. Preliminary results were shared during a Wide Consortium Meeting in March, 2021. Following the meeting, additional countries expressed their interest to participate in the study. Therefore, the online questionnaires were re-opened for a second tranche of collection from March to the end of April 2021.

A questionnaire was considered completed when answers from the three sectors involved were obtained: overall, 14 questionnaires were submitted by 8 different countries (Table 1). Table 1 shows the hazard track – food chain – country combinations investigated.

Country	Hazard track – food chain combination			
	***Campylobacter*– poultry meat food chain**	**Hepatitis E – wild boar meat food chain**	***Listeria* – dairy products food chain**	***Salmonella* – pork meat food chain**
France	x			x
Germany	x			x
Italy		x	x	
Norway	x	x	x	x
Portugal		x		
Spain				x
The Netherlands		x		
The United Kingdom				x

Table 1. Countries and combinations explored in WP2-T1

The questionnaires were compiled by experts belonging to 10 institute partners of the MATRIX project and 5 non-partner institutes[1].

[1] DISCLAIMER: The present document reports and analyses data collected using the above mentioned questionnaires, which were compiled by one expert each. We therefore acknowledge that some information may be not complete or up to date, reflecting the knowledge of the respondent on the specific topic by that time. Our findings are based on the informed assessment of sector-specific experts: therefore, an unavoidable degree of bias is a limitation of our approach.

Mapping

Completeness was assessed through the questionnaires: questions with full answers were considered as complete; if not, additional information was requested to the respondent to complete it.

Answers were categorised in order to be graphically displayed, in:

- events;
- actors;
- data;
- metadata;
- event producing data;
- identified data sources;
- sharing potential.

The interpretation of the information gathered with the questionnaires and graphically displayed with the mapping was performed by the Hazard-Track (HT) leaders[2], whose expertise was fundamental in the contextualization of the results.

In the following chapters an overview of the results is presented, as a combination of description, tables and figures. Particularly, Figure 1 represents the template utilised for the graphic display of the mapping.

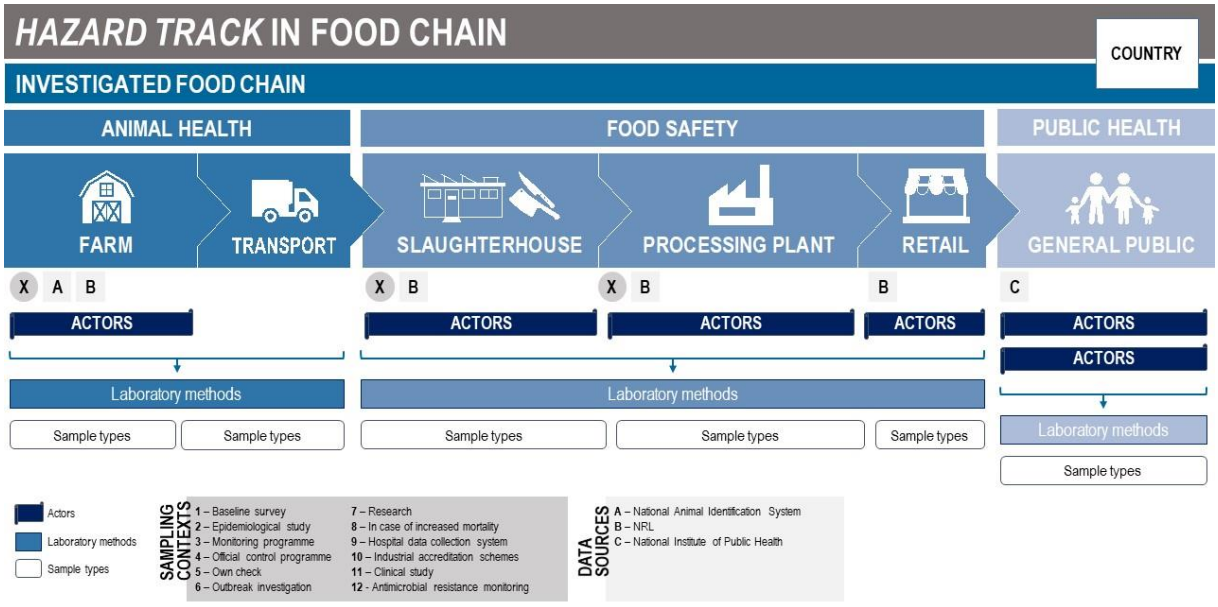

Figure 1. Template of the mapping

[2] For the Emerging Threats hazard-track, the interpretation and description of the results was implemented by experts from Istituto Superiore di Sanità (ISS).

Campylobacteriosis is the most frequently reported zoonotic disease in the EU with 220,682 human cases reported in 2019 [7]. Raw poultry is often contaminated with *Campylobacter* since the bacterium can live in the intestines of healthy animals. Eating undercooked chicken or ready to eat foods that have been in contact with raw chicken is the most common source of infection. The cost of campylobacteriosis to public health is estimated by EFSA to be around 2.4 billion euros a year [8].

Campylobacter is a priority disease in EFSA's extended control programme for zoonotic diseases and EFSA has produced baseline surveys reports on the prevalence of *Campylobacter* in chicken and on the risk factors that contribute to the prevalence of the bacteria in chicken-derived food, such as faecal contamination of environment, carcasses, meat, surroundings. Findings from the 2008 baseline survey indicate that slaughterhouse processing offers an opportunity for *Campylobacter* risk mitigation [9]. Even if 50% to 80% of human cases of campylobacteriosis may be attributed to the chicken reservoir as a whole, handling, preparation and consumption of broiler meat may account for 20% to 30%. For this reason, risk mitigation measures are also aimed at reducing the cross contamination during the final preparation stage in domestic settings.

Campylobacter spp. surveillance chain in poultry meat was investigated in three countries: Germany (DE), France (FR), and Norway (NO) (Figure 2-4). Specifically, the following steps of the food chain were taken into consideration to explore surveillance activities:

- Animal level: hatchery, farm and transport;
- Food level: slaughterhouse, processing plant and retail;
- Human level: general public.

Norway, France, and Germany share many similarities in the overall organisation of the national surveillance programmes for *Campylobacter* spp. in humans and in the poultry meat food chain, animal and food sectors. The major differences between Norway and the other countries were the pre-slaughter test and handling of flocks infected with *Campylobacter* spp., as they are referred to the production of frozen or cooked products, exclusively. Norway has no official surveillance program targeted at the slaughterhouse performance. Furthermore, the surveillance is subject to a formal evaluation in Norway, which is not the case in the other countries. In France surveillance data of the poultry meat food chain appears to be not shared nationally, in contrast to the other countries.

Animals. In Norway and France, surveillance programmes for the detection of *Campylobacter* spp. at the farm level are in place (Figure 3-4). In addition, Norway has an output-based surveillance of *Campylobacter* spp. in case of increased flock mortality. All flocks are tested at least six days prior to slaughter and PCR-positive flocks are slaughtered separately and used for frozen or cooked products. Hatcheries and transportation are not included in the surveillance programmes in any of the three countries. However, in Germany, there are outbreak- and research-related activities at the farm and hatchery levels, while flock-related surveillance (caecal content, Table 4) is done at the slaughterhouse (Figure 2). Both Germany and Norway collect a wide variety of information regarding isolates from animals at the national level, while in France, the collection of data takes place at the local level (Table 2). Norway is the only country that shares any surveillance data regarding animals at the national level, while France and Germany reported that no data is shared at the national level (Table 3).

Slaughterhouse. In France and Germany, several sampling activities are conducted during slaughter, including the EU-mandatory neck skin surveillance after primary cooling as well as additional sampling of the carcass, environment, and equipment. Meanwhile, no sampling related to production hygiene or chilled carcass status in Norwegian poultry slaughterhouses (Figure 2-4) was reported for *Campylobacter* spp., due to pre-slaughter separation of flocks, positive for *Campylobacter* spp.. France was the only country to report environmental or equipment sampling (Figure 3). Furthermore, all three countries have faecal or caecal sampling (Figure 2-4, Table 4) related to flock or single animal status for *Campylobacter* spp. in slaughterhouses. In France, samples are collected anytime for official controls, or before and after cleaning and disinfection (depending on project objectives) for research projects; in Germany, samples are collected randomly; in Norway, samples are collected earlier during the day, later during the day, generally during the production, in order to have distributed samples over the day. Furthermore, in Germany, surveillance activities in place for *Campylobacter spp*. in poultry at the slaughterhouse also include data collection on batch identification number, type of production (conventional or organic), origin of the animals, tape/strip speed, slaughtering capacity, and number of animals slaughtered per day. In France, it depends on project objectives.

Processing and Retail. In France, the surveillance of *Campylobacter* spp. is conducted by own-check[3] and control authorities by sampling fresh meat products for product status and from equipment for the detection and status of cross contamination critical points. Also, research activities are in place. In Germany, fresh meat products and other meat preparations are monitored with official control programmes, own-check and during outbreak investigations, while in Norway, official control programmes, own-check and outbreak investigations were reported to be in place for *Campylobacter* spp. in poultry processing and retail, but the sampling was not specified. The activities are carried out via the food business operators (Figure 2 and 4, Table 6). In all three investigated countries, in the case of designed surveillance programmes, the sampling programmes are designed to investigate the exposure to *Campylobacter* spp. in general. In addition, in France, it is targeted to consumer groups (e.g. vulnerable consumers, high amount consumers of the particular food) and to ensure the conformity of products placed on the market.

Laboratory methods. For detection of *Campylobacter* spp., France and Germany use the ISO 10272-1 protocol (Figure 2 and 3). In France, both detection and enumeration protocols are applied. In Germany, a combination of the ISO 10272-1 detection protocol and PCR-based detection is applied. For typing purposes, both France and Germany have access to whole genome sequencing (WGS), whereas this is generally not the case in Norway, in animal and food sectors (Figure 2-4). All countries have access to WGS and other relevant typing methods in the public health sector. In Norway, culture-dependent methods and PCR are used for the detection of *Campylobacter* spp.

Surveillance of human campylobacteriosis. In France, Germany and Norway, data are collected via suspect sampling of clinical cases for confirmed cases and outbreaks in the human population. In addition, Germany also conducts suspect sampling for probable cases (based on epidemiological link to confirmed cases). All three countries report that they have consistent data related to case detection but report having little to no epidemiological data on risk exposure, such as occupational risk, contact

[3] Programme designed to effectively control processes by identifying critical control points (CCPs), establishing critical limits for each CCP, monitoring CCPs, gathering data, keeping records, and implementing corrective actions and verification procedures. HACCP is applied by the food or feed business operators (Codex Alimentarius).

to livestock, data on domestic food exposure (Table 8), though this seems different when dealing with outbreaks (data partially collected, Table 9). In Germany, France and Norway, data are collected during epidemiological studies, outbreak investigations and research activities (Figure 2-4). In addition, in Norway, clinical studies are in place and a number of different actors are involved in the surveillance activities for the public health sector (Figure 4).

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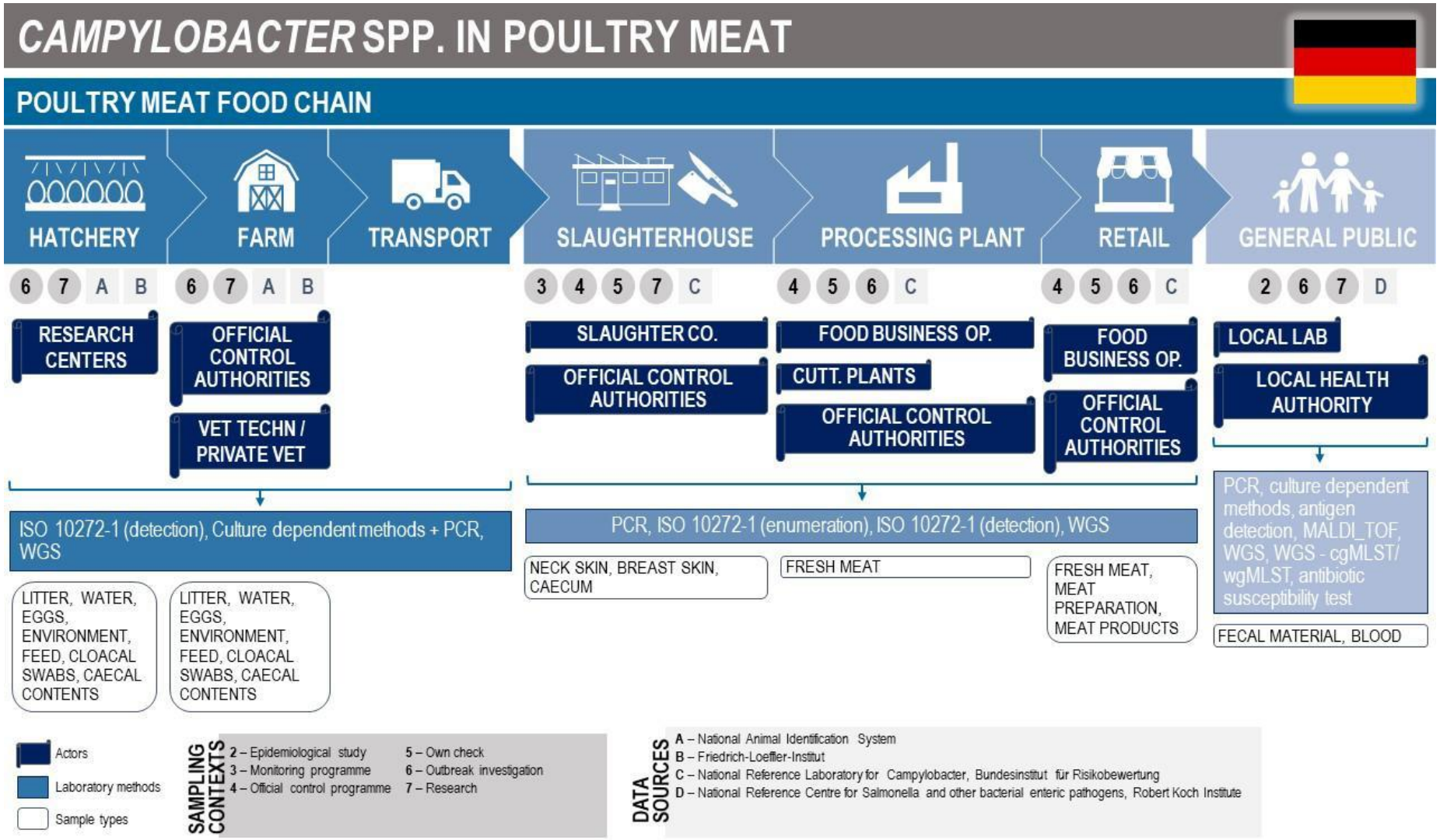

Figure 2. Mapping of surveillance of *Campylobacter* spp. in poultry meat food chain in Germany

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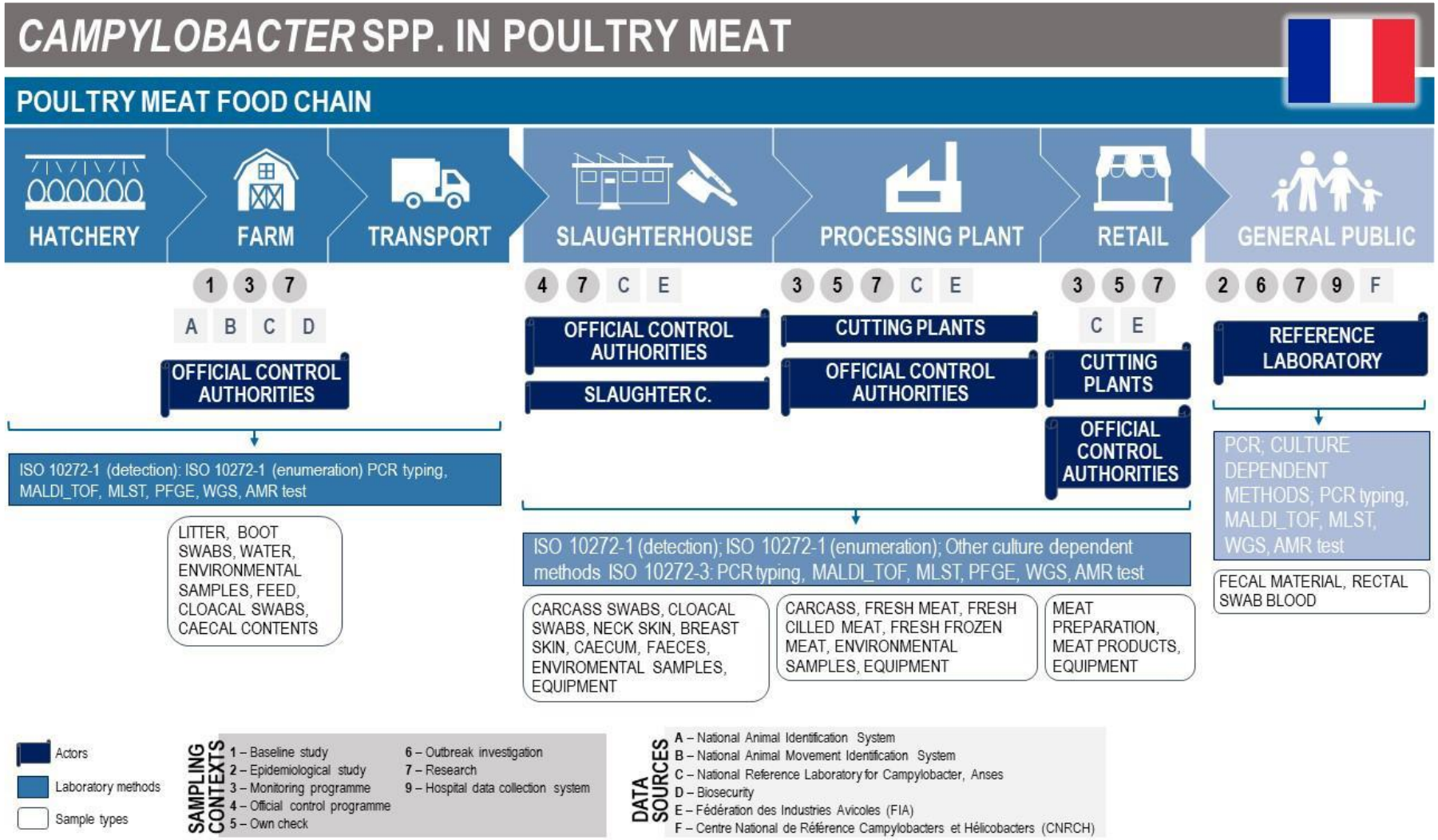

Figure 3. Mapping of surveillance of *Campylobacter* spp. in poultry meat food chain in France

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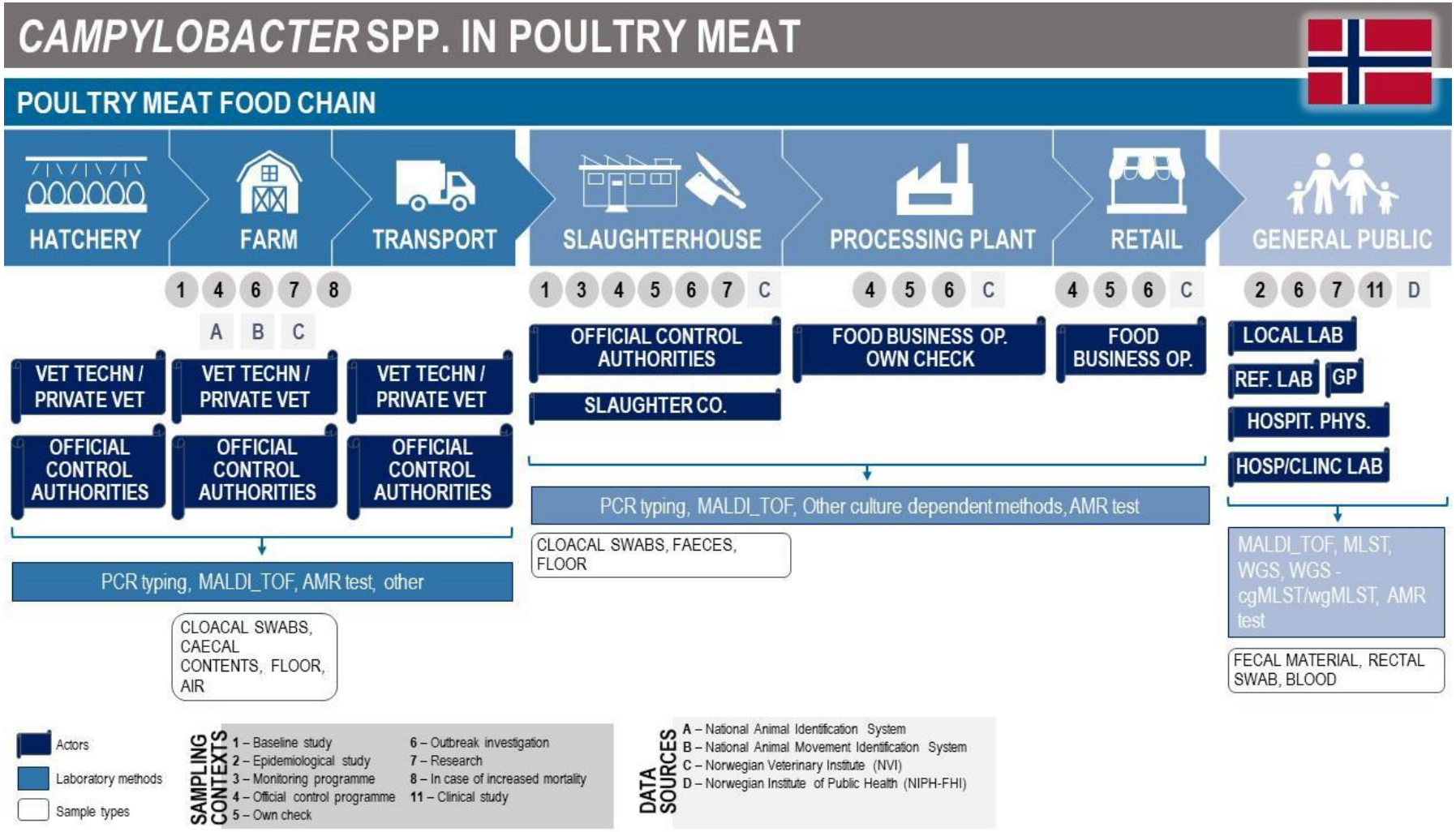

Figure 4. Mapping of surveillance of *Campylobacter* spp. in poultry meat food chain in Norway

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Campylobacter spp. metadata

I. *Campylobacter* surveillance in animals

	Collection level														
	National level			**Sub-national / Regional level**			**Local level**			**Intersectorial: human, animal, food**			**Not shared**		
Collected information	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**
Type of specimen		X	X												
Sampler			X												
Date of sample collection		X	X				X								
Place of sample collection		X	X				X								
Date of sample receipt		X	X				X								
Date of laboratory result		X	X				X								
Other															

Table 2. Information collected on isolates, at each level.

Information shared at national level	***France***	***Germany***	***Norway***
Number of confirmed cases			X
Number of suspected cases			
Number of depopulated animals			
Number of dead animals			
Type of specimen (litter, boot swabs, water, environmental samples, etc.)			
Sampler			
Date of sample collection			X
Place of sample collection			
Sampling context (official control program, monitoring, etc.)			X
Other (please specify)			

Table 3. Information collected during surveillance shared at national level.

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II. *Campylobacter* surveillance in food

	Single			Batch		
	France	***Germany***	***Norway***	***France***	***Germany***	***Norway***
Carcass swabs	X		X	X		
Neck skin	X	X		X		
Breast skin	X	X		X		
Cloacal swabs	X		X	X		X
Caecum	X	X		X	X	
Faeces	X		X	X		X
Other	X *		X			X

**It depends on surveillance activities: single and batch sample unit are collected for research projects; pool of neck skins for mandatory surveillance.*

Table 4. Sample unit in place in the different countries, per sample type.

	Area								
	Portioning			*Grading and packaging*			*Secondary chilling (before distribution)*		
Collection of specimens	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**
Carcass swab				X			X		
Neck skin	X			X			X		
Breast skin	X			X			X		
Cloacal swab									
Caecum									
Feces									
Environmental	X			X			X		
Equipment	X			X			X		

Table 5. Collection of samples during the secondary processing (after slaughter and dressing).

	Level of collection											
	Production level			*Distribution level*			*Retail level*			*Border control by export or import*		
Metadata collected	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**	**FR**	**DE**	**NO**
Registration number of the Food Business Operator- FBO	X		X	X			X			X		
Production date	X		X	X						X		
Expiry date	X		X	X			X	X		X		
Batch number	X	X	X	X			X	X		X		
Product size			X	X			X					
Storage temperature			X				X					
Packing conditions			X					X				
Small scale or large scale FBO												
Other								X				

Table 6. Metadata collected during routine surveillance activities, at each level.

Information	Country		
	France	**Germany**	**Norway**
Type of specimen (carcass swab, fresh meat, environmental, etc.)		X	
Food item		X	
Expiration date		X	
Sampler			
Date of sample collection		X	X
Time of sample collection (before or after disinfection, end of production, etc.)			
Place of sample collection		X	
Stage of processing		X	
Sampling context (e.g. monitoring or official control)	X	X	X
Other (please specify)			X

Table 7. Information collected during surveillance shared at the national level.

III. *Campylobacter* surveillance in humans

Section	Information routinely collected by official surveillance	France	Germany	Norway
Demographic data	*Age (or date of birth)*	X	X	X
	Gender	X	X	X
	Potential risk factors (e.g. transplantation, immunodeficiency, etc.)			
	Profession			
	Occupational exposure			X
	Place of residence	X	X	X
	Travel history	X	X	X
	Other information (please specify)		X*	X**
Epidemiological data	*Case status (probable or confirmed)*	X	X	
	Date of notification		X	X
	Source of notification	X	X	X
	Probable or confirmed place of exposure - Restaurant			X
	Probable or confirmed place of exposure - Home			X
	Probable or confirmed place of exposure - Farm			
	Probable or confirmed place of exposure - Backyard flock			
	Probable or confirmed place of exposure - Travel related	X	X	X
	Probable or confirmed type of exposure - Food	X		X
	Probable or confirmed type of exposure - Contact with animals			
	Probable or confirmed type of exposure - Link with other cases	X	X	
	Probable or confirmed type of exposure - Occupational exposure			X
	Probable or confirmed date of exposure			
	Other (please specify)			
Clinical data	*Date of clinical onset*		X	X
	Date of recovery(e.g. date of the resolution of symptoms, date of discharge from the hospital, etc.)*			
	Fatal (yes / no)		X	X
	Date of death		X	X
	Hospitalized (yes / no)	X	X	X
	Symptoms (e.g. asymptomatic, fever, meningitis, encephalitis, influenza-like symptoms, other, unknown)		X	X
	Treatment provided			
	Other (please specify)			
Laboratory data	*Type of specimen (stool, blood)*	X		X
	Sampler (institution that collects clinical specimen e.g. hospital, local laboratory etc.)	X		X
	Date of sample collection	X		X
	Date of sample receipt	X		X
	Date of laboratory results		X	X
	Laboratory results - Detection	X	X	X
	Laboratory results - Serology			X
	Laboratory results - Characterization	X	X	X
	Other (please specify)			

**Living/Being cared for/Working in a community care facility*
***Open field to specify underlying medical conditions*

Table 8. Type of information routinely collected by official surveillance.

Data fields are available in the case of ad hoc data collection	*France*	*Germany*	*Norway*
Number of human cases		X	X
Number of hospitalizations	X	X	X
Number of deaths	X	X	X
Source identified as probable or confirmed	X	X	X
Link with other cases	X	X	X
Level of evidence		X	
Laboratory results	X	X	X
Other (please specify)			

Table 9. Data availability in case of *ad hoc* data collection.

Listeriosis is an animal and human disease caused by *Listeria monocytogenes;* even if rare, listeriosis in humans is often severe causing hospitalisation and even death. Listeriosis had the highest proportion of hospitalised cases of all zoonoses under EU surveillance in 2019 [7]. Animals, including cattle, sheep and goats, can carry the pathogen. *Listeria* causes persistent contamination on food-processing plants [10]. The disease is often contracted by eating contaminated ready-to-eat foods (RTE) usually consumed without any additional cooking [11]. Good manufacturing practises, hygiene practises and effective temperature control throughout the food production, distribution and storage chain - including at home - can limit the growth of *Listeria* in RTE.

Listeria spp. surveillance chain in dairy products was investigated in two countries: Norway (NO) and Italy (IT) (Figures 5 and 6). Specifically, the following steps of the food chain were taken into consideration to explore surveillance activities:

- Animal level: farm;
- Food level: production plant and retail;
- Human level: general public.

The study is not showing the full *Listeria* surveillance in the two counties, but a significant part of it as the surveillance done by the official organisations are better covered than internal surveillance done by the food business operators in their own quality ensuring system. *Listeria monocytogenes* is considered among the top five groups of pathogens in Italy and Norway, and there is a mandatory microbial criterion for the bacterium in ready-to-eat food. This fact involves a duty to carry out surveillance both for monitoring and management.

There have been human listeriosis outbreaks with nationally produced cheese in both countries. Dairy products are important both economically and in the food culture in Italy and Norway, but the size of the trade is different. Italian cheeses are exported worldwide in large amounts. Norwegian cheeses are, with only few exceptions, produced and consumed domestically, but the assortment of cheeses has increased during the last few decades thanks to the regrowth of small scale cheese production and import of cheeses. International trade involves that the international demands have to be met, not only in business to business relations, but also on a national level. In line with this, extensive surveillance from competent authorities on products to be traded is reported from both countries.

There are differences between the countries regarding how the surveillance system is organised. Both countries consist of regions with cultural diversity, but the population density and national systems are different. In Italy, the regions are more autonomous than in Norway, which means that the sharing of data is not automatic. In Norway, the national and regional surveillance programmes are integrated and data shared accordingly.

Animals. Official controls of animals were reported from Italy, while controls performed by private veterinarians and/or technicians were reported from Norway. However, the kind of samples and situations for sampling (e.g. miscarriage, ill animals, bulk milk) were basically the same in both countries. The number of sampling methods applied for the animal sector appears higher in Italy than in Norway (Figures 5 and 6). The difference may be due to the fact that the purpose of the analyses in Norway, where the prevalence of *Listeria* in animals is very low, is diagnostic. Milk from infected

animals is destroyed and further characterisation is therefore not needed. Based on the responses, the sharing of data appears higher in Italy than in Norway, as Italy shares nationally, sub-nationally and between sectors while Norway has responded "not shared" (Table 10). This is unexepected, as only few laboratories are involved in the diagnostics in Norway, and these already work collaboratively at national level. And further, even though the information is not shared automatically, it is available upon request. The number of confirmed cases per region? is reported and shared nationally in both countries (Table 10).

Production and retail. Surveillance of the food sector appears similar in the two countries both in terms of samples analysed (production environment and products) (Figures 5 and 6), and in terms of metadata collected in the production, distribution and retail parts of the food chain. Specimen collection timing for surveillance of *Listeria* in food is up to the company in both Italy and Norway: specifically, in Italy, it is based on own-check[4] procedures, and in Norway, it depends on the purpose of the sampling.. In both investigated countries, samples are also taken on the border, mostly related to import (Table 13). Surveillance activities in place for *Listeria* in dairy production plants include: cleaning and sanitation procedures, critical control points (CCP), review of hazard analysis and critical control points (HACCP) plans, verification routines of CCP and product safety control, and review of shelf-life study in both Italy and Norway. Moreover, they include production flow mapping in Italy. Information collected for food products, in Italy and Norway, include both the compliance with criteria listed in Regulation (EC) n. 2073/2005 and the presence of *Listeria*, plus it includes the concentration of *Listeria* at the end of the shelf-life in Norway. In case of designed surveillance programmes, in both countries, the sampling programme is designed to investigate the exposure of *Listeria* in general, or to target import/export controls. In Norway, it could be designed also to target special segments of producers (e.g. small scale producers, unpasteurized milk, etc.) or consumer groups (e.g. vulnerable consumers, high amount consumers of the particular food, etc.). Moreover, in both countries the information about the expiration date of foodstuff samples is collected and reported at the national level (Table 14).

Laboratory methods. Regarding analytical methods used in the food sector, enumeration by the end of shelf life is performed in Norway while it was not reported from Italy. On the other hand, both countries are typing isolates. The data do not indicate whether all isolates are typed, what the triggers for typing are, which situations the data are shared and how often. However, the focus on typing methods probably reflects the rapid change of methods including the recent implementation of WGS in outbreak investigations. The high similarity of surveillance in the food sector indicates the high international focus of *Listeria monocytogenes* as a foodborne pathogen. In the public health sector, while Norway reports WGS based methods, Italy reports several other typing methods, including WGS. This could be due to the fact that more laboratories are involved in Italy, and that they use different methods, while in Norway one reference lab confirm and follow up samples for human isolates of *Listeria*.

Surveillance of human listeriosis. Both countries collect and investigate isolates from confirmed human listeriosis cases, that means invasive listeriosis. The age, gender, and place of residence are

[4] Programme designed to effectively control processes by identifying critical control points (CCPs), establishing critical limits for each CCP, monitoring CCPs, gathering data, keeping records, and implementing corrective actions and verification procedures. HACCP is applied by the food or feed business operators (Codex Alimentarius).

collected in both countries, and also the travel history in Norway (Table 15). The two countries report differently about sharing and analysis of data, despite both report the same kind of samples and analytical methods for typing (Table 16). We are aware that there is official sharing of the number of cases that are updated daily.

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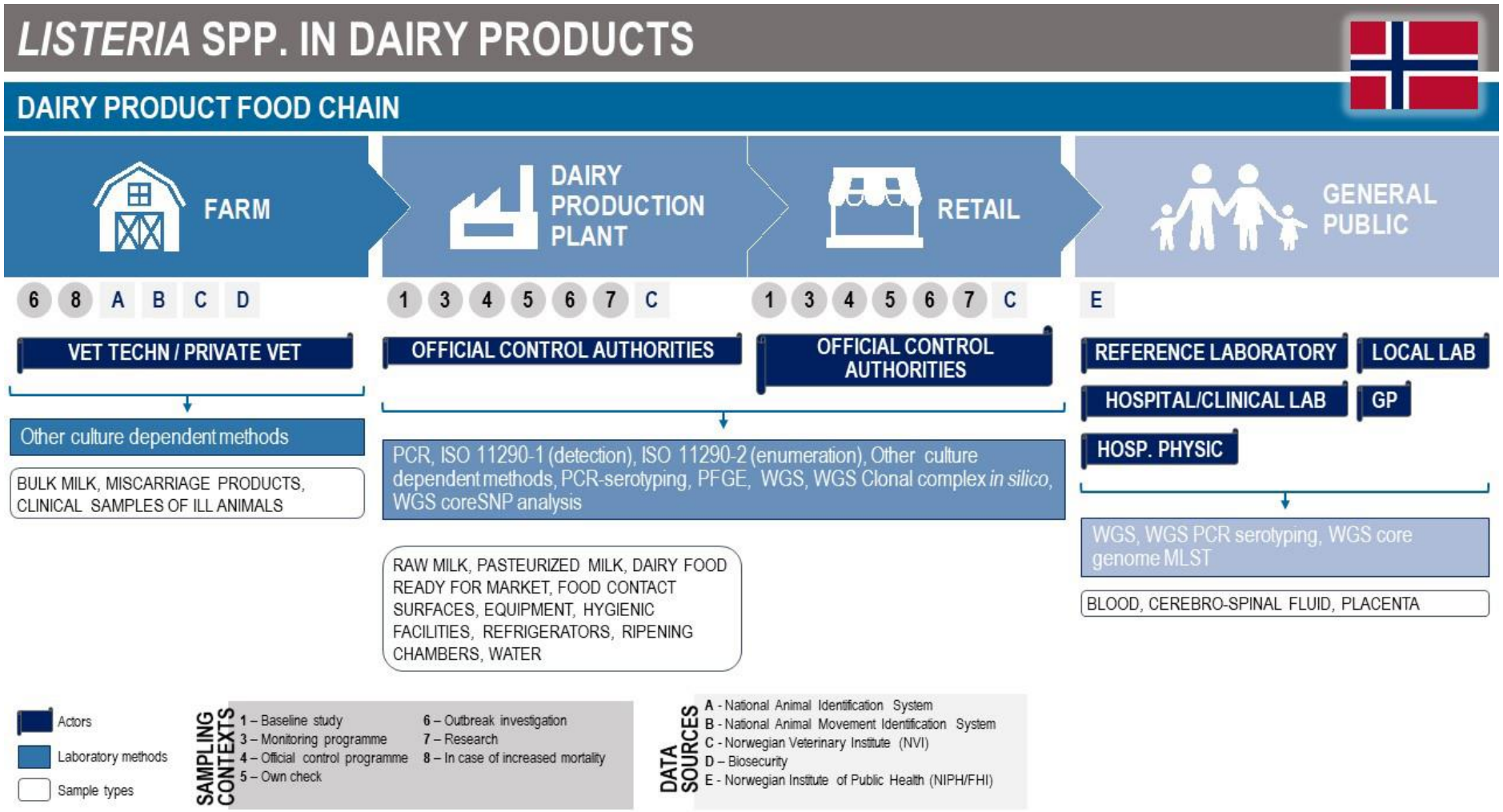

Figure 5. Mapping of surveillance of *Listeria* spp. in dairy products food chain in Norway.

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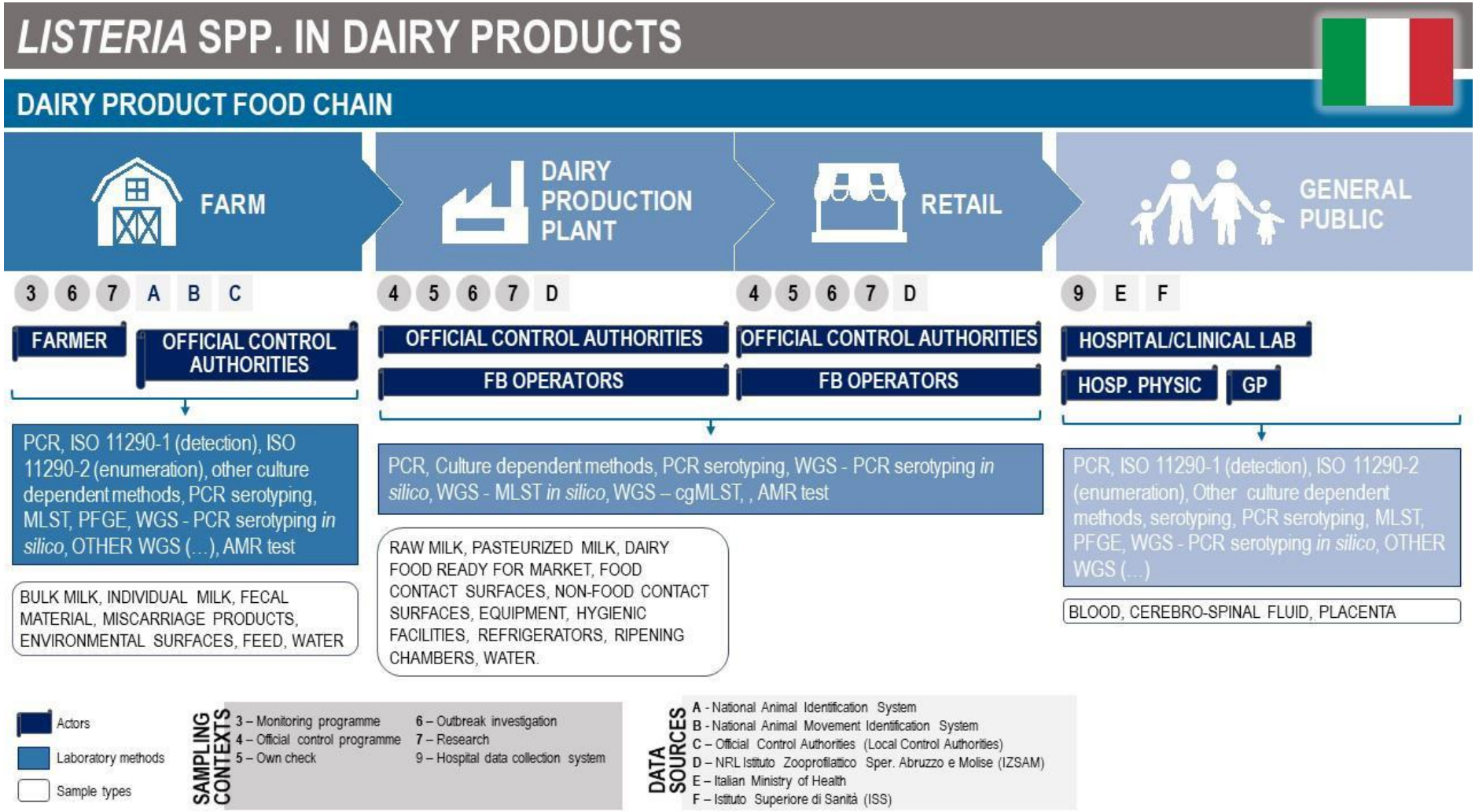

Figure 6. Mapping of surveillance of *Listeria* spp. in dairy products food chain in Italy.

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Listeria spp. metadata

I. *Listeria* surveillance in animals

	Collection level									
	National level		Sub-national / Regional level		Local level		Intersectorial: human, animal, food		Not shared	
Collected information	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**
Type of specimen		X		X				X	X	
Sampler		X		X				X	X	
Date of sample collection		X		X				X	X	
Place of sample collection		X		X				X	X	
Date of sample receipt		X		X				X	X	
Date of laboratory result		X		X				X	X	
Other										

Table 10. Information collected on isolates, at each level.

Information collected at national level	**Norway**	**Italy**
Number of confirmed cases	X	X
Number of suspected cases		X
Number of depopulated animals		
Number of dead animals		X
Type of specimen (bulk milk, miscarriage products, etc.)		X
Sampler		X
Date of sample collection		X
Place of sample collection		X
Sampling context (official control program, monitoring, etc.)		X
Other (please specify)	X*	

**The information is available only upon request.*

Table 11. Information collected during surveillance shared at national level.

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II. *Listeria* surveillance in food

	Collection of specimens									
	Food producing environment		Ingredients or food		Personnel		Cleaning materials		Other	
Area	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**
Unloading area (reception of raw milk and ingredients)	X	X	X	X		X		X		
Storage of milk	X	X	X	X						
Production lines	X	X	X	X		X		X		
Cold room	X	X	X	X						
Ripening room	X	X	X	X						
Packaging area	X	X	X	X						
Loading area	X	X	X	X						
Storage area (packaging materials, detergents, etc.)		X		X						
Facilities (WC, etc.)		X				X				
Administrative unit										
Other										

Table 12. Areas of the cheese production plants and the specimens that are collected.

	Level of collection									
	Production level		Distribution level		Retail level		Border control by export or import		Other	
Metadata collected	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**	**Norway**	**Italy**
Registration number of the FBO(FBO: Food business operator)	X	X	X	X	X	X	X	X		
Production date	X		X		X		X			
Expiry date	X	X	X	X	X	X	X			
Batch number	X	X		X		X	X			
Product size		X		X	X	X				
Animal species (milk-producing animal)	X	X	X	X	X	X	X			
Storage temperature	X	X	X	X	X	X	X			
Packing conditions	X		X		X		X			
Small scale or large scale FBO	X		X		X		X			
Other									X	

Table 13. Metadata collected during routine surveillance activities, at each level.

Information	*Norway*	*Italy*
Type of specimen (food, environmental, etc.)	X	X
Food item	X	X
Expiration date	X	X
Sampler	X	X
Date of sample collection	X	X
Time of sample collection (before or after disinfection, end of production, etc.)	X	
Place of sample collection	X	X
Stage of processing	X	X
Sampling context (e.g. monitoring or official control)	X	X
Other (please specify)		

Table 14. Information, collected during surveillance, shared at the national level.

III. *Listeria* surveillance in humans

Section	Information collected	Norway	Italy
Demographic data	*Age (or date of birth)*	X	X
	Gender	X	X
	Potential risk factors (e.g. pregnancy, transplantation, etc.)		
	Profession		
	Occupational exposure		
	Place of residence	X	X
	Travel history	X	
	Other information (please specify)		
Epidemiological data	*Case status (probable or confirmed)*	X	X
	Date of notification	X	X
	Source of notification	X	X
	Probable or confirmed place of exposure - Restaurant*		
	Probable or confirmed place of exposure - Home*		
	Probable or confirmed place of exposure - Farm*		
	Probable or confirmed place of exposure - Travel related*		X
	Probable or confirmed type of exposure - Food		
	Probable or confirmed type of exposure - Contact with animals		
	Probable or confirmed type of exposure - Link with other cases		
	Probable or confirmed type of exposure - Occupational exposure		
	Probable or confirmed date of exposure		
	Other (please specify)		X *
Clinical data	*Date of clinical onset*	X	X
	Date of recovery(e.g. date of the resolution of symptoms, date of discharge from the hospital, etc.)*		
	Fatal (yes / no)		
	Date of death		
	Hospitalized (yes / no)	X	X
	Symptoms (e.g. asymptomatic, fever, meningitis, encephalitis, influenza-like symptoms, other, unknown)		
	Treatment provided		
	Other (please specify)		
Laboratory data	*Type of specimen (rectal swab, blood, placenta etc.)*	X	
	Sampler (institution that collects clinical specimen e.g. hospital, local laboratory etc.)	X	
	Date of sample collection	X	
	Date of sample receipt	X	
	Date of laboratory results	X	
	Laboratory results - Detection	X	
	Laboratory results - Serology	X	
	Laboratory results - Characterization	X	
	Other (please specify)		

**There are important differences among regions in the details of information collected on cases. Moreover, Regions have a high degree of autonomy in organising the epi surveillance beyond the minimum national requirements.*

Table 15. Type of information routinely collected by official surveillance.

Data fields are available in the case of ad hoc data collection	*Norway*	*Italy*
Number of human cases		X
Number of hospitalizations		X
Number of deaths		
Source identified as probable or confirmed		X
Link with other cases		X
Level of evidence		
Laboratory results		X
Other (please specify)		

Table 16. Data availability in case of ad hoc data collection.

Salmonella is a widely distributed bacteria, with many animal reservoirs including farmed livestock. Salmonellosis, the illness resulting from *Salmonella* infection, is the second most common cause of foodborne disease outbreaks in Europe [12]. Consumption of contaminated food is the most common cause of salmonellosis in humans, however the contaminated food consumed is not limited to meat products and can include salad and processed plant products [13]. As salmonellosis does not always require medical treatment or hospitalisation, there is a significant under reporting of the disease burden in humans. Salmonellosis is a priority disease in EFSA's extended control programme for zoonotic diseases and all EU member states have implemented enhanced *Salmonella* control programmes in poultry.

Being a widely spread bacteria, the definition of a single point of exposure in the farm to fork processing chain for pork meat is especially challenging: cross-contamination of carcasses and food products is an ongoing challenge. The movement of food and processed products within Europe adds complexity in tracing *Salmonella*; to support local monitoring activities EFSA and ECDC produce a joint publication monitoring trends across Europe [7], which includes human cases acquired during travel within the EU.

In conjunction with *Salmonella* surveillance and monitoring in the farm to fork production chain, prophylactic measures also aimed at ensuring safe food preparation in the kitchen to prevent human infection during food consumption [14], [15].

Salmonella spp. surveillance chain in pork meat was investigated in five countries: France (FR), Germany (DE), Spain (SP), Norway (NO), and The United Kingdom (UK) (Figures 7 to 11). Specifically, the following steps of the food chain were taken into consideration to explore surveillance activities:

- Animal level: farm and transport;
- Food level: slaughterhouse, processing plant and retail;
- Human level: general public.

Animals. A number of different actors are involved in the surveillance activities at farm level. The most commonly reported actors were official control authorities, followed by veterinary technicians or private veterinarians, laboratories, farmers and the industry, and eventually also Universities / Research centres / Federal Institutions. In overall, these actors perform not only official controls, but also implement monitoring programmes, research, outbreak investigations, baseline survey, industrial accreditation schemes. Moreover, surveillance activities are in place for antimicrobial resistance monitoring in Spain and in case of increased mortality in the farm in the UK. France was the only country to report sampling activities, in the context of research projects, at transport likely because no official controls were reported at farm or during transport. All the investigated countries share information gathered from surveillance activities at the national level (Tables 17 and 18).

Slaughterhouse. All investigated countries have in place carcass swabs sampling (Figures 7 to 11) related to production hygiene criteria (Table 19). In Norway and the UK surveillance is carried out by official control authorities; in Norway samples are collected before cleaning and disinfection while in UK randomly. In France and Germany, several sampling activities are conducted during slaughter by official control authorities together with the industries; in France, the collection of samples depends

on the site and on the daily organisation while in Germany, sampling is performed randomly. In France, laboratories and the French pork and pig Institute were reported among the actors in charge of own-check[5] and research activities sampling, among the others, also environmental or equipment samples are collected (Figure 7). Moreover, in France, surveillance activities in place for *Salmonella spp*. in pigs at the slaughterhouse also include data collection on the production flow mapping, personnel movement, cleaning and sanitation procedures, and intervention at slaughter (scheduled slaughter, logistic slaughter, etc.).

Processing and Retail. In Spain, France and Germany, minced meat and meat preparations are monitored by official control authorities and food business operators performing respectively surveillance and own-check activities both at processing plant and retail (Figures 7 to 9). In Norway and the UK, surveillance is carried out at processing plants by official control authorities while no sampling is performed at retail (Figures 10 and 11). Also at these stages in France many different actors, such as official control authorities, cutting plants, laboratories, French pork and pig institute, are involved in collecting data and samples (Fig. 7). During the secondary processing (portioning, grading and packaging, secondary chilling), fresh meat is collected at portioning in Germany and Norway, and during chilling in France. In addition, in France, sampling is also conducted at retail (minced meat, meat preparations and mechanically separated meat). In Germany, meat samples are collected randomly.

In general, in France, Germany and Spain, sampling conducted in designed surveillance programmes aims to investigate the exposure to *Salmonella* spp. In addition, in France, it is targeted to consumer groups (e.g. vulnerable consumers, high amount consumers of the particular food), and for import/export; in case of non-compliance, depending on the risk analysis carried out, additional analyses may be carried out on the products concerned.

Laboratory methods, pig meat food chain. Serotyping is performed from all the investigated countries in each sector. Improvements to identification and characterisation of *Salmonella* through the use of WGS is becoming more widespread through sampling across the complete farm to fork production chain as seen in the information gathered from the questionnaires. AMR test is always performed aiming to investigate the occurrence of antimicrobial resistance among *Salmonella* serovars isolated from animal, food and human sources.

Surveillance of human salmonellosis. In France, Germany and Norway, data collection for human cases takes place for confirmed cases and outbreaks, and in both cases it is case based. In addition, Germany also conducts suspect sampling for probable cases (also case based). Many actors are involved in reporting data such as reference laboratories, hospital/clinical laboratories, and also local health authorities and local laboratories, during epidemiological studies, outbreak investigations and research. All investigated countries report that they have consistent data related to case detection; Norway and Germany also have epidemiological data on risk exposure during routine surveillance. France collects additional epidemiological data during outbreak investigations (Table 23).

[5] Programme designed to effectively control processes by identifying critical control points (CCPs), establishing critical limits for each CCP, monitoring CCPs, gathering data, keeping records, and implementing corrective actions and verification procedures. HACCP is applied by the food or feed business operators (Codex Alimentarius).

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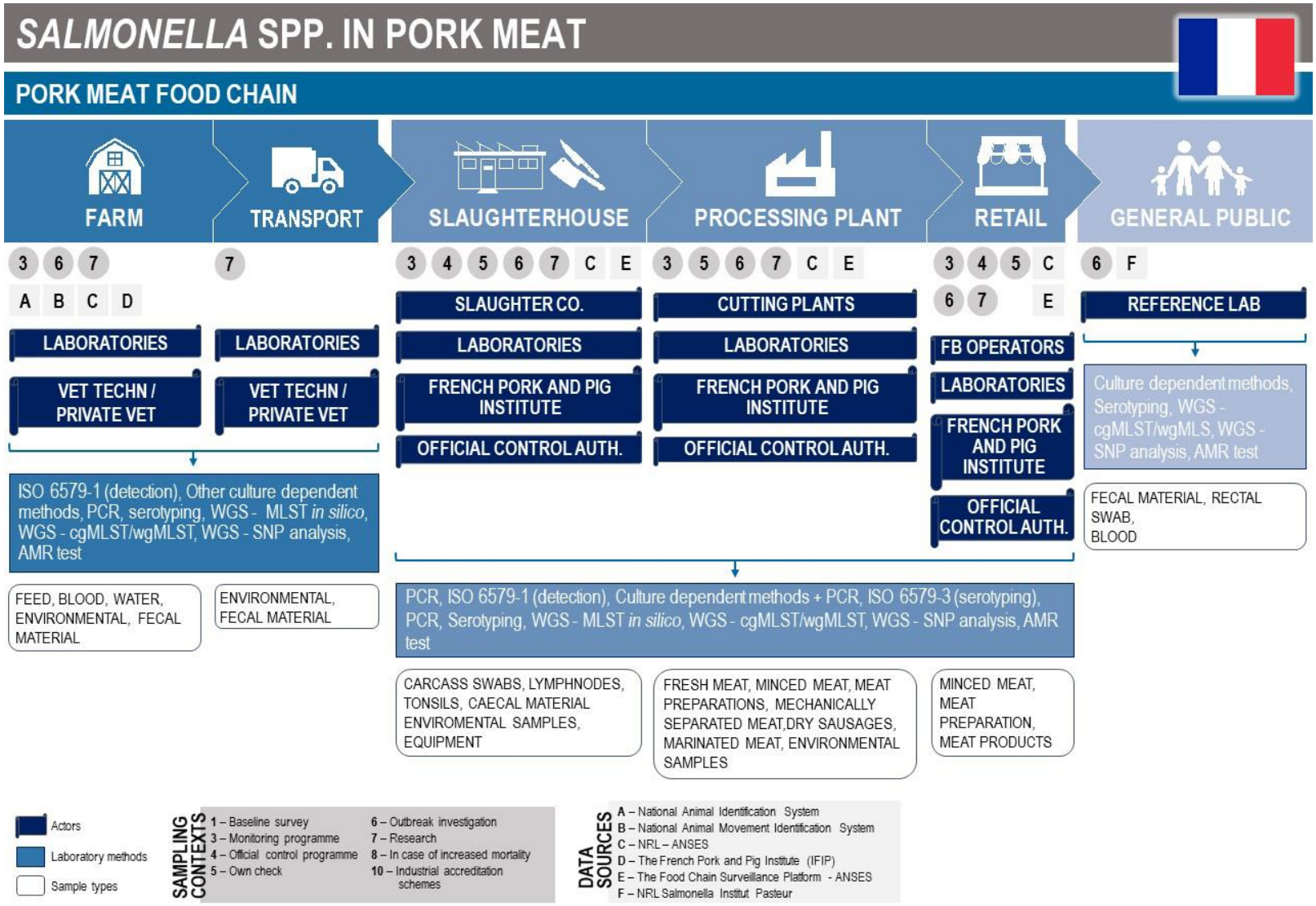

Figure 7. Mapping of surveillance of *Salmonella* spp. in pork meat food chain in France.

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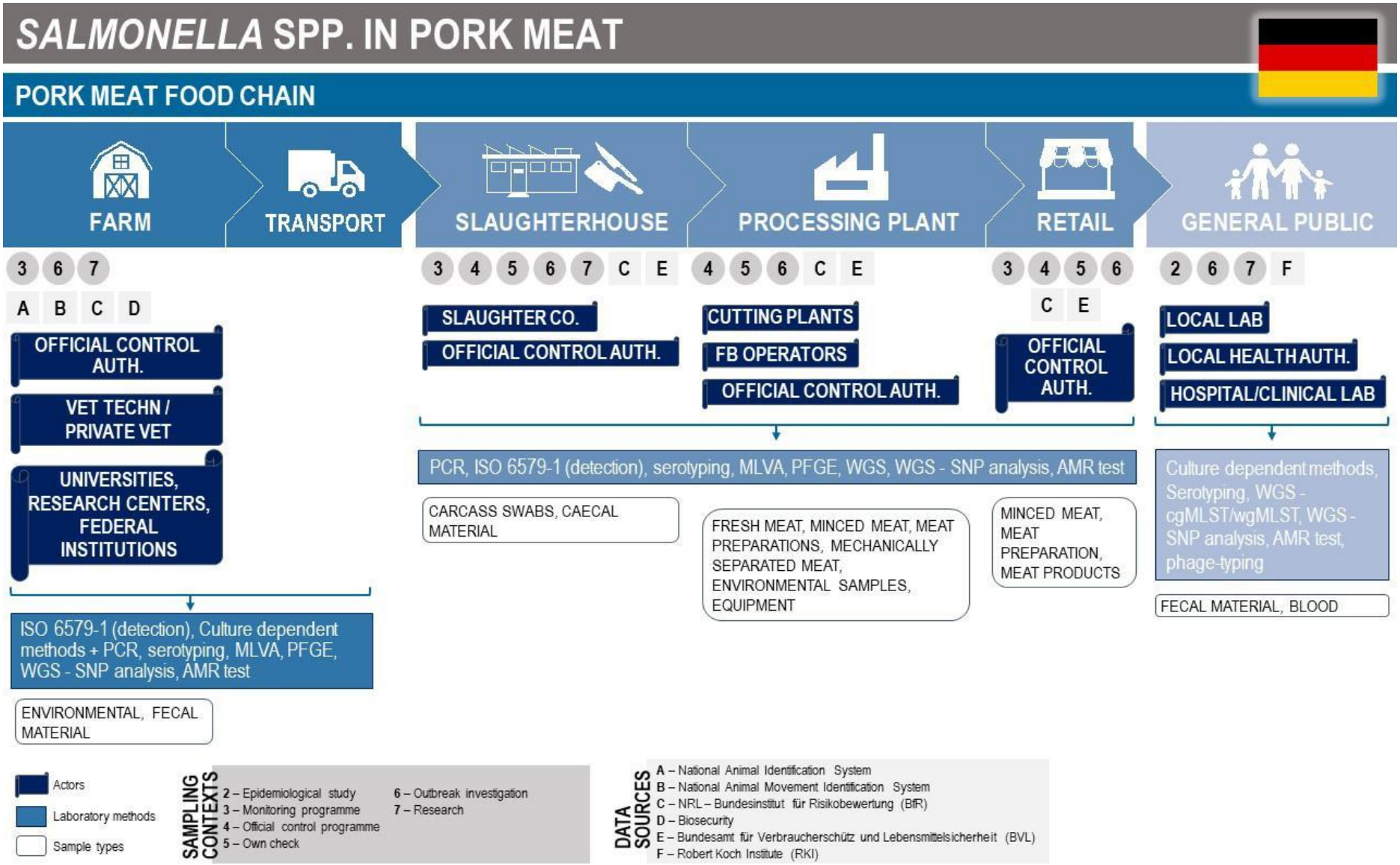

Figure 8. Mapping of surveillance of *Salmonella* spp. in pork meat food chain in Germany.

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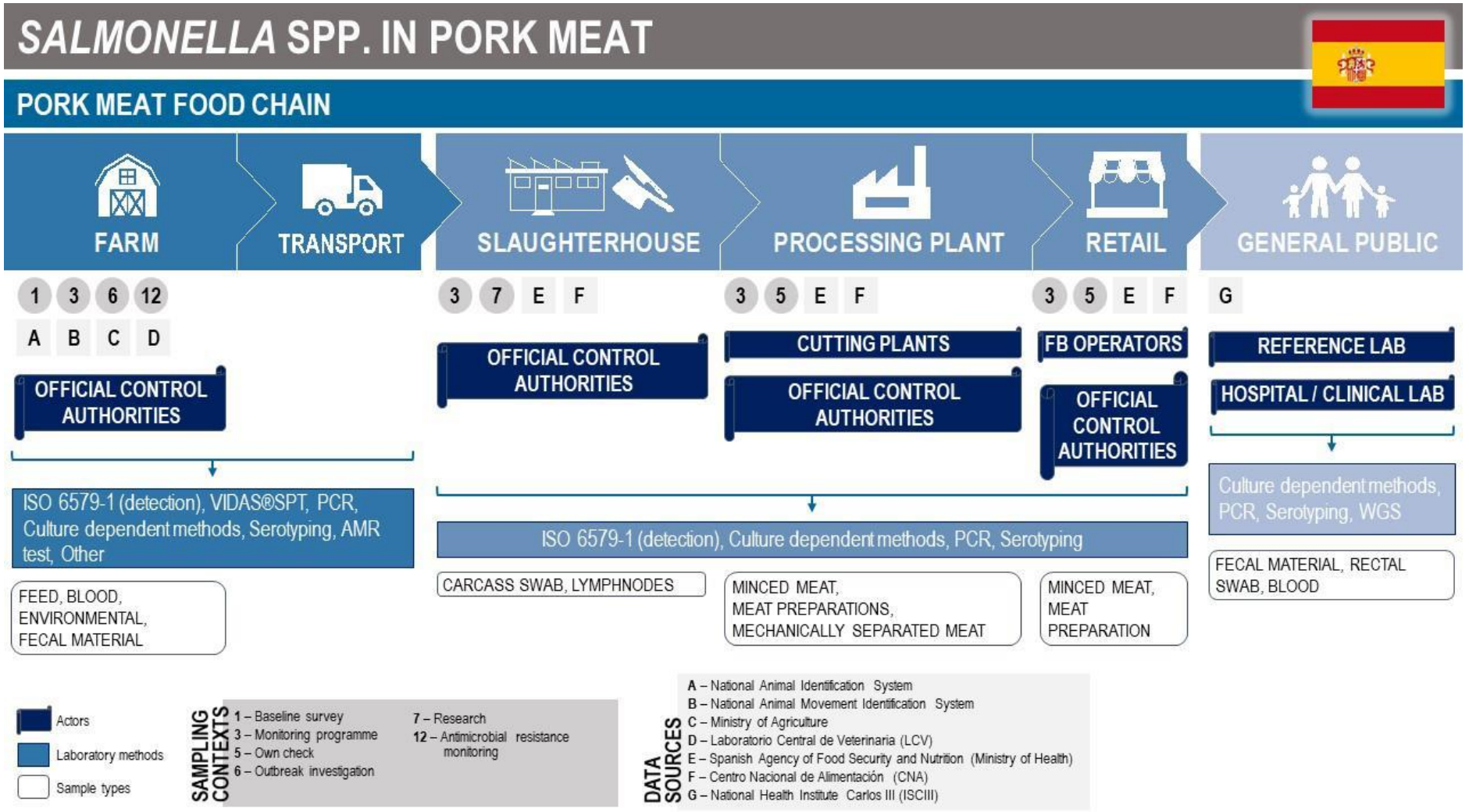

Figure 9. Mapping of surveillance of *Salmonella* spp. in pork meat food chain in Spain.

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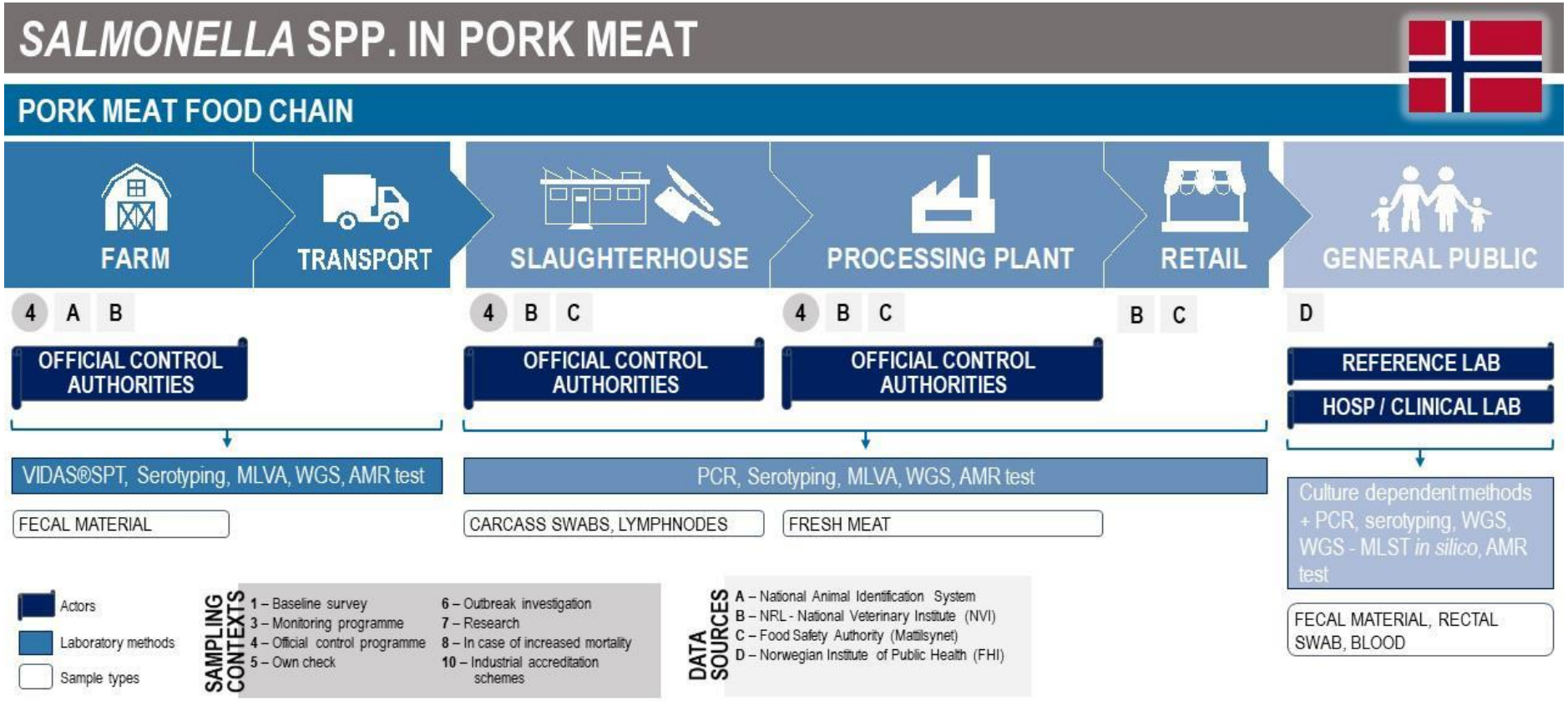

Figure 10. Mapping of surveillance of *Salmonella* spp. in pork meat food chain in Norway.

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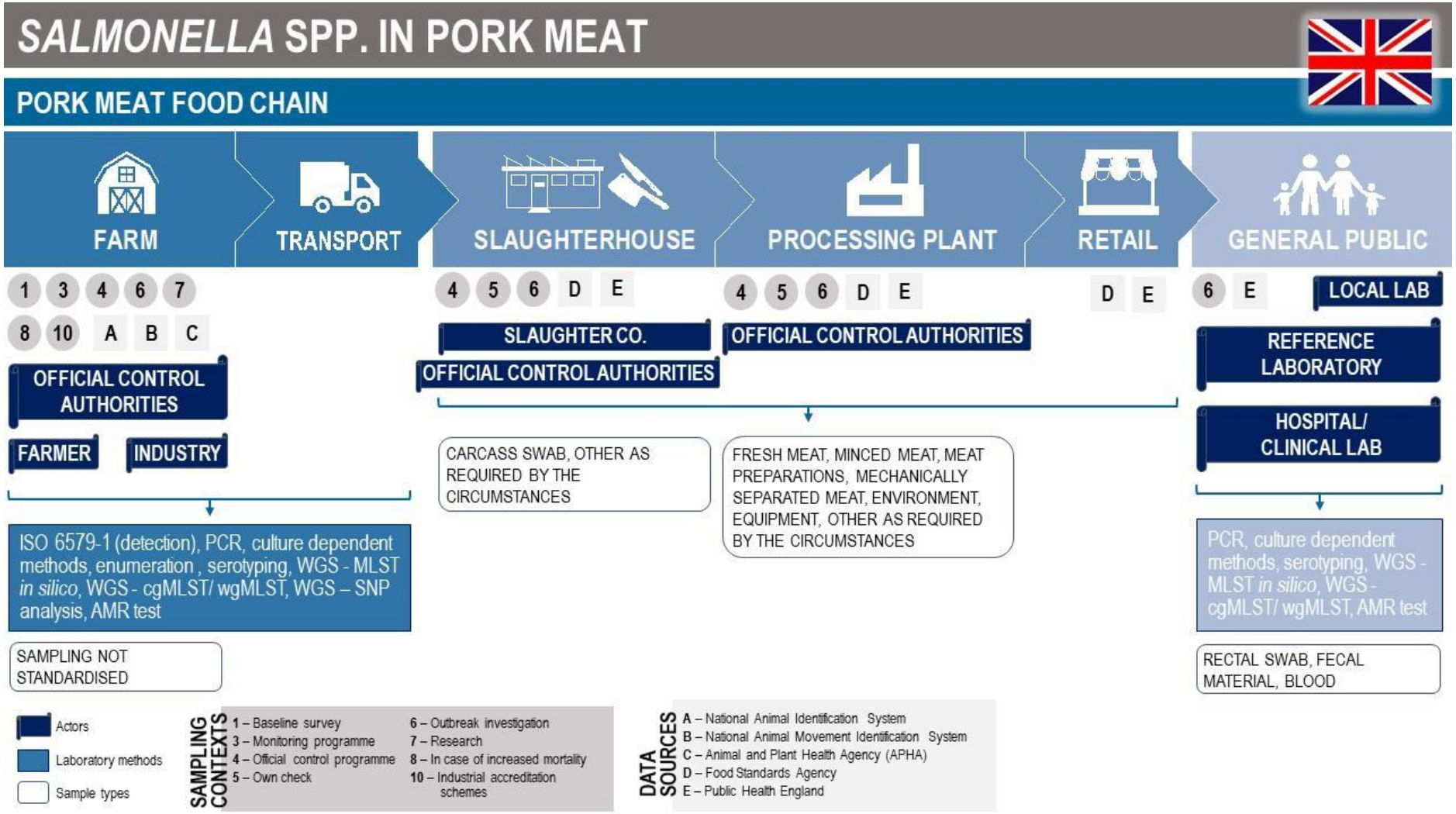

Figure 11. Mapping of surveillance of *Salmonella* spp. in pork meat food chain in the UK (excluded Northern Ireland)

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Salmonella spp. metadata[6]

I. *Salmonella* surveillance in animals

	National level			
Collected information	**FR**	**DE**	**NO**	**SP**
Type of specimen	X	X	X	X
Sampler	X		X	
Date of sample collection	X	X	X	
Place of sample collection	X	X	X	X
Date of sample receipt	X	X	X	
Date of laboratory result	X	X	X	
Other		X*		

**Farm registration number/business unit, recipient (laboratory ID) and sender (veterinary ID).*

Table 17. Information collected on isolates at each level.

Information shared at national level	**FR**	**DE**	**NO**	**SP**
Number of confirmed cases	X		X	X
Number of suspected cases				
Number of depopulated animals	X			
Number of dead animals	X			
Type of specimen (blood, water, environmental samples, etc.)	X		X	
Sampler	X		X	
Date of sample collection	X		X	
Place of sample collection	X		X	
Sampling context (official control program, monitoring, etc.)	X		X	X
Other (please specify)				X*

**Shared trough national reports annually*

Table 18. Information collected during surveillance shared at national level.

[6] Only public available data have been presented for the UK (excluding Northern Ireland) in the present document. Specifically, no data regarding the UK will be presented in the metadata chapter.

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II. *Salmonella* surveillance in food

	Single				Batch			
Type of sample	**FR**	**DE**	**NO**	**SP**	**FR**	**DE**	**NO**	**SP**
Carcass swabs	X	X	X		X			X
Lymph nodes	X		X					
Tonsils	X							
Caecal material	X	X						
Other								

Table 19. Sample unit in place in the different countries, per sample type.

	Country			
Information	**FR**	**DE**	**NO**	**SP**
Type of specimen(carcass swab, fresh meat, environmental, etc.)	X	X	X	X
Food item	X	X		X
Expiration date		X		
Sampler			X	
Date of sample collection	X	X	X	X
Time of sample collection (before or after disinfection, end of production, etc.)				
Place of sample collection		X	X	X
Stage of processing	X	X		X
Sampling context (e.g. monitoring or official control)	X	X	X	X
Other (please specify)				X*

**Place (in terms of Autonomous Community (NUT 2))*

Table 20. Information collected during surveillance shared at the national level.

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	Level of collection																			
	Production level				*Distribution level*				*Retail level*				*Border control by export or import*				*Other (please specify)*			
Metadata collected	**FR**	**DE**	**NO**	**SP**	**FR**	**DE**	**NO**	**SP**	**FR**	**DE**	**NO**	**SP**	**FR**	**DE**	**NO**	**SP**	**FR**	**DE**	**NO**	**SP**
Registration number of the Food Business Operator	X				X				X				X				X			
Production date	X				X				X				X				X			
Expiry date	X				X				X	X			X				X			
Batch number	X	X			X				X	X			X				X			
Product size	X				X				X				X				X			
Storage temperature	X				X				X				X				X			
Packing conditions	X				X				X	X			X				X			
Small scale or large scale FBO	X				X				X				X				X			
Other																				X*

**This information is not available from shared data by AESAN*

Table 21. Metadata collected during routine surveillance activities, at each level.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.

III. *Salmonella* surveillance in humans

Section	Information collected	FR	DE	NO	SP
Demographic data	Age (or date of birth)	X	X	X	X
	Gender	X	X	X	X
	Potential risk factors(e.g. transplantation, immunodeficiency etc.)				X
	Profession			X	
	Occupational exposure				
	Place of residence	X	X	X	
	Travel history	X	X	X	
	Other information (please specify)		X*		
Epidemiological data	Case status (probable or confirmed)		X		X
	Date of notification	X	X	X	X
	Source of notification		X	X	
	Probable or confirmed place of exposure - Restaurant			X	
	Probable or confirmed place of exposure - Home			X	
	Probable or confirmed place of exposure - Farm			X	
	Probable or confirmed place of exposure - Travel related		X	X	
	Probable or confirmed type of exposure - Food			X	
	Probable or confirmed type of exposure - Contact with animals			X	
	Probable or confirmed type of exposure - Link with other cases		X	X	
	Probable or confirmed type of exposure - Occupational exposure			X	
	Probable or confirmed date of exposure			X	
	Other (please specify)				X**
Clinical data	Date of clinical onset		X	X	X
	Date of recovery (e.g. date of the resolution of symptoms, date of discharge from the hospital, etc.)			X	
	Fatal (yes / no)		X	X	
	Date of death		X	X	
	Hospitalized (yes / no)		X	X	X
	Symptoms (e.g.: asymptomatic, fever, diarrhoea, abdominal pain, vomiting, other, unknown)		X	X	X
	Treatment provided				
	Other (please specify)				X***
Laboratory data	Type of specimen(rectal swab, stool, blood)	X		X	X
	Sampler(institution that collects clinical specimen e.g. hospital, local laboratory etc.)	X		X	
	Date of sample collection	X		X	
	Date of sample receipt	X		X	
	Date of laboratory results	X	X	X	
	Laboratory results - Detection		X	X	X
	Laboratory results - Serology			X	X
	Laboratory results - Characterization	X		X	X
	Other (please specify)				

Living/Being cared for/Working in a community care facility.

***Information is available only through the public annual or weekly reports and through EFSA reports.*

**** Hospitals record the detailed data. Information on hospitalizations are stored in a national database maintained by the Ministry of Health. National official programme coordinates the regional surveillance programmes.*

Table 22. Type of information routinely collected by official surveillance.

Data fields available in case of ad hoc data collection	FR	DE	NO	SP
Number of human cases	X	X		
Number of hospitalizations	X	X		
Number of deaths	X	X		
Source identified as probable or confirmed	X	X		
Link with other cases	X	X		
Level of evidence	X	X		
Laboratory results	X	X		
Other (please specify)		X*		

**Answers valid for outbreak investigations*

Table 23. Data availability in case of ad hoc data collection.

Hepatitis E in wild boar meat food chain

Hepatitis E is a human disease caused by Hepatitis E virus (HEV), a quasi-enveloped positive RNA virus belonging to the *Hepeviridae* family that is transmitted by faecal-oral route. Hepatitis E is usually a self-limiting disease with a low fatality rate (below 0.5%), but it may lead to chronic infection in immunocompromised subjects (e.g. transplant patients) and develop into fulminant liver failure in pregnant women (reach a fatality rate of 25% in this group). Transmission dynamics of HEV vary worldwide: the genotypes G1 and G2 of the virus are restricted to humans and are responsible for large waterborne outbreaks in low-income countries. On the opposite, G3 and G4 genotypes are zoonotic, infecting several animal species, including domestic pigs, wild boars and deer - and are the main cause of reported cases in developed countries, where the foodborne pathway acts as the major transmission route. Indeed, the risk associated with the consumption of raw and undercooked pork, wild boar and deer products has been clearly established [6] and several studies demonstrated the association between wild boar meat consumption and sporadic HEV events or small outbreaks. An overview of the HEV surveillance systems in Europe indicates that case definition and reporting systems are not yet harmonised. To promote comparability of data between EU / EEA countries, ECDC issued an Operational Guidance [16] in 2019 to implement or adjust national HEV surveillance based on criteria for clinical testing and for acute and chronic case definition, established by the European Association for the Study of the Liver (EASL). This harmonisation of clinical data is still ongoing in Europe and will provide stronger evidence for risk assessment in the coming years.

The Hepatitis E surveillance chain was investigated in four countries: Norway (NO), the Netherlands (NL), Portugal (PT) and Italy (IT) (Figures 12-15). Specifically, the following steps of the food chain were taken into consideration to explore surveillance activities:

- Animal level: wild boars (hunting and farm);
- Food level: slaughterhouse, game handling establishment and retail;
- Human level: general public.

HEV is not included in the list of zoonotic agents under Directive 2003/99/EC of the European Parliament, nor is considered among food safety microbiological criteria under Commission Regulation (EC) 2073/2005. Therefore, significant variability in surveillance activities in different countries may be expected. Furthermore, centralization of data collection for surveillance activities differs among countries depending on the sector (human health, food safety, animal welfare) involved and its organisation at national level.

Animals. HEV in wild boars is not a notifiable disease in any of the responding countries and surveillance is not in place neither for wild nor for farmed animals, with the exception of Norway, which reported surveillance on voluntary basis for wild animals, involving hunters. Surveillance is not conducted on animals found dead either. On the contrary, surveillance activities in the form of research projects and monitoring programmes, are reported by The Netherlands and Italy (only in some Regions). In this case sampling of blood/serum (The Netherlands, Italy and Norway) and/or of liver, meat juice, faeces (Italy) is conducted in association with real time RT-PCR detection, ELISA for Ab detection and, occasionally, molecular characterization. Data on surveillance activities and on tested specimens are stored in collection systems at the national level in the Netherlands and in Norway. Information regarding the type of specimen and the date of sample collection are recorded at the national level in the Netherlands and Norway during surveillance activities. Moreover, in Norway, information on the sampler, the place of sample collection, the date on sample receipt and

date of laboratory result are collected at national level. No information amongst the proposed ones was reported to be collected, at any level, in Italy and Portugal (Table 24).

Production and retail. No surveillance activities are ongoing for HEV in slaughterhouses in the four responding countries (Figures 12-15). Similarly, wild boar slaughtered for own consumption, wild boar at the game-handling establishments, and food products derived from wild boar at retail level are not subjected to targeted surveillance for HEV in either Italy, Portugal or Norway. Non-systematic surveillance activities in all of these steps of the production chain are undertaken in Italy within research projects and monitoring programmes that involve control authorities and the sampling of wild boar tissues and organs (liver, gallbladder, meat, blood/serum, faeces), meat and meat products/preparations, and environmental samples. In Italy, samples are collected on a single basis (type of specimen: liver, gallbladder, bile, faeces). No other information regarding Hepatitis E surveillance in food with regard to wild boar meat was reported from Italy or the other investigated countries. Analytical details on methods were provided only by Italy and show application of real-time PCR for HEV detection (protocol shared at the national level by the National Reference Laboratory for Foodborne Viruses) and of a nested RT-PCR for molecular characterization/typing.

Laboratory methods. Information on laboratory methods were provided by the four responding countries for clinical samples (Figures 12-15). Details on methods applied on veterinary samples were provided by the Netherlands, Italy and Norway, while information associated with the food sector was only reported by Italy. The lack of responses on methodologies applied to food products is probably related both to the absence of surveillance in place at this level and to the absence of internationally standardised analytical methods - which are often a requirement for food control - for the detection/quantification of HEV in meat and meat products. With regards to the provided information by the respondents to the questionnaire, and considering the nature of the pathogen, molecular methods are the standard analytical approach for HEV detection. Real-time PCR is transversally used for clinical, food and veterinary samples for viral RNA detection. ELISA is applied on blood/sera (human or wild boars). Characterization, when done, is mostly performed by RT-nested-PCR of regions used for typing, followed by sequencing. Whole genome sequencing (WGS) is occasionally applied to human and animal samples.

Surveillance of human hepatitis E. Hepatitis E is a notifiable disease in Italy and Portugal, hence an official definition for "case" and "outbreak" is available in these countries. In Italy, the Netherlands and Portugal, data collection for human cases takes place for probable cases and confirmed cases, and in both it is case-based. In addition, in Italy and Portugal, it is in place also for outbreak (also case-based). Data collected for clinical cases are summarised in Table 25. Testing (RNA detection and/or Ab detection) is prevalently carried on serum/plasma and, to a lesser extent, on stools. Routine typing of strains is reported by the Netherlands, Italy and Portugal, which also report sharing of diagnostic results at national/sub-national level. A national centralised database for laboratory data is present in the Netherlands and Italy.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.

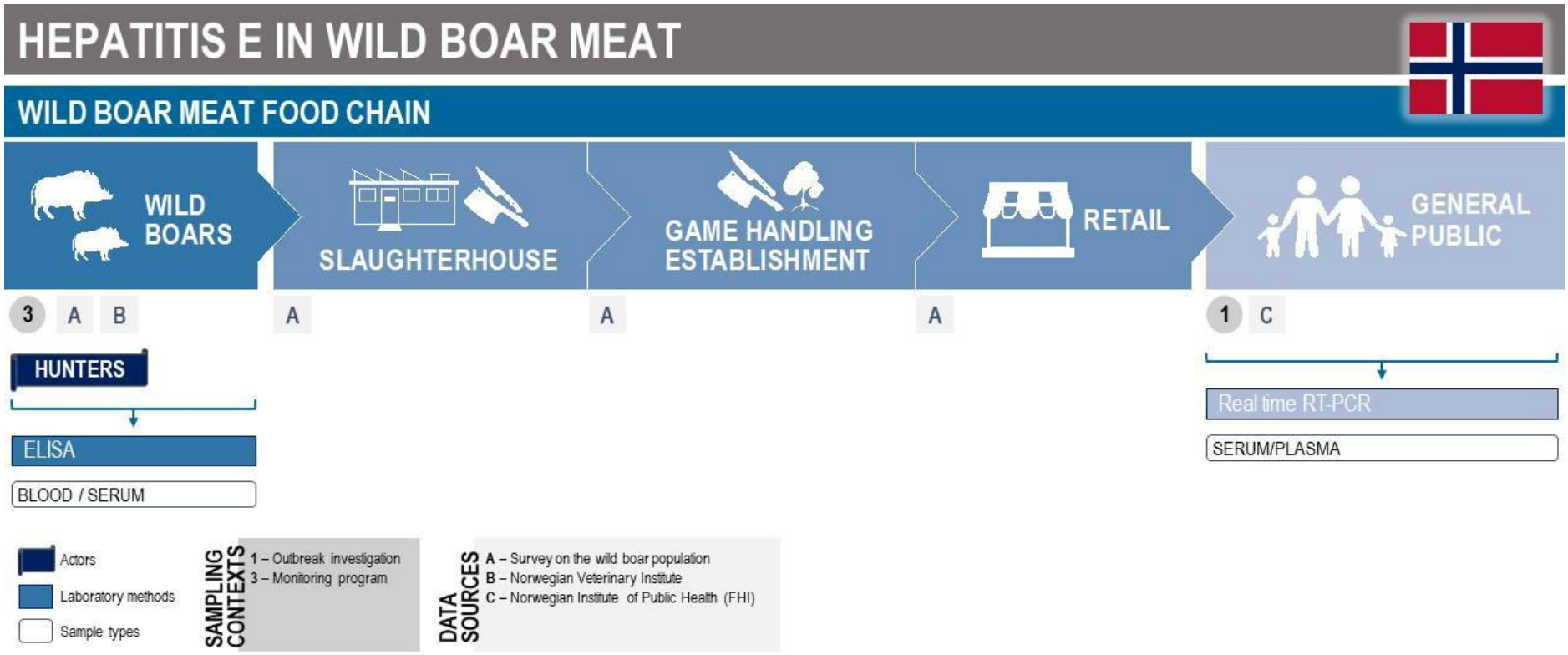

Figure 12. Mapping of surveillance of Hepatitis E in wild boar meat food chain in Norway.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.

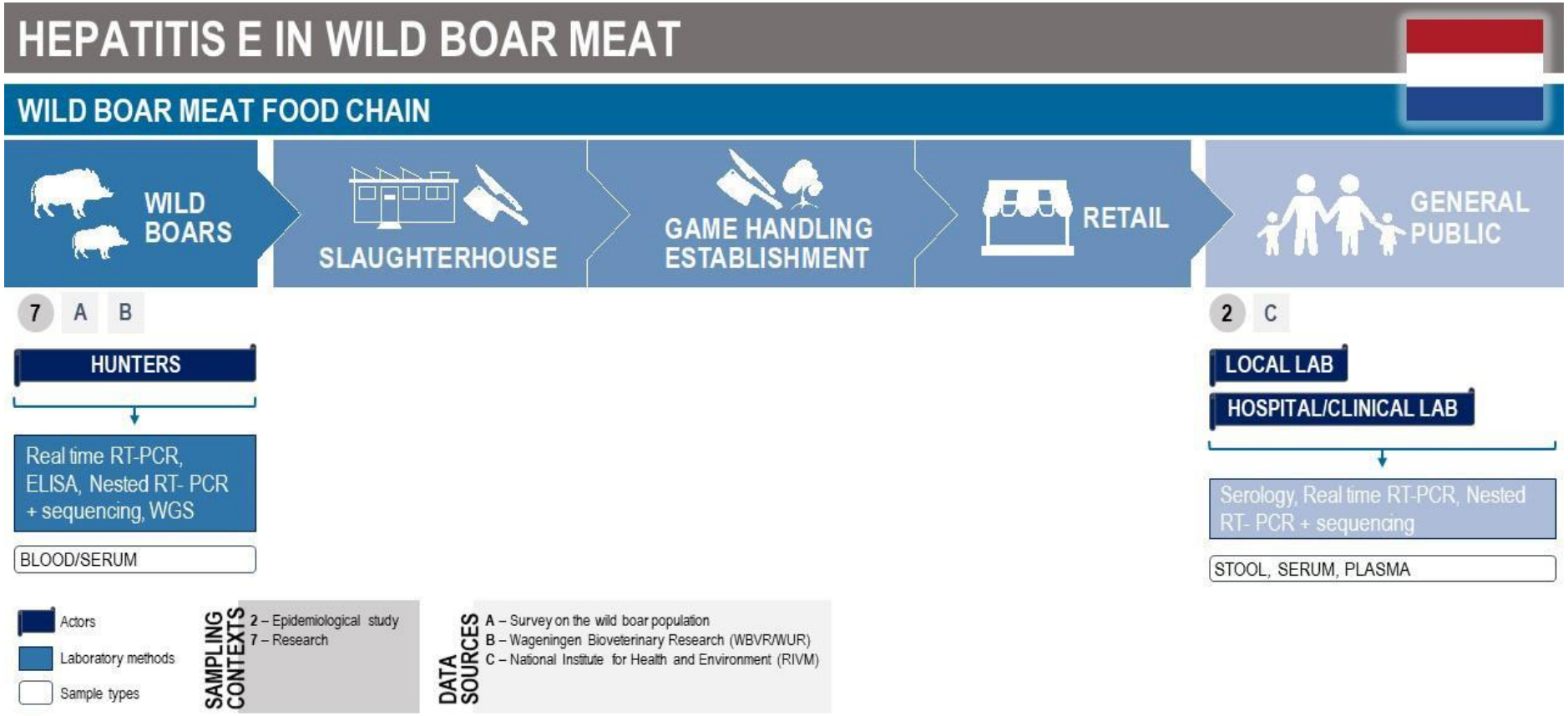

Figure 13. Mapping of surveillance of Hepatitis E in wild boar meat food chain in the Netherlands.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.

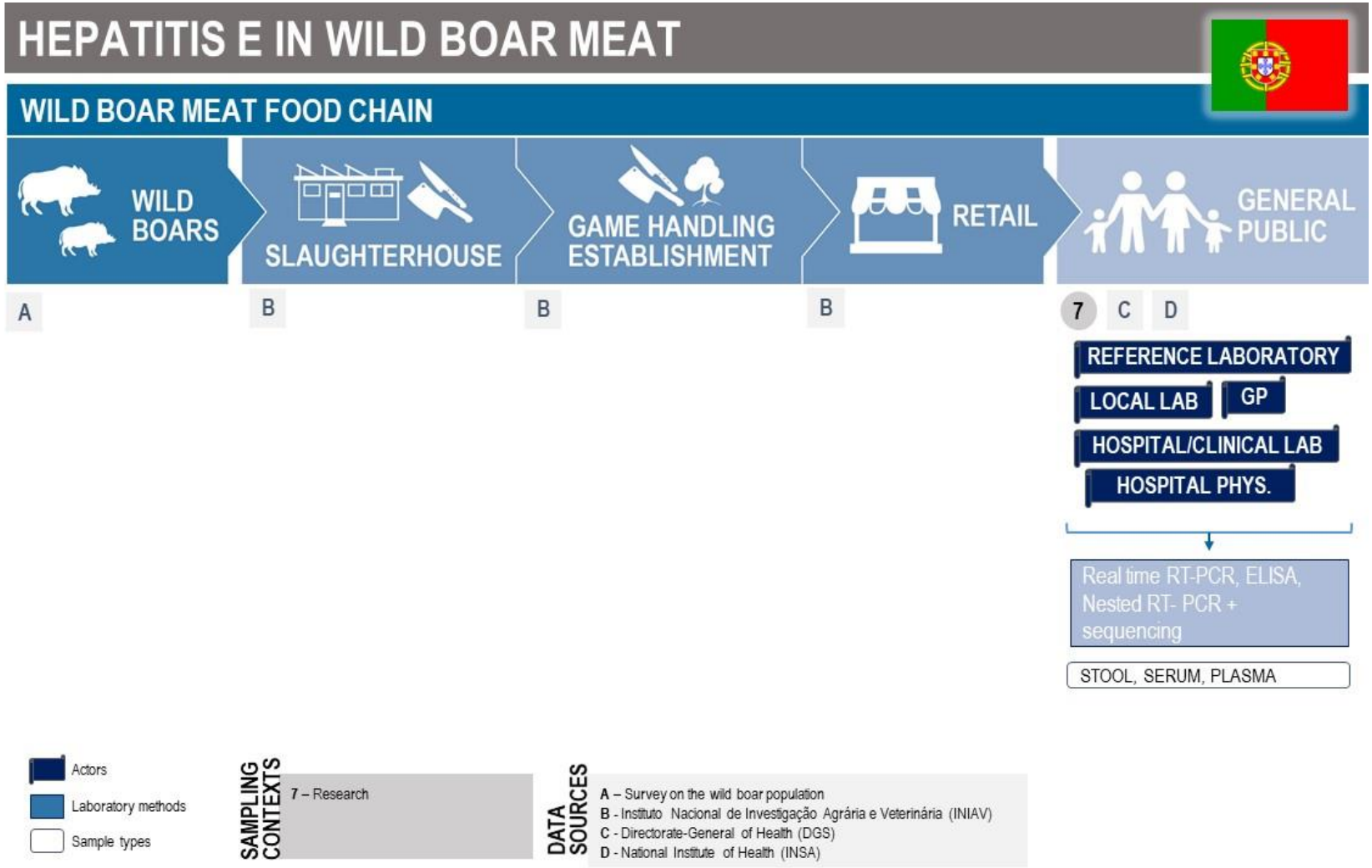

Figure 14. Mapping of surveillance of Hepatitis E in wild boar meat food chain in Portugal.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.

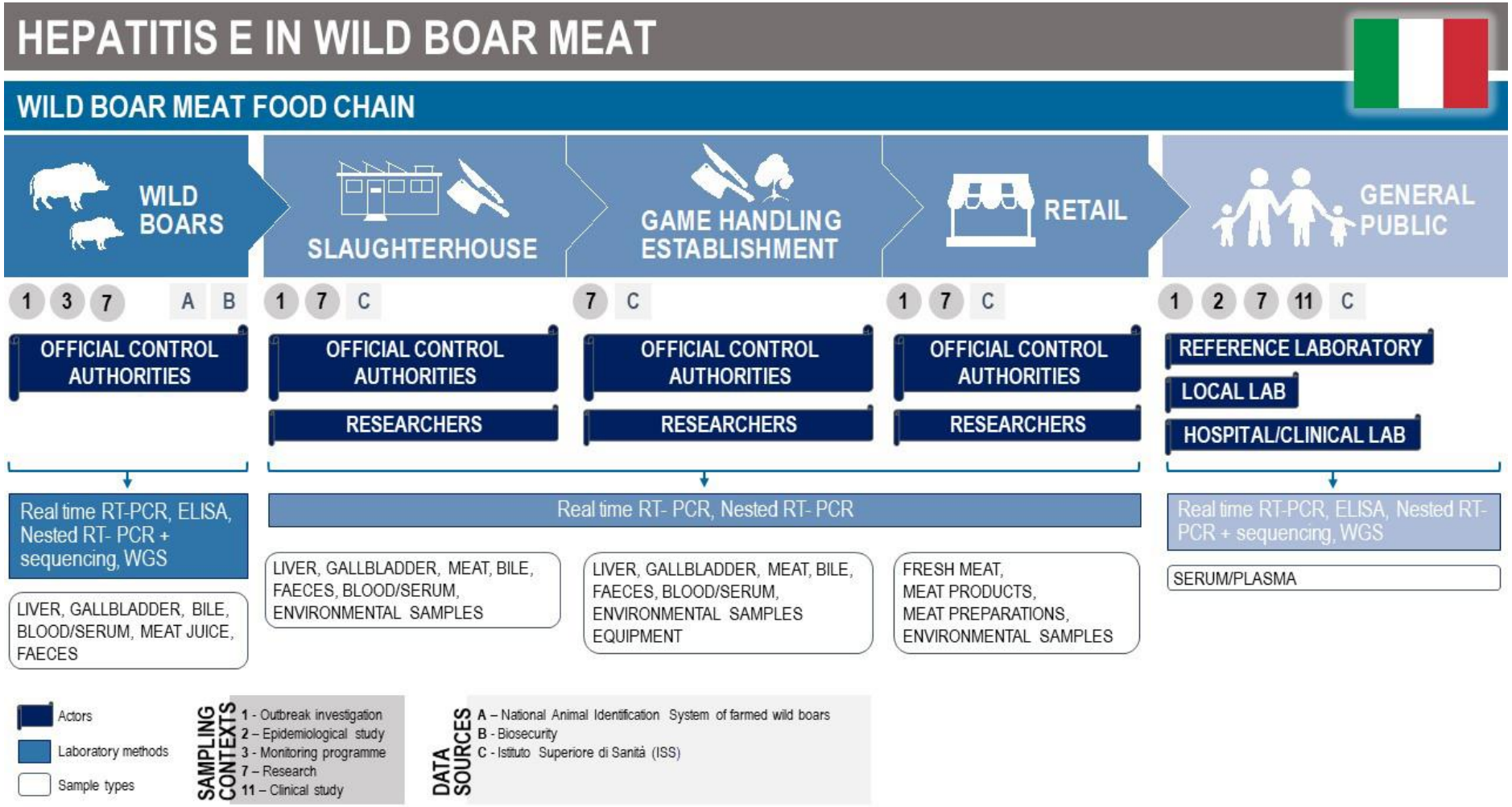

Figure 15. Mapping of surveillance of Hepatitis E in wild boar meat food chain in Italy.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.

Hepatitis E metadata

I. Hepatitis E surveillance in animals

Information collected at national level	IT	NL	NO	PT
Number of confirmed cases		X	X	
Number of suspected cases				
Number of depopulated animals				
Number of dead animals				
Type of specimen (faeces, serum, etc.)			X	
Sampler			X	
Date of sample collection			X	
Place of sample collection			X	
Sampling context (official control program, monitoring, etc.)			X	
Other (please specify)				

Table 24. Information collected during surveillance, shared at national level.

II. Hepatitis E surveillance in food

No other information regarding Hepatitis E surveillance in food with regard to wild boar meat was reported from the investigated countries.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 773830.

III. Hepatitis E surveillance in humans

Section	Information collected	IT	NL	NO	PT
Demographic data	*Age (or date of birth)*	X	X		X
	Gender	X	X		X
	Potential risk factors(e.g. transplantation, chronic liver diseases etc.)	X			
	Profession	X			X
	Occupational exposure	X			X
	Place of residence	X			X
	Travel history	X	X		X
	Other information (please specify)				
Epidemiological data	*Case status (probable or confirmed)*	X			X
	Date of notification	X			X
	Source of notification	X			X
	Probable or confirmed place of exposure - Restaurant				X
	Probable or confirmed place of exposure - Home				X
	Probable or confirmed place of exposure - Hunting				X
	Probable or confirmed place of exposure - Travel related	X			X
	Probable or confirmed type of exposure - Food	X			X
	Probable or confirmed type of exposure - Contact with animals	X			X
	Probable or confirmed type of exposure - Link with other cases				X
	Probable or confirmed type of exposure - Occupational exposure	X			X
	Probable or confirmed date of exposure				
	Other (please specify)				
Clinical data	*Date of clinical onset*	X			X
	Date of recovery (e.g. date of the resolution of symptoms, date of discharge from the hospital, etc.)				
	Fatal (yes / no)				X
	Date of death				X
	Hospitalized (yes / no)	X			X
	Symptoms (e.g. asymptomatic, fever, jaundice, fatigue, asthenia, nausea, other, unknown)	X			X
	Other (please specify)		X		
Laboratory data	*Type of specimen(stool, serum, etc.)*	X	X		X
	Sampler (institution that collects clinical specimen e.g. hospital, local laboratory etc.)	X	X		X
	Date of sample collection	X	X		X
	Date of sample receipt	X	X		X
	Date of laboratory results	X			X
	Laboratory results - Detection	X	X		X
	Laboratory results - Serology	X	X		X
	Laboratory results - Characterization	X			X
	Other (please specify)				

Table 25. Type of information routinely collected by official surveillance.

Data fields are available in the case of ad hoc data collection	IT	NL	NO	PT
Number of human cases	X	X		
Number of hospitalizations		X		
Number of deaths		X		
Source identified as probable or confirmed	X	X		
Link with other cases	X			
Level of evidence				
Laboratory results	X	X	X	X
Other (please specify)				

Table 26. Data availability in case of ad hoc data collection.

Discussion & conclusions

The mapping of surveillance activities in place for the four targeted pathogens in different European countries was the first step in the identification of best-practices for multi-sectoral collaboration. While efforts have been made to collect information on the different surveillance chains, it is likely that some processes have not been included as the information is not available. Also, it should be noted that additional requirements on various points in the farm to fork chain may include elements of zoonoses control and prevention that target multiple microbiological hazards, including investigated hazards, but do not appear in the information above.

Even if the present study is not showing the full surveillance chain, a significant part of it has been explored and the findings show the activities currently carried out, the actors in charge of these activities and the type of outputs coming from them. Despite some differences in the surveillance systems, it can be concluded that several countries have extensive surveillance programmes for the investigated pathogens at the animal, food and human levels. Our survey/study highlighted that countries analyse and share data. Further studies would be needed to characterize the collaborations among actors, and the contexts/situations where the sharing of data and information occur. .

The mapping exercise gave the opportunity to identify the focal points, institutes and laboratories responsible for data management at national level for animal health, food safety and public health laying the groundwork to characterise multi-sectorial collaboration and identify areas for improvement. We recommend the use of this approach to document the existing surveillance chains and to identify clearly the actors involved in the surveillance in each step at all levels.

Relevant MATRIX outputs from MATRIX WP2-T1 will be included in the Ph.D. project of an expert from 28-IZSAM, member of the MATRIX Consortium and specifically working on WP2, as a case study on the application of the One Health Approach. The project presents two case studies regarding the application of One Health in different contexts i.e. vector-borne and food-borne diseases. The project belongs to the Ph.D. course in "Infectious Diseases, Microbiology and Public Health" at the Sapienza University of Rome (Italy).

WP2-T2: Identify cross-sectorial surveillance chain linkages, particularly, which outputs should be shared and how they should be shared for OH oriented decision making

Method

To complement the results from the questionnaire that was performed within WP2.1, it was decided to arrange a workshop with participants in MATRIX WP2. The purpose of the workshop was to collect information from different countries about information sharing between sectors in One Health Surveillance (OHS) work at a national level, with a focus on the hazard tracks in MATRIX. More specifically, the needs of sharing information and data, what to share, when to share and how to share were discussed at the workshop. Three different levels of OH work were to be considered: strategic work, regular issues and outbreak situations.
The aims of the workshop were the following:

- To understand how information and data (concerning OHS) are currently shared between sectors within the MATRIX countries.
- To discuss how the current situation could be improved, with a specific focus on the following points: where would we like to be in ten years from now and what needs to be done to get there?

The following questions were sent out prior to the workshop for preparation of presentations and discussions:

- Considering the situation for one of the hazard tracks of MATRIX in your country
  - Describe the current situation of OHS in your country with respect to sharing information between sectors at three different levels: strategic work, regular issues, outbreaks.
  - How and when is information shared between sectors? (For example: routinely in a common database, sporadically through email, information sharing at meetings, in written reports, etc.).
  - What information is shared and at what level is information shared? (For example: aggregated or sample based, animal or herd level, WGS, etc.).

- Regarding the desired situation in ten years from now, the following points were considered:
  - What is the ideal method/strategy for sharing information between sectors?
  - How often?
  - What information, and at what level of detail?
  - What would be the additional value of this?
  - What needs to be in place for this to work?
  - Suggestions on how to improve the current situation?

- Provide a good example of OH collaboration and sharing of information between sectors in your country.

After the workshop information was collated from the presentations and the following discussions through notes and recordings of the workshop. The information collected was put together per

country and hazard track in a table and a summary was written and checked with the participants from the presenting country for agreement before writing the report.

Results and discussion

The presentations focused on the hazard tracks in MATRIX and how the OHS system works in different countries. The workshop aimed primarily at capturing needs about sharing of information and data between sectors within a country. Each country that volunteered to give a presentation was given the choice to present about one of the hazard tracks in MATRIX as an example while discussing the questions of the workshop. The countries could choose hazard track depending on what was a good example to share with others or an interesting case to present.

The following hazard tracks were presented and discussed during the workshop:

- *Campylobacter* in Sweden and Denmark
- *Salmonella* in Germany and France
- *Listeria* in Norway and The Netherlands
- Emerging threats: Hepatitis E virus in Italy and Sars-CoV2 in UK

The presentation from the UK about Sars-CoV-2 was mainly an update of the work that is being performed within the OHEJP JIP COVRIN project, which is about Sars-CoV-2 research integration and preparedness. Specifically, ongoing activities in COVRIN WP3, which concerns risk assessment and surveillance, were presented. This WP involves mapping of surveillance data and the presentation gave an overview of the current Sars-CoV2 surveillance in pets, livestock and wildlife in the UK.

The following discussion after the presentations did not focus specifically on the hazard tracks but more on the OH collaboration in general, with focus on information sharing. Commonalities and differences between countries were identified. The discussion also focused on what was perceived as important to make OH collaborations work (a prerequisite for sharing information between sectors).

The workshop itself was meant to be a learning event, an opportunity to describe and reflect upon the situation within a country, and to share good examples and to gain inspiration from others. In total, there were 32 participants from eight countries in the workshop that was held on Microsoft Teams on the 7th of October 2021 (Annex II[7]- Summary of information collected per country).

Current situation of OH collaboration

To make sure to include all aspects of information sharing between sectors, three levels of OHS were supposed to be addressed at the workshop: strategic work, regular work and outbreaks.

Some countries have specific national groups that work with OH questions on a **strategic level** (e.g. Sweden and Denmark). These groups meet a few times per year and share information between

[7] DISCLAIMER: The present document presents information collected during a workshop. The collated information was checked for errors with the participants of the workshop. We therefore acknowledge that some information may be not complete or up to date, reflecting the knowledge of the people involved in this specific task at that time. Our findings are based on the informed assessment of sector-specific experts: therefore, an unavoidable degree of bias is a limitation of our approach.

sectors (at an aggregated level) at meetings. The Danish Strategy plan work group for *Campylobacter* consists of representatives from Technical University of Denmark (DTU) food, Danish Agriculture and Food council (DAFC), Danish Veterinary and Food Authority (DVFA) and Representatives from the poultry sector. This group develops a new strategy every four years. In Sweden, the Zoonosis council is a group with a strategic focus that handles questions on all types of zoonotic infections. The Zoonosis council consists of representatives from nine different authorities, mainly from the public health, animal health and food safety sector. The majority of participating countries did not have a cross sectorial group that works with strategic questions at a national level.

Regular issues concerning OHS are dealt with in different ways depending on hazard track and country. In Denmark, there is a cross-sectoral *Campylobacter* surveillance group that meets regularly. In Sweden there is a cross-sectoral group for all zoonotic infections (SUBU) that meets (online) every other week to share information about ongoing outbreaks or new findings. Also, in the Netherlands, there is a cross-sectoral group that meets once a month (Dutch Signalling Forum Zoonoses): information about WGS in *Listeria* is shared every 4-6 weeks between the National institute for public health and the environment (RIVM) and Wageningen Food Safety Research (WFSR). In Norway, regular meetings are held at the director level. The same core group is used for all hazards, but experts for different hazards can be included in meetings when relevant. In other countries, no interaction (or sharing of information) takes place between sectors on a regular basis (e.g. for *Salmonella* in Germany). In Italy, the surveillance for HEV only includes the public health sector and there are no regular cross sectorial collaborations.

During the workshop, it was mentioned by several countries that it is easier to work together and share relevant information between sectors during **outbreaks** (e.g. Italy, Sweden, Germany, Norway and the Netherlands). There are established routines on how to share information during outbreaks, and sharing of data takes place outside of databases. Details are shared as needed, as far as it is allowed (e.g. Sweden and the Netherlands). Most countries have specific outbreak groups that operates or routines that are followed during outbreaks, which facilitates communication between sectors.

Other types of cross sectorial collaborations that were mentioned during the workshop are the establishment of working groups during the production of national annual reports on infectious zoonotic diseases. One example is the report *Surveillance of infectious diseases in animals and humans in Sweden*. For this report, disease specific groups have been formed with representatives from public health, animal health and food safety sectors and discussions take place every year about the surveillance results from the previous year. Another example of cross sectorial collaboration is the working group on surveillance of *Salmonella* in France (ONDES, Optimisation Nationale des Dispositifs d'Épidémio-surveillance des *Salmonella*). The purpose of this group is to optimise the *Salmonella* monitoring programs at the national level in France. A two-year participatory work about a conceptual and co-constructed national system for *Salmonella* surveillance has been performed and the operational phase will begin in 2022.

What is the desired situation in ten years from now?

The participants shared their thoughts on how they would like to collaborate between sectors regarding information sharing.

When to share

What was considered most important about timeliness was to share information frequently. In order to act on a change, it is valuable to receive information at an early stage (this is often as soon as results are ready, in real time if possible). However, it is good to set criteria for when to share certain results to avoid misunderstanding and to build trust between authorities in different sectors.

What to share

The type of information that is relevant to be shared differs between hazards. For *Listeria* for example, the dose is as important as the DNA profile. Information about clonal complex (CC) groups together with relevant metadata is enough to share between sectors (e.g. in Norway). The CC-analysis with PCR is easy, has high capacity and is easy to interpret. The importance of having strategies defining the information that should be shared for each hazard was highlighted by participants.

Most countries share WGS results between sectors to some extent, usually with no or little metadata (e.g. Denmark and the Netherlands). It would be desirable to share relevant WGS results (as agreed between sectors) on a regular basis and also to share relevant metadata about samples and the surveillance together with the results. For strategic purposes, it is common to share aggregated data at cross-sectorial meetings, it was not considered as necessary to share details at all times. Besides, to share raw data between sectors was not considered to be of much use. It was reported that it is important to share relevant data and to agree upon what to share beforehand. The purpose of communicating and sharing information between sectors is primarily to prevent or reduce risks. The relevant information to share is what enables decisions to be made and actions to be taken.

How to share and to collaborate

The participants underlined the importance of trust and having opportunities to meet and discuss. Sharing of information between sectors frequently takes place in meetings or through personal contacts, via e-mail or by phone. To facilitate OH collaboration and sharing of information it is valuable to have established cross-sectorial working groups. It is important to meet and discuss about surveillance to be able to understand the information from other sectors. The lessons learned from the ONDES working group in France include the importance of sociological skills to have effective working groups. It takes time to get to know each other and to build trust and reach a mutual understanding. To facilitate this process, it is good to formalise how the group should work, define the roles, for example who does what, when and how. To come together and agree on common goals across the sectors (also the public and private sectors) is advisable.

Countries reported that they do not have a national database used by more than one sector. The general perception is that a common database or access to each other's databases will not replace the value of expertise, data should always be interpreted by experts to avoid misunderstandings. In the Netherlands, limited information regarding *Listeria* is shared through a shared folder between the RIVM and WFSR.

What needs to be in place for this to work?

There are several criteria to be met to be able to share relevant information at the right time. Agreements on what to share and when are necessary as well as on legislation that allows sharing of information and data across agencies, both within and between sectors. It is also good to establish a

common understanding about the surveillance objective(s) and the shared data between authorities/sectors. An infrastructure and a common data format that enables data sharing is also necessary.

Additional value of sharing

Easy access to information can shorten the time to act on a change and to reach out with important information. Sharing more often also shortens reaction time, with possible prevention of more cases. A good system provides opportunities to detect an undesirable event before it becomes a problem , for example early detection of new diseases. Collaboration in established cross-sectorial groups creates mutual understanding, personal contacts and builds trust with other sectors.

Conclusion

From the workshop we can conclude that collaboration and sharing between sectors occur for most countries during outbreaks, and that information including datasets are not publicly available resources in some countries. What can we learn from that? One way to improve the OH collaboration is to actively learn from outbreaks and exercises by performing cross-sectorial evaluations. Creating formal groups for frequent sharing of regular issues and groups to address strategic questions is another possibility to develop OH-ness.

Another conclusion is the aspect of timeliness of sharing and also to agree upon what data and information is relevant to share for actions to be taken. To share raw data may not be the best solution; experts within a sector are always needed to interpret data. Personal contacts are important and make communication easier. Opportunities to meet and discuss in informal cross-sectoral groups is a good way to collaborate and build trust. Sociological skills are important to make a strong group.

Future work within the MATRIX project

The results from WP2-T2 will be used in the following WP2-T3 which concerns the best-practise guidelines, but also in the requirement analysis of WP5-T1 and the work with the roadmap in WP5-T2.

References

[1] One Health EJP, "ORION: One health suRveillance Initiative on harmOnization of data collection and interpretatioN," *2018*. https://onehealthejp.eu/jip-orion/ (accessed Dec. 09, 2021).

[2] E. Commission, "COHESIVE - One Health EJP." https://onehealthejp.eu/jip-cohesive/ (accessed Dec. 09, 2021).

[3] European Commission, "NOVA - One Health EJP." https://onehealthejp.eu/jrp-nova/ (accessed Dec. 09, 2021).

[4] NOVA, "D-3.1 Full mapping of the chain process for three main productions in EU," Zenodo, 2020. [Online]. Available: https://doi.org/10.5281/zenodo.3734082.

[5] One Health EJP ORION, "ORION Knowledge Hub - Catalogue." https://aginfra.d4science.org/web/orionknowledgehub/catalogue (accessed Jan. 13, 2022).

[6] EFSA BIOHAZ Panel (EFSA Panel on Biological Hazards) *et al.*, "Scientific Opinion on the Public health risks associated with hepatitis E virus (HEV) as a food-borne pathogen," *EFSA J.*, vol. 15, no. 7:4886, p. 89, Jul. 2017, doi: 10.2903/j.efsa.2017.4886.

[7] EFSA and ECDC, "The European Union One Health 2019 Zoonoses Report," *EFSA J.*, vol. 19, no. 2, p. 6406, Feb. 2021, doi: 10.2903/J.EFSA.2021.6406.

[8] European Food Safety Authority, "Campylobacter." https://www.efsa.europa.eu/en/topics/topic/campylobacter (accessed Dec. 09, 2021).

[9] European Food Safety Authority, "EFSA explains zoonotic diseases: Campylobacter," 2014. https://www.efsa.europa.eu/en/corporate/pub/factsheetcampylobacter (accessed Jan. 12, 2022).

[10] J. Lundén, "Persistent Listeria monocytogenes contamination in food processing plants," Helsingin yliopisto, 2004.

[11] EFSA, "Listeria." https://www.efsa.europa.eu/en/topics/topic/listeria (accessed Jan. 12, 2022).

[12] EFSA, "Salmonella." https://www.efsa.europa.eu/en/topics/topic/salmonella (accessed Jan. 12, 2022).

[13] European Centre for Disease Prevention and Control, "Salmonellosis (non-typhi, non-paratyphi)." https://www.ecdc.europa.eu/en/salmonellosis (accessed Dec. 09, 2021).

[14] World Health Organization, "Five Keys to Safer Food Manual," *Five Keys to Safer Food Manual*. p. 30, 2006, Accessed: Dec. 09, 2021. [Online]. Available: https://www.who.int/publications/i/item/five-keys-to-safer-food-manual.

[15] C. E. Coipan *et al.*, "Concordance of SNP-and allele-based typing workflows in the context of a large-scale international Salmonella enteritidis outbreak investigation," *Microb. Genomics*, vol. 6, no. 3, p. e000318, Feb. 2020, doi: 10.1099/mgen.0.000318.

[16] European Centre for Disease Prevention and Control, "Options for national testing and surveillance for hepatitis E virus in the EU/EEA – Operational guidance," Stockholm: ECDC, 2019. doi: 10.2900/417723.

Annex I- WP2-T1 Questionnaires

Annex II- WP2-T2 Summary of information collected per country