H2020-SFS-2018-2020

DECIDE

Data-driven control and prioritisation of non-EU-regulated contagious animal diseases

Deliverable 5.1

Status quo regarding psychological and social preconditions of the use of data tools

WP5 – Implementation and behavioural strategies for animal disease management

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Delivery date 21 December 2022
Dissemination level Public
Type Report

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000494.

Revision History

Author Name (Partner short name)	Description	Date
Angela Bearth (ETHZ), Xiao Zhou (ETHZ), Charlotte Doidge (UoN), Jasmeet Kaler (UoN)	First draft (v0.1)	17.10.2022
Moderators of focus groups and other involved project partners	Feedback on v0.1	11.11.2022
Angela Bearth (ETHZ), Xiao Zhou (ETHZ), Charlotte Doidge (UoN), Jasmeet Kaler (UoN)	Revision (v0.2)	11.11.2022
Project lead and some additional feedback from project partners	Feedback on v0.2	21.11.2022
Angela Bearth (ETHZ)	Revision (v0.3)	12.12.2022
Miel Hostens (UGent), core group	Review of v0.3	16.12.2022
Angela Bearth (ETHZ)	Final revision (v0.4)	19.12.2022
Johannes Ripperger (accelCH)	Formal checks of v0.4	20.12.2022
Angela Bearth (ETHZ)	Final version (v1.0)	21.12.2022

Content

Abbreviations

Abbreviation	Description
EU	European Union
FVE	Federation of Veterinarians of Europe
WP	Work Package

Partner short names

Short name	Organisation
UU	Universiteit Utrecht
UGent	Universiteit Gent
ETHZ	Eidgenössische Technische Hochschule Zürich
UoN	The University of Nottingham
SVA	Statens Veterinärmedicinska Anstalt
INRAE	Institut National de Recherche pour l’Agriculture, l’Alimentation et l’Environemment
NVI	Veterinærinstituttet – Norwegian Veterinary Institute
IRTA	Institut de Recerca i Tecnologia Agroalimentàries
AHI	Animal Health Ireland Initiative
IDELE	Institut de l’Elevage
IfA	Innovation for Agriculture
GD	Gezondheidsdienst voor Dieren B.V.
SLW	SLW Biolab s.c.
accelCH	accelopment Schweiz AG

Executive Summary

This Deliverable is a report on …

- the insights gathered on the status quo of data tools in European animal farming.
- the most important drivers and barriers of technology adoption from the perspective of the key stakeholders (i.e., farmers, veterinarians, decision makers).

Objectives of the Deliverable

With the help of this deliverable, …

- user-friendly data tools can be developed and evolved
- evidence is available on data tool attributes that might drive or hinder their uptake and continued use.

Activities

The core activity was the development of semi-standardised interview guidelines and survey questionnaires together with the DECIDE project partners. These were used to conduct focus group interviews and online surveys in various countries focusing on all four species. The results were analysed and synthesised in close collaboration with other DECIDE project partners. Also, a review of the existing literature was conducted.

Outcome

This deliverable presents generalisable and species-specific findings about a) stakeholders' needs and preferences regarding data collection, tools and visualisation, b) stakeholders' use of data for decision making, and c) barriers to the development and implementation of data tools.

Next steps

A dissemination workshop will be organised for all DECIDE project partners. This workshop will allow for an open discussion about the report's findings and implications for the other WPs and the data tools. Further, data collection and analysis will be concluded, and scientific papers will be prepared and submitted.

1 Introduction

Innovation in animal farming is driven by the needs and challenges of farmers, veterinarians, and other decision makers. Visualising data and generating insights through data tools could support these stakeholders and health and welfare decision making on farms (Astill, Dara, Fraser, & Sharif, 2018; Colby & Johnson, 2002). However, in order to develop successful data tools, insights on the *status quo* of data use and the psychological and social pre-requisites of the use of such data tools are needed. This report summarises these insights, gathered within WP5 in close collaboration with the other project partners in DECIDE.

1.1 Objectives of the deliverable

- What is the *status quo* of data collection, sharing, analysis and utilisation for decision making on European animal farms?
- Which challenges regarding animal health and welfare are top-of-the-mind for the stakeholders?
- What needs do the stakeholders express regarding the collection, sharing and the use of on-farm data?
- How are decisions about animal health and welfare made on animal farms? Which perspectives do different stakeholders have on decision making?

2 Literature review on health and welfare decision making and data

Animal diseases are increasingly challenging animal farming by lowering production, increasing costs and labour, and leading to poor animal welfare (Rushton et al., 2018). Multiple factors, such as experience, collaboration on and across farms, and self-confidence are supportive factors for on-farm decision-making (Best, Pyatt, Roden, Behnke, & Phillips, 2021; Brady et al., 2020; Doidge, Ferguson, Lovatt, & Kaler, 2021; Sadiq, Ramanoon, Shaik Mossadeq, Mansor, & Syed Hussain, 2019). Oppositely, limited resources, low risk awareness, poor compliance with veterinarian's advice, othering, or distrust of control measures and veterinarians, are cited in the literature as barriers to informed on-farm health and welfare management (Baazizi et al., 2019; Best et al., 2021; Brocket, Fishbourne, Smith, & Higgins, 2021; Ciaravino et al., 2017; Doidge et al., 2020; Hamilton, Evans, & Allcock, 2019; Kaler & Green, 2013; Ranjbar, Rabiee, Ingenhoff, & House, 2020; Sadiq et al., 2019). To date, various technologies have already been integrated into animal farming to manage production, finances and/or animal health and welfare. This literature review summarises the available scientific insights on the psychological and social preconditions of technology usage in animal farming across different stakeholders. For this, two search tools (i.e., Web of Science, Scopus) were searched using various combinations of search terms (e.g., livestock, animal, digital, technology, perception). This search and the subsequent screening procedure resulted in a total of 32 articles, focused on cattle (n = 22), pigs (n = 2), salmon (n = 1) and multiple and additional species (n = 7).

Most of the included articles focused on farmers, while disregarding the role that other stakeholders might play in decision making. Even in a very early article, farmers regarded advances in technology as important elements for decision making but they were unsure if technology would help them resolve uncertainty or support farm management (Van Tassell & Keller, 1991). Overall, five types of technologies were the focus of the articles: (1) precision livestock farming systems, (2) information support technology, (3) data management systems, (4) diagnostic technology, and (5) disease risk assessment tools.

2.1 Precision livestock farming systems

Precision livestock farming systems were covered in 16 articles (e.g., remote-controlled camera monitors, sensors, indoor climate control, electronic identification technology, automatic milking systems) (Dhraief et al., 2019; Eastwood, Ayre, Nettle, & Dela Rue, 2019; Goller, Caruso, & Harteis, 2021; Hansen, Bugge, & Skibrek, 2020; Hansen & Stræte, 2020; Hartung, Banhazi, Vranken, & Guarino, 2017; Kaler & Ruston, 2019; Krampe, Serratosa, Niemi, & Ingenbleek, 2021; Lima et al., 2018; Millar, Tomkins, White, & Mepham, 2002; Ögür, 2021; Stuart, Schewe, & Gunderson, 2013; Tejeda, Chahine, Du, Lu, & Westerhold, 2020). Farmers regarded this technology as user-friendly and efficient. However, some farmers criticised the information overload, poor data visualisation, and the high cost of implementing this technology. Moreover, farmers were concerned about less interaction with their animals, lack of relevant skills, poor user experience and technology maintenance. The following factors were cited as main reasons for the adoption of precision livestock farming systems: financial concern (e.g., reduction of production costs and risks), use (e.g., user friendliness), farm and farmer characteristics (e.g., size, age, income, knowledge), psychological (e.g., belief in technology), and social factors (e.g., network, relationship with technology company). Two articles (Krampe et al., 2021; Millar et al., 2002) investigated contextual factors, namely consumers' attitudes towards digital technology in animal farming. Generally, improved animal health and welfare, improved environmental quality and increased transparency were perceived benefits of precision farming among consumers. However, heavy industrialisation, less transparency of information communication, misuse and leakage of farm data were the main concerns that farmers expressed.

2.2 Information support technology

Information support technology was either used to access and communicate information (i.e., weather, animal health, prices) or to monitor disease prevalence (Calba et al., 2015; Karimuribo et al., 2016; Kihara & Gichoya, 2015; Marescotti, Demartini, Filippini, & Gaviglio, 2021; Schulz, Prior, Kahn, & Hinch, 2022; Spink & Jane, 1996; Wadkar, Singh, Mohammad, Malhotra, & Kale, 2016). The adoption of computers and smartphone applications varied across farmers. Easy access to information, facilitated communication with veterinarians, and sharing information with others were perceived as benefits of information support technology. Lack of skills and resources (i.e., time, money), small font or tool sizes, and a lack of internet coverage were perceived as weaknesses by the users.

2.3 Data management systems

Five articles incorporated data management systems, all focused on dairy farmers (Alpass et al., 2004; Hay & Pearce, 2014; Hennessy, Läpple, & Moran, 2016; Jofre-Giraudo, Streeter, & Lazarus, 1990; Woodburn, Ortmann, & Levin, 1994). Generally, farmers used various systems for data collection and management (e.g., Excel spreadsheets, specific program) and to manage farm business or record farm practices (e.g., parasite treatment, mating). Compared to non-users, users of these data management systems relied less on their experience and reported having more time to manage their farm.

2.4 Diagnostic technology

Two articles focused on stakeholders' needs regarding diagnostic technology for pig, poultry, cattle, and dairy cows (described as rapid test devices) (Mkenda, Buller, & Bruce, 2021; Nannucci et al., 2020). Stakeholders expressed some willingness to use this technology for a diagnostic test if the price was reasonable, the test was user-friendly (e.g., easy to use and interpret, easy to store results and transfer to others) and fitted to the conditions on their farm. However, farmers were concerned about false negative test results as they might miss the timely treatment of their animals. In the referenced studies, poultry farmers, specifically, preferred a technology that could be used to monitor the environment and detect diseases at the flock level.

2.5 Disease risk assessment tools

One article investigated salmon farmers' views of disease risk assessment tools (Soon & Baines, 2012). This spreadsheet-based tool outputs information, highlights risks and suggest actions to the farmers. After using the tool, the extent of interest in this tool varied across farmers. The farmers appreciated the following output the most: veterinary medicine, water quality, type of disease, and photos of diseased fish.

3 DECIDE: Species-specific activities and insights

3.1 Cattle

3.1.1 Activities

The development of digital tools for cattle health is being conducted through a Living Lab approach called FormIT (Bergvall-Kareborn & Stahlbrost, 2009). The FormIT Living Lab is a co-creative approach where stakeholders (e.g., intended users) are involved in the development of the tool from initial concept to mature prototype. The FormIT Living Lab has three phases, each with four stages (Figure 1) (Bergvall-Kareborn & Stahlbrost, 2009). The concept phase focuses on the needs of the stakeholders to enable the development of initial concepts of the tools and to evaluate these concepts (Bergvall-Kareborn & Stahlbrost, 2009). The prototype phase aims to understand stakeholders' requirements of the tool in order to design prototypes and evaluate usability of these prototypes. The tool will then enter the innovate phase when the prototype becomes mature. This is where the tool is tested in a real life setting by the intended users and the user experience is evaluated.

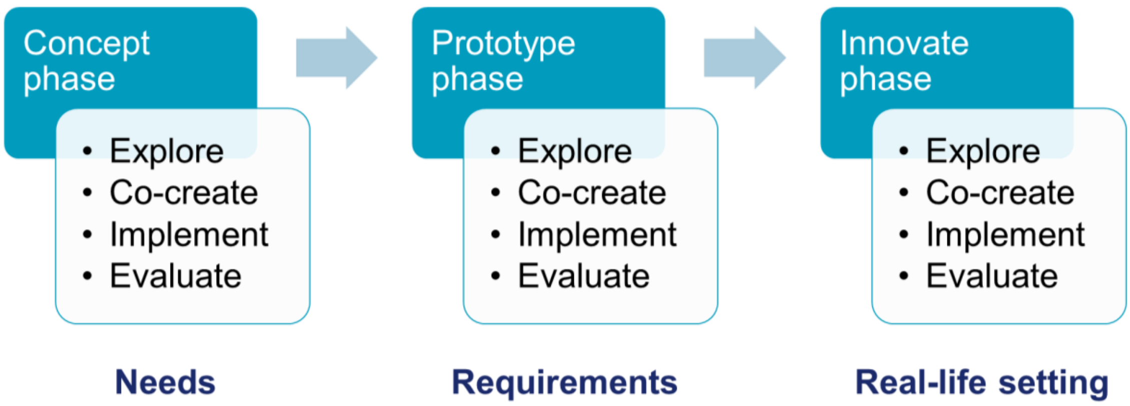

Figure 1. Phases and stages of the FormIT Living Lab for cattle (adapted from Bergvall-Kareborn & Stahlbrost, 2009).

The first stage of the cattle Living Labs aimed to explore the needs of different stakeholders. As farmers were a key user group for digital tools for cattle, we aimed to understand their needs through focus groups. The focus groups covered the topics of data and technology use, respiratory and gastrointestinal disease management of youngstock, and goals for the future of their farms. This report focuses on the results of 11 focus groups of cattle farmers from the UK and Sweden (UoN, IfA, SVA, Table 1). Data has also been collected in Belgium (UGent), France (INRAE, IDELE), Ireland (AHI), The Netherlands (GD, UU), and Norway (NVI), and is in the process of being transcribed and translated.

Table 1: Participants in the cattle farmer focus groups.

Country	Production system	Number of focus groups	Number of participants
Sweden	Dairy	3	13
UK	Beef	4	15
	Dairy	4	19

3.1.2 Main insights

This section discusses some of the themes that were generated from the analysis of the focus groups.

Data administration. Farmers had to carry out data administration practices which can act as a barrier to data utilisation. For example, some farmers who collected paper-based data needed to digitise it by entering this data into computer software. Farmers also often collected data from multiple technology sources which did not integrate with each other. Therefore, farmers would have to spend time manually merging data into the same dataset. Farmers usually had negative perceptions of this data administration process. They thought that it was a waste of time and would rather be spending time with their cows. This means that not all the farmers completed data administration, which restricts their abilities to analyse, interpret and utilise the data. Technologies on the farm can help to facilitate the data administration process by providing cow-side digital recording. Furthermore, technologies should be designed to be compatible with other common data-driven technologies on the farm. This would reduce the need for data administration.

> "*I'd like a bit more integration and Cow Manager's [software] got the breeding information on it but not any yield information so it would be nice to have it all integrated*" (UK Dairy Focus Group 3)

> "*We have to add everything twice. We have the actual data for the milk pen, it goes via the collars of the cows, but we cannot report through it, so I have to report elsewhere. It feels a bit like double work*" (Swedish Dairy Focus Group 1)

Connections between data practices. All farmers collected data, but not all of them actually utilised this data. The spatial and temporal connections between the data collection and data analysis are important to achieve value from the data. Technology can alter how time is shared between data practices. For example, technologies may make the data collection process more efficient but as more data is collected data administration and analysis may take longer. Technology use may also compete for time with other farm management practices which farmers may have preference for. Farmers also thought about the spaces that they were collecting and analysing data. Farmers generally preferred being with their animals. However, most data analysis tasks were carried out in office spaces because they had the appropriate infrastructure (e.g., electricity, internet connection). Technologies that can merge collecting, processing, and analysing data at the cow-side may help to reduce the ties to the office space. However, the infrastructural requirements of technology need to be considered for this.

> "*As I say, [brother-in-law] does it with a pen and paper but I can make the assumption at scale or when I've got my hand on the animal [using technology] whereas he will have to go back in and start working them out and then make his assumptions*" (UK Beef Focus Group 3)

> "*I am not great with technology. We enjoy working with cows. Not sitting and doing stuff on a computer. It feels like we have to do a lot of computer stuff, but we think it's fun to work with cows. Not to sit at a computer. It feels like we have a lot to do with data that we would have liked to have been without*" (Swedish Dairy Focus Group 1)

3.2 Pigs

3.2.1 Activities

Based on discussions between DECIDE project partners (ETHZ, UoN, UU, GD, SVA, AHI, IRTA), the activities of understanding pig stakeholder needs were split into two different strands. The first strand involves stakeholders from the Netherlands, Ireland, and Spain and focused on veterinarians as advisors and decision makers. The second strand involves stakeholders from Sweden and focused on farmers as decision makers.

First strand (Netherlands, Ireland, Spain). Six focus groups with twenty-eight pig veterinarians (company veterinarians, independent veterinarians, and veterinarians working on genetics, feeding, technology and economy) were conducted. The focus group guideline focused on key challenges, and data use and needs for decision making and health and welfare management.

Second strand (Sweden). The development of the Swedish pig tool follows the FormIT Living Lab approach (Bergvall-Kareborn & Stahlbrost, 2009). The first stage of the Living Lab was to explore stakeholders' needs regarding controlling diseases on pig farms. The insights presented here come from three focus groups with thirteen Swedish pig farmers. The topics of discussion included future farm goals, data use, technology use and management of respiratory and gastrointestinal diseases in youngstock.

3.2.2 Main insights on veterinarians

Key challenges. Health and welfare decision-making of participants has changed from the diagnosis and treatment at the individual animal level to controlling diseases at the company level. Health and welfare management of pigs requires the involvement of multiple parties, including veterinarians, farmers, managers, and experts from other fields (e.g., nutritionists, facility engineers). Thus, the veterinarians not only relied on their own experience, available data, and technology to make health and welfare decisions but also needed to be involved in the farm and understand its context through communications and collaboration with all involved people. Independent veterinarians, in particular, lacked a user-friendly and resource-efficient way to manage data, as they have to gather data from different sources and transfer data to their own platform.

Data use for decision making and health and welfare management. Data play an important role in the veterinarians' diagnosis and decision-making. However, according to the participants, data is currently not well-used to visualise health trends or to give early warnings for preventing health and welfare problems. It is common for participants to request data from the pig farm or company before or during farm visits. Most data are delivered on paper or in a digital format and is then transferred to the veterinarians' individual system for data management, analysis, and visualisation (e.g., Microsoft Excel, Microsoft Power BI, Adobe Acrobat or other PDF reader). Four types of data were utilized for decision making and health and welfare management: farm level data, laboratory tests, slaughterhouse data, and reports from authorities. Most frequently used data at the farm level were production data such as feed and water consumption, mortality, growth rate (e.g., weight), environment measures (e.g., humidity, temperature), treatments (e.g., injections, medicine), clinical signs (e.g., cough count), and pig behaviour. Laboratory data included results of blood sampling, tissue sampling and antimicrobial susceptibility tests. Slaughterhouse data covered post-mortem findings (e.g., pleurisy, pneumonia levels). Participants also used reports (e.g., from health authorities or scientific institutions) to identify key health and welfare problems. Aside from quantitative data, qualitative data such as observations of the pigs' behaviour (e.g., animal pictures or videos) were highlighted as potentially helpful for veterinarians.

Needs regarding technology for health and welfare management. Overall, participants expressed positive attitudes towards data tools for health and welfare management in the future as they were perceived as user-friendly and time-efficient. However, they were worried about the application of data tools in practice. First, they were not confident about their own skills of using data tools and were concerned about resources to acquire the necessary skills. Second, they were sceptical regarding the ability of such a tool to update health- and welfare-related data continuously. Third, the veterinarians stressed that data tools cannot completely replace humans as they relied a lot on their on-farm observations and communication with the farmers. The following specific tools were highlighted as potentially useful by the veterinarians: (1) early warning tools, (2) data sharing and visualisation tools, (3) tools that link different data sources, and (4) tools with model-based prediction.

> "*If I could have a visual or analytical control of when an abnormal behaviour [stressed, vice behaviour, such as tail- or ear-biting] occurs, for me, it would be a super tool. Other [functionalities]: water consumption and feed consumption, because it allows you to have that alarm that something may be happening."* (Spanish Pig Focus Group 1)

> "*Things [health and environmental data] come in from all sorts of sides, but if you have a central dashboard - for a farmer as well - that we can look at, then, we'll really be able to take steps, where you link it all together, but that's what's missing."* (Dutch Pig Focus Group 1)

3.2.3 Main insights on farmers

This section discusses some of the themes generated from the analysis of the Swedish pig farmer focus groups.

Farmer experience and knowledge. Many of the pig farmers expressed the importance of using their own knowledge and experience for identifying diseases in their pigs. These farmers believed that the best way to detect diseases early was through having an "eye for the animals". Farmers generated an understanding of their pigs by using their senses and emotions. For example, farmers could identify sick animals by touching or smelling them. Some of the farmers were not sure how a technology to identify or control diseases can work without having this experiential knowledge or emotional response. Some technologies can facilitate farmers' sensory responses, e.g., thermometers show the pigs temperatures. However, farmers were also concerned that technology may reduce their abilities to use their sensory responses, e.g., robotic systems.

> "*I think it's difficult to integrate technology because it depends on your eye for the animals. All of you here know this. Certain things you need to do by hand when pigs are being born and such. It's hard to have a robot for this."* (Swedish Pig Focus Group 3)

> "*I probably just feel the sows most of the time. When you have been doing this for 30 years, or over 20 years you get a bit like-- you just put your hand on them and say, "You have a fever, now I know, good"."* (Swedish Pig Focus Group 3)

Value of group level data. The farmers usually managed pigs in groups. For example, a sow and her piglets were managed as a family group and sows may be managed by weight groups. This meant that farmers tended to value technologies that could collect data at a group level. Some examples of group-level technologies used on pig farms were group weighing scales and early warning systems which detect group-level deviations in drinking behaviour.

> *"There is a balance in the floor… You grab a litter from the birthing centre, walk with them to the balance, note the number on the list, and then WinPig calculates the average."* (Swedish Pig Focus Group 1)

> "*There have been a few times when we have detected weaning diarrhoea in groups, and then you then get an alarm that the water consumption is deviating*" (Swedish Pig Focus Group 2)

3.3 Poultry

3.3.1 Activities

For poultry, specifically for broilers, an anonymous online survey was developed and shared among European stakeholders. The key target participants were farmers/producers and veterinarians, but the branched questionnaire also allowed for the exploration of other expertise in the European broiler industry (e.g., retailers or buyers, managers of slaughterhouses, regulators, feed producers). The survey explored two areas of interest: (1) the *status quo* of data collection and decision making on broiler farms and (2) the needs and challenges of stakeholders in decision-making about broiler health and welfare. The areas of interest and research questions were jointly developed in several meetings between researchers (ETHZ, GD, UU, SLW, AHI) and in several rounds of pretesting with stakeholders (i.e., producers, veterinarians). The survey was distributed through the DECIDE project partners' networks (ETHZ, GD, UU, SLW, AHI). The link to the questionnaire was also shared through the Federation of Veterinarians of Europe (FVE). The recruitment efforts were substantially hampered by the still ongoing Avian influenza outbreak in Europe (European Food Safety Authority et al., 2022). Currently, N = 75 stakeholders have participated in the online survey. Data collection is ongoing and is to be expected to conclude in February 2023. To increase participation rates, new recruitment methods will be applied (i.e., flyers at farming conventions, personal contact to stakeholders).

3.4 Salmon

3.4.1 Activities

Focus groups and interviews were conducted in three European countries (Ireland, Norway, Scotland) targeting three types of stakeholders: Veterinarians and health experts, regulators (government and certification bodies), farmers and producers. The guideline covered challenges in salmon farming, data use for health and welfare decision making and needs of stakeholders. Additionally, an already existing dashboard was presented to and discussed with the stakeholders to gain some specific insights into their preferences regarding data tools and likely users of the tool. The dashboard makes use of historical monthly reporting of stock and mortality from farms in Norway and has four tabs with different functionalities: (1) map of Norway and bar chart showing the active farms and colour categorisation (mortality in the selected months), (2) map of Norway and bar chart showing all farms with a mortality above baseline and colour categorisation (duration of mortality above baseline), (3) map of Norway and line graph showing the median monthly mortality for all farms with mortality below baseline and regional mortality with time series, and (4) model for mortality based on different factors like temperature and regional differences with predictive functionality for the whole country and single farms. A total of 17 focus groups and interviews were conducted in Norway (three focus groups per type of stakeholders), Ireland (two focus group/interviews for regulators; one interview for producer; one interview for veterinarian), and Scotland (three focus groups for veterinarians and health experts; one focus group for regulators). Currently, data is available from 14 focus groups and interviews from all three countries, while the remaining focus groups and interviews are still to be transcribed and translated. Thus, the following insights focus on the veterinarians' perspective.

3.4.2 Main insights on veterinarians

The main challenges of health management. The following key challenges for salmon health management were mentioned by the participants: (1) environment and climate challenges (e.g., plankton blooms) (2) management of gill health, sea lice infections and the related injuries to salmon, (3) data management (e.g., data organisation, analysis and visualization)

> *“Probably environmental factors, which have become more of an issue in the past years, which are very hard to control. For example, harmful algae blooms, jellyfish blooms. Those have been an increasing problem and it's hard to see a easy solution to them”* (Irish Focus Group 1)

Data use for health and welfare decision making. The participants agreed that data played an essential role in salmon health management and decision making, for example to check on the salmon's health status, plan the next steps, and improve management performance. Aside from quantitative data, decision making was driven by communications with neighbouring farms and site staff, site observations, and professional experience. Most data were delivered in CSV or PDF format or on paper, while some data can be obtained through logging into the company's system. Four types of data were utilised by the participants: (1) general data collected on the salmon farm (e.g., mortality, plankton, water temperature, sea lice count, gill score, cleaner fish, oxygen levels, number of sea lice treatment), (2) data estimated by the management programs (feed rates, biomass, stocking density, average weight), (3) laboratory data (e.g., blood biochemistry test, PCR sample test, histology test, amoebic gill disease swab, bacterial swab) and (4) the Veterinary Health and Welfare Plan (i.e., records of monthly events related to health management). The data was used for different purposes, such as comparing data of different farms for benchmarking or analysing trends in mortality data or parasite counts for early warnings. Comparisons across farms were seen as difficult as there was no standard way for recording certain measures from environmental or laboratory test data on different farms. Various data management technologies are used for data access, data organisation, visualisation and communication (e.g., programs such as Fishtalk, Aquafarm, Mercatus, iWISE, Fishcontrol, Fishjournal, Power BI, Microsoft Excel, Microsoft Teams). However, most participants reported low user-friendliness (e.g., poor visualization, poor dataset linkage between different platforms).

> *"As fish vets, we're always having to calculate how relevant the findings from one, two - from individuals, how important the sample is that you're looking at, how relevant or representative of the wider population that is. That involves assessment of the available information. Fish health, we're always looking at things like mortality, we're looking at the wider environment and gathering as much information about the environment that fish are in, to make the best assessment of what might be going on."* (Scottish Focus Group 1)

Need regarding technology for health management. Overall, the stakeholders expected that data tools could improve health and welfare management but some of them relied more heavily on their own professional experience, observations at farm sites, and discussions with others to make health decision. Most participants mentioned the following functionalities of data tools as particularly beneficial: (1) data analysis and data visualization (i.e., effectively utilize data, plot the data, trend data with time scale), (2) linkage between multiple databases, (3) data organisation (i.e., user-friendly ways of searching data), (4) remote monitoring of the environment in real-time (e.g., plankton monitor from the farm and from neighbouring farms). Participants agreed that general health-related data could be communicated within or between companies based on confidential agreements. Specifically, environmental measures (e.g., real-time plankton, oxygen levels, water temperature), sea lice, gill disease and other bacterial disease were largely suggested to be shared with neighbouring farms as they had common sea areas.

> *"Like I said, we're also using two separate platforms as well so those two don't interlink, which means you have to pull the data off both sets of platforms and try and pull them together externally on Excel yourself and graph."* (Scottish Focus Group 2)

> *"If there are variations in the occurrence, average values, and maybe also towards the other diagnosis set based on the sample results. In a kind of timeline maybe? So I really think it's cool to present it in a timeline manner, perhaps combined with lice levels above or below the limit, and the treatment. There's a lot to be included in the same timeline here, I understand now."* (Norwegian Focus Group 2)

Participants' views of the dashboard. Regarding the first functionality, some participants viewed the visualisation of mortality (e.g., traffic light system to indicate mortality level) across the map of Norway as a useful tool for salmon health management and suggested that mortality data could be shared within or between companies. Some participants expected more data to be included in this map (e.g., gill disease, bacterial disease, sea lice and related treatment). However, some participants missed the context of mortality data in the dashboard (e.g., reasons of mortality). Most participants perceived the second functionality — visualisation of consecutive mortality rates on the map of Norway as less useful than the previous function (mortality across map of Norway). Specifically, they would like to view the real-time mortality data instead of consecutive recordings of high mortality data in time. Although some participants in Norway and Ireland regarded this function as useful as it created an alert of high mortality and drove health management, it was difficult to interpret the information as it lacked context. The third functionality, namely the visualisation of trend data in mortality rates in time (line chart), was seen as very useful for benchmarking by some participants because it showed the trend of mortality data within a specified time period. However, again, the lack of context was criticised by some participants. Lastly, the fourth functionality raised interest from some stakeholders in Ireland and Norway because of benchmarking and anticipation of risk period. However, many participants in Scotland held sceptical attitudes toward the prediction function because their management software already had predictive modelling functionalities and they were aware that many factors could influence the accuracy of predicted results. In all three countries, the stakeholders voiced concerns about sharing some of this information with the general public, and would want it to be disclosed to industry experts only.

4 Conclusions

4.1 Challenges, solutions, and learnings

Coordination across the project and beyond. A pre-requisite of this task was the common understanding of the methods that should be applied, and the resources required (i.e., time to recruit stakeholders, time to conduct focus groups and interviews, time of stakeholders). This required several meetings with the project team of WP5, with project partners from DECIDE from other WPs, with the data leaders from the various species case-studies and project partners involved in the development of data tools, and with our stakeholders across species. Based on these discussions, a matrix was created that highlighted which methodological approaches would be fitting for each country and species (i.e., focus groups, interviews, surveys) and which stakeholders should be involved. To facilitate these preparatory efforts, the *WP5 Collective* was created, aside from the individual meetings mentioned above. Two WP5 Collective events were organised to facilitate the exchange of ideas and information across WPs. All DECIDE project partners were invited to attend these two events. These events were used to give specific inputs on social science insights and methods, to discuss difficulties and solutions (e.g., recruiting of stakeholders), and exchange ideas for the data tools.

Recruiting of stakeholders and stakeholder engagement. Recruiting was challenged by several external factors (i.e., Avian influenza, farmer protests in the Netherlands), and lack of time or motivation of the stakeholders. Nonetheless, the project partners in DECIDE managed to collect a substantial amount of data and reported predominantly positive experiences while engaging with our stakeholders.

Contextual factors. As consumer preferences may act as contextual factors and might influence stakeholders' views of data tools, a consumer survey was conducted in the United Kingdom. This survey focused on salmon health and welfare management and investigated consumers' views of various sea lice treatments.

Ethical approval and informed consent. Prior to data collection ethical approval was sought at both involved universities (ETHZ, UoN). Participants provided their informed consent prior to participation and care was taken to comply with European, Norwegian, Swiss, and United Kingdom data protection laws.

4.2 Next steps

As not all data collection was concluded by the end of 2022, the remaining data will be collected within the first quarter of 2023. In the first half of 2023, four separate WP5 Collective events will be organised to disseminate the insights gathered in this task and to discuss the implications for the next steps for each species and for specific data tools. In collaboration with WP3, a list of the data tools that are being considered and developed in the DECIDE project will be prepared. This list will highlight specific aspects that will be further investigated by WP5 to provide insights on stakeholder needs (e.g., technology readiness level, regarding visualisation and output of data, functionality, or expected outcome and behaviour of stakeholders). Eight articles will be prepared for publication in peer-reviewed journals based on the collected data. Moreover, the results will be presented at national and international conferences (i.e., Society of Risk Analysis Europe, Society for Veterinary Epidemiology and Preventive Medicine) and will be disseminated through various public and scientific channels. Subsequently, the immediate next steps are outlined for each species.

4.3 Cattle: Living Lab

The next steps for the cattle living labs will be to continue along the concept phase (Figure 2). We will conduct a qualitative survey to understand cattle veterinarians needs regarding the control of respiratory and gastrointestinal diseases. We will also conduct a quantitative survey with dairy farmers to explore the needs of a larger sample of farmers. The survey will be designed based on the results of the farmer focus groups.

We will then move to the co-create and implement stages of the concept phase. In these stages, a workshop will be held with researchers who are involved in the development of cattle tools. The aim of the workshop will be to develop initial concepts, scenarios and personas based on the needs of the stakeholders identified in the explore stage. The concepts, scenarios and personas will be evaluated by stakeholders (e.g., farmers, veterinarians) in the evaluate stage.

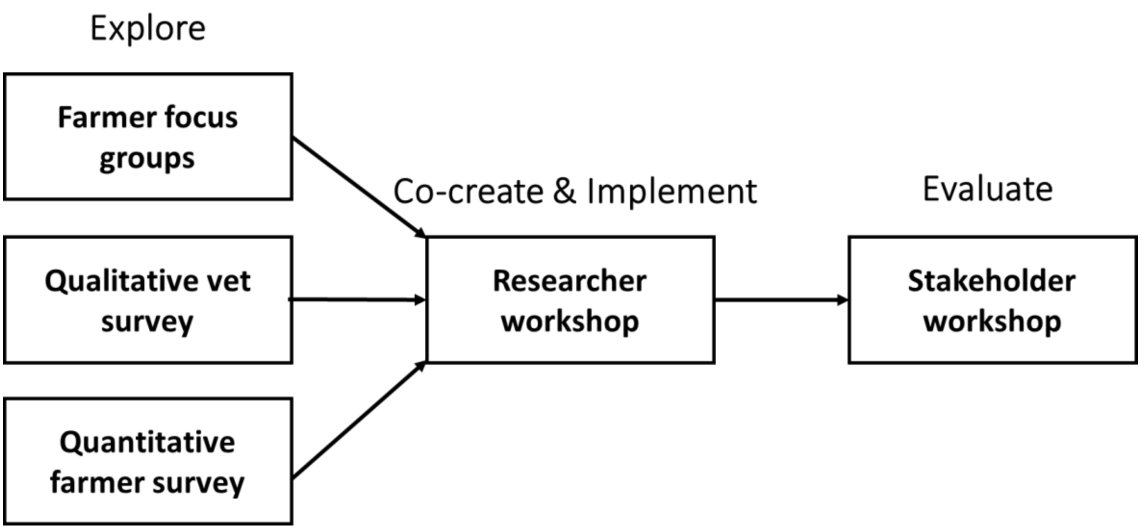

Figure 2: Next steps for the concept phase of the cattle living labs.

4.4 Pig: Living Lab and survey with farmers in selected countries

The Swedish pig living labs will follow a similar route as the cattle living labs and continue along the concept phase. In the explore stage, a qualitative survey will be conducted with Swedish pig veterinarians to understand their needs for a tool. In the co-create and implement stage, researchers from WP3 and WP5 will hold discussions to generate some concepts and scenarios based on the results from the explore stage. There will then be a stakeholder workshop to evaluate these.

Subsequently, the qualitative insights gained from pig veterinarian focus groups will be broadened in a mixed method approach, specifically an online survey with pig farmers will be developed and shared with stakeholders across Ireland, UK, Spain, Germany, Switzerland, and the Netherlands. This online survey will focus on the status quo of data collection and use and the challenges and needs of pig farmers regarding data tools and health and welfare management.

4.5 Poultry: Online survey

The online survey will remain accessible until the minimum sample size of n = 150 will be collected. Subsequently, the data will be analysed and will be discussed with the poultry data leader and involved project partners from DECIDE. In addition to this, semi-structured interviews with various stakeholders from the broiler industry are planned to complement the findings from the online survey.

4.6 Salmon: Focus groups and interviews

The remaining focus groups targeting famers, producers and regulators will be analysed. After analysis, a workshop will be organised for the salmon data leader and involved project partners to discuss the findings considering the existing dashboard or other data tools that could be developed.

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