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DECIDE

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

Deliverable 5.2

Case-specific reports on potential of different data tools from WP3

WP5 – Implementation and behavioural strategies for animal disease management

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Content

Abbreviations

Abbreviation	Description
AI	Artificial Intelligence
DAFM	Department of Agriculture Food and Marine
EU	European Union
NGO	Non-governmental organisation
WP	Work Package

Partner short names

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

Executive Summary

This Deliverable is a report on the case-specific insights into European stakeholder's needs for data tools to utilise data regarding animal health and welfare management. It provides insights into potential data tools that meet stakeholders' needs within the scope of the DE-CIDE project.

Objectives of the Deliverable

The objective of this deliverable is to identify important features of data tools that facilitate decision-making and health and welfare management targeting species-specific stakeholders (i.e., farmers, veterinarians, other decision makers). This can be used to provide guidance for future data tools being developed or improved by addressing different stakeholder groups' needs for health and welfare management regarding specific animal species (i.e., cattle, pig, poultry, salmon).

Activities

To achieve the objective of this deliverable, a variety of activities were carried out in close collaboration with DECIDE partners. Qualitative work (i.e., semi-structured interviews) and quantitative work (i.e., online surveys) were conducted to investigate stakeholders' needs for data-driven decision-support tools. Key stakeholders were recruited in various European countries targeting different animal species. The results were analysed, discussed and summarised together with project partners in regular meetings. Dissemination workshops were held for all DECIDE project partners to discuss about the report findings and implications for the development of data tools. Two scientific papers have been accepted. Two workshops were organised for the DECIDE project: 1) a workshop for the cattle group during the General Assembly meeting held in Copenhagen to explore stakeholders' needs and perceptions of technology, 2) a workshop focused on stakeholder judgment and decision making and data tool design in collaboration with WP3.

Outcome

This deliverable gives an overview of species-specific finding about:

- Stakeholders' needs regarding data tools for animal health and welfare management.
- Feasibility of potential data tools to be developed and used by stakeholders.
- Challenges in the development, implementation and evaluation of data tools.

Next steps

- Conduct case-specific evaluation studies of prototypes in pilot implementations in close collaborations with WP3.
- Evaluate how message framing and uncertainty impact stakeholders' perceptions and decision-making.
- Explore new opportunities of generating insights for DECIDE despite challenges in recruiting stakeholders.

1 Introduction and objectives

1.1 Introduction

Data-driven strategies hold the potential to enhance the decision-making practices of stakeholders regarding animal health and welfare management (Sawant & Shah, 2013). The literature review in prior deliverable D5.1 (Status quo regarding psychological and social preconditions of the use of data tools) reveals that various data and technologies have been employed on farms to manage production and collect the information in relation to animal health (Goller et al., 2021; Hennessy et al., 2016; Mkenda et al., 2021; Schulz et al., 2022; Soon & Baines, 2012; Zhou et al., 2022). However, the terms "data divide" and "technology divide" are prevalent among stakeholders in all four species, which describe a gap between the generation and utilisation of data with the application of technologies (Doidge et al., 2023b; Hennessy et al., 2016; Marshall et al., 2022). Previous studies have investigated various factors affecting stakeholders' adoption of technologies for animal production, including sociodemographic (Dhraief et al., 2019), farm characteristics (Dhraief et al., 2019), the investment cost of technology (Kaler & Ruston, 2019), technical skills (Eastwood et al., 2019; Schulz et al., 2022), and the perceived user-friendliness of technologies (Doidge et al., 2023b). Moreover, stakeholder engagement studies within WP5 have shown that, in some cases, there currently is a gap between the data that is needed to inform stakeholders about health and welfare of the animals and the data availability (e.g., data collected too infrequent or delay in the data delivery). For example, developing a data tool that relies on a stable internet access might not work for an off-the-grid farm or a data tool that updates environmental data monthly might not meet on-farm requirements, as decisions must be taken on a timely basis. Given that multiple tools are developed in the DECIDE project (see deliverable D3.1 Requirement analysis for a comprehensive list), more social science insights are needed to consider stakeholder needs.

To improve the efficiency and effectiveness of using data for animal health and welfare management, raw data need to be transformed into useful information in a format that adapts to stakeholders' information processing capacity (Ackoff, 1967; Benjelloun et al., 2023; Hoch & Schkade, 1996; Marshall et al., 2022). Exploring and understanding stakeholders' needs for the data tool will provide inputs for tool developers and facilitates the evaluation of data tools in the pilot implementations in collaboration with WP3. Therefore, this deliverable focuses on stakeholders' perceptions and needs regarding the use of technologies for the management of animal health and welfare. It draws from insights from prior studies, which have been reviewed and discussed with DECIDE partners through a series of workshops and meetings.

1.2 Objectives of the deliverable

In comparison to the prior deliverable D5.1 (Status quo regarding psychological and social preconditions of the use of data tools), this report delves further into stakeholders' needs for and derives more specific implications for the data tools currently under development within DECIDE. The deliverable addresses the following challenges:

- How do stakeholders view the current technologies for data generation, data collection, data analysis and interpretation?
- What do stakeholders need regarding the technologies to utilise data for animal health and welfare management?
- Which kind of functions regarding data tools can facilitate stakeholders' management of animal health and welfare and support their decision-making?
- In what way do design choices in data tools support and have wanted and unwanted effects on stakeholders' judgment and decision making?

1.3 Overview of prior and ongoing species-specific case studies

There are 13 studies exploring stakeholders' needs for data utilisation and technologies regarding health management of four animal species: cattle, pig, poultry and salmon. These studies are planned and carried out using either qualitative methods, such as focus group discussions, individual interviews, and qualitative surveys, or quantitative methods, such as online surveys and experiments. An overview of the involved studies can be found in Table 1. Some of these studies were already included and discussed in deliverable D5.1 (Status quo regarding psychological and social preconditions of the use of data tools).

Table 1. Lists of species case studies within WP5 in collaboration with DECIDE partners.

Species	Stakeholder	Country	Study method	Objective
Cattle	Beef and dairy farmers	UK	Focus groups	To explore why data and technologies are, and are not, being used on cattle farms.
	Dairy farmers	SE	Focus groups	To understand the social, cultural, and ethical implications of data and technology use on farms.
	Beef and dairy farmers	BE, FR, IE, NL, NO, SE, UK	Focus groups	To understand farmers' experiences, values, and perceptions of data use, technology use, and disease management to identify their needs.
	Veterinarians	IE, UK	Qualitative survey	To understand cattle veterinarians' experiences, values, and perceptions of data use, technology use, and disease management to identify their needs.
Pig	Veterinarians (in-house, independent and those who work on feeding, genetics, technology and economy)	IE, ES, NL	Focus groups	To explore veterinarians' perceptions and needs for the data tool in pig health and welfare management.
	Pig farmers, producers, and integrators	IE, ES, NL	Quantitative survey	To explore the status quo of data utilisation with the application of data tools in pig health and welfare management; to assess the perceived usefulness of two mock data tool dashboards for managing infectious respiratory and gastrointestinal diseases in pigs.
	Farmers	SE	Focus groups	To understand the social, cultural, and ethical implications of data and technology use on farms.
Poultry	Veterinarians, Farmers	PL, NL, IE, UK	Quantitative online survey	To explore the status quo of data utilisation and application of data tools in poultry health and welfare management.

	Health decision makers in the Polish broiler industry (farmers, veterinarians, integrators, veterinary authorities, diagnostic laboratories and other animal health and welfare managers)	PL	Focus groups and interviews	To investigate the requirements and capacities of stakeholders in terms of data utilisation and data tools for health management and production management.
	General public, veterinary students	CH	Online experiment	To investigate the impact of design elements in footpad lesion dashboard on judgment and decision making.
Salmon	Site managers (technical managers, health managers), health experts (veterinarians, biologist), inspectors	NO, UK (GB-SCT), IE	Focus groups and interviews	To explore the current state of data utilisation and application of data tools in management of salmon health and welfare; to understand stakeholder' needs for data tools; and to evaluate an existing protype for salmon health management.
	General public	UK	Online experiment	To test consumers' views of salmon farming and challenges; to explore the decisional context and societal pressure for stakeholders in salmon farming
	General public, veterinary students	UK	Online experiment	To investigate the impact of design elements in salmon mortality dashboard on judgment and decision making

2 Potential of data tools for stakeholders in cattle farming

For the cattle case, a Living Lab approach is being taken (Ståhlbröst & Holst, 2012). This deliverable describes the results of the exploratory phase of the concept stage of the Living Lab, in which users' needs were investigated prior to the development of any tools. Farmers and veterinarians are identified as key users of data tools on farms. Therefore, we conducted focus groups with dairy and beef farmers and a qualitative survey with cattle veterinarians. In total, 18 focus groups were conducted with 80 dairy farmers in Belgium, Ireland, the Netherlands, Norway, Sweden, and the UK and 10 focus groups were also conducted with beef farmers in France, Ireland, and the UK. The qualitative survey collected responses from 36 veterinarians in the UK and 24 in Ireland.

2.1 Focus group discussion with cattle farmers (UK and Sweden)

The following section include results from the farmer focus groups conducted in the UK and Sweden (UoN, IfA, SVA). 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 analysed. The results showed that farmers often did not make use of their data because data preparation and interpretation could generate states of displeasure (Doidge et al., 2023b). Farmers also thought that technologies were only suitable for certain farming systems (e.g., large dairy farms). This suggests that we need to change the meanings of using data and technologies by (1) providing a more positive emotional experience when using our tools and (2) ensuring different farming systems are represented in communications related to the tools.

Farmers also suggested that they did not have the competencies to turn their data into meaningful information and interpret their data. There were some farmers who used technologies in combination with their observational instincts. However, some farmers mentioned that they found it difficult to use technologies and they preferred to use their own experiential knowledge. Therefore, when we develop the data tools, we should ensure that farmers test the prototypes at various stages so that the design can be adapted to align with their existing technological competencies.

The presence of appropriate social structures was important for improving data use on farms. Whilst farmers appeared open to sharing their data with their veterinarian, some farmers discussed how they did not have access to a veterinarian who was interested in looking at their data. Similarly, some farmers mentioned how they found discussion groups valuable because they could receive feedback on their practices, but other farmers did not have access to discussion groups. Therefore, for successful technology adoption, we need to provide opportunities for farmers to discuss their data and technologies.

The analyses showed how technologies and data were important in the management of farm staff. For example, farmers could use technology to track their workers' daily activities on the farm and help to increase standardisation of farm tasks. Technologies facilitated communication and collaboration between farmers and workers, which can make their shifts easier by providing consistency to routines. Thus, we need to consider if and how multiple users will be using our data tools on farms.

The results also indicated that technologies and data can change the identities of farmers, workers, and their animals (Doidge et al., 2023a). Data and technologies can also generate new norms for farmers and their animals to follow. Emotions played a key role in the way animals were managed and technologies were used by farmers. Overall, it is important to consider changes to identity, emotions, and norms as potential consequences of adoption of the data tools that we are developing.

2.2 Needs for the cattle data tool

The following needs for the cattle data tool were uncovered:

- A positive emotional experience when using the tool.
- Aligns with farmers existing technology competencies.
- Provides opportunities for feedback and discussion of data.
- Multiple stakeholders on the farm can use the tool.

3 Potential of data tools for stakeholders in pig farming

A total of three studies were conducted to explore pig stakeholders' needs for the data tool (ETHZ, UoN, UU, GD, SVA, AHI, IRTA). The first study (3.1) comprised focus group interviews targeting pig veterinarians (i.e., in-house, independent veterinarians and those who work on feeding, genetics, technology use and economic assessment) in Ireland, the Netherlands, and Spain. The second study (3.2) is an online survey targeting pig industry stakeholders (i.e., pig farmers, producers, and integrators) in Ireland, the Netherlands, and Spain, which is still ongoing. The third study (3.3) targets pig farmers in Sweden. Design, data collection, analysis and interpretation are conducted in close collaboration with other WPs (WP3, WP4) and the pig data leaders and data tool developers.

3.1 Focus group discussion with pig veterinarians (Ireland, Netherlands, Spain)

Six focus group discussions were conducted with pig veterinarians, including seven Dutch participants, eight Irish participants, and twelve Spanish participants. Most veterinarians stressed that a variety of data are being collected on pig farms, but that these data are currently not used well to manage the pig health and

welfare. Specifically, the veterinarians delineated two types of technologies tasked with the generation, collection, recording, analysis, and sharing of data.

One type of technology comprises digital tools employed on pig farms, mainly including sensors (measuring and collecting data, e.g., feed/water consumption, environment, weight, cough, treatment, relocation), cameras (e.g., recording pig behaviours), alarm system (e.g., generating alarms when detecting abnormal data e.g., unexpected changes of mortality rates, feed and water consumption, weight, manure score, or farm temperature) and production management system (e.g., recording the information of production and finance). However, veterinarians emphasised that these digital tools were not extensively adopted by pig farms or companies, and there exists a "technology divide" characterised by unequal access to digital technologies (Doidge et al., 2023b; Hennessy et al., 2016). Firstly, farms with old infrastructure were generally less prone to invest in technology compared to modern farms or integrated companies. Likewise, old farmer might be less interested in using technology than young farmers. Secondly, lack of a perceived benefits and farmers' concerns about investment cost of technology may hinder them from applying digital tools. Thirdly, the absence of an internet connection impeded the employment of digital tools on pig farms. While certain digital tools have been implemented on pig farms, veterinarians mentioned that these technologies were not effectively utilised for the management of pig health and welfare. For instance, it required time, labour, and skill to maintain these digital tools and to analyse and interpret the data, which were beyond of pig farmers' routine work.

Another type of technology encompasses the data tools utilised by the veterinarians, including data management software or online platforms (e.g., processing, analysing, and visualising data), and communication platforms for telemedicine (e.g., WhatsApp). Moreover, some veterinarians used online platform or mobile device to receive alerts from farms when detecting abnormal data such as mortality or getting a reminder for planned actions such as update of antibiogram and schedule the vaccination. In general, veterinarians used software applications, which were not specifically designed for pig farming data, such as Excel or Power BI, for data analysis and data interpretation. Data were often utilised for benchmarking against other farms and for identifying potential risks when abnormal data were detected. A few important limitations of these data tools were mentioned by veterinarians, which could potentially inform the development of tools specifically designed for managing and analysing pig farming data. Firstly, veterinarians often collected data from different data sources and then transferred the data into their own software to analyse and visualise data, which was labour-intensive and time-consuming. Some Spanish veterinarians were concerned about the limitation of using these software programs such as Excel to manage and analyse data. Secondly, these data tools did not facilitate continuously tracking and monitoring the data. Spanish veterinarians perceived the disease visualisation system was useful as it shows the prevalence of infectious respiratory and digestive problems by regions, but such a data tool seemed not be widely implemented. While some alarm systems have been employed to detect abnormal data, such as particularly low or high water consumption, some veterinarians mentioned it lacked decision-support information to address the potential health problems connected with abnormal data.

3.2 Online survey with pig industry stakeholders (Ireland, Netherlands, Spain)

An online survey was conducted in collaboration with WP4 to investigate how pig industry stakeholders utilise data and data tools for pig health and welfare management. The second part of this survey evaluated the perceived usefulness of two mock dashboards that facilitated the management of infectious respiratory and gastrointestinal diseases. The first mock dashboard (Figure 1) visualises pig mortality on a specific farm at different time intervals, as well as the regional and national average in pig mortality. Pig farmers can use this dashboard for benchmarking against other farmers or against the regional and national average level. Also, they can use it to check pig mortality by cause of death. The second mock dashboard (Figure 2) is an early warning dashboard that visualises cough counts per pen on a specific farm in real time. This dashboard can

generate an alert when the count exceeds a pre-defined value. Data collection is still ongoing, but first insights are reported below. The following section will present results regarding the data collected from 30 participants in Ireland, 111 participants in Spain and 11 participants (who completed the survey) in the Netherlands.

Figure 1. Mock dashboard visualising pig mortality over time for benchmarking.

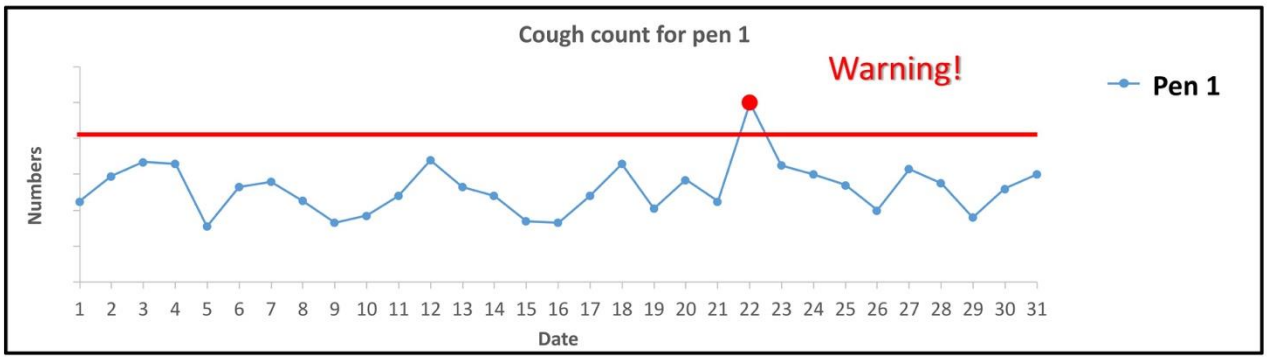

Figure 2. Mock early warning dashboard visualising cough counts per pen on a specific farm in real time.

Status quo of data collection and data tool use. The participating pig industry stakeholders reported different levels of using data tools to collect and record data. Most data were currently recorded on paper or manually collected and then transferred into a data management system. For example, most stakeholders (*n* = 73, 48%) reported that mortality data were manually collected and then were transferred into a data management system, followed by those (*n* = 53, 35%) who reported that mortality were recorded on paper. Another 13% (*n* = 19) of the stakeholders utilised digital tools for automated data collection and recording and the remaining 4% (*n* = 7) of the stakeholders did not collect or record mortality data. Most stakeholders

reported that they did not collect/record data about indoor air quality (e.g., ammonia level) (*n* = 112, 74%), followed by humidity (*n* = 102, 67%), water intake (*n* = 67, 44%), slaughterhouse data (*n* = 65, 43%), clinical signs (*n* = 64, 42%), outcome of therapeutic treatment (*n* = 59, 39%), and behaviours (*n* = 53, 35%). Stakeholders expressed different beliefs about the role of technology, with *n* = 110 (72%) (strongly) disagreeing that technology will replace their role in pig farming, with *n* = 94 (62%) (strongly) disagreeing that technology is useless for controlling disease and *n* = 104 (68%) (strongly) disagreeing that technology will reduce the contact with pigs and with *n* = 128 (strongly) agreeing (84%) that they have confidence in using technology to assist in their daily job for pig health management.

Mortality dashboard. Most stakeholders rated the benchmarking tools as somewhat useful (*n* = 65, 43%), whereas 49 stakeholders (32%) rated it as useful. The remaining stakeholders either rated it as not useful or were unable to determine its usefulness (*n* = 38, 25%). For stakeholders who perceived this dashboard was useful or somewhat useful, a total of 93 stakeholders (82%) reported to be willing (somewhat) to upload the mortality data for this purpose. Most participants preferred to upload the mortality data weekly (*n* = 44, 39%), followed by monthly (*n* = 40, 35%), daily (*n* = 15, 13%), quarterly (*n* = 10, 9%) and yearly (*n* = 4, 4%). According to the open responses from 14 stakeholders, Spanish stakeholders mentioned that the dashboard lacked contextual information to inform the benchmarking (e.g., location of other farms, type of farm system, differentiate the cause of mortality), and they would like to see if the change in mortality rate was statistically significant or not. Some Irish stakeholders relied more on their own judgment to manage pig health and they are not willing to continuously upload the data. Also, they mentioned that the mock dashboard did not provide preventative measures or support to prevent the disease outbreak. One Dutch stakeholder unclosed that the similar kind of dashboard had already been used by some veterinarians.

Early-warning tool. Most stakeholders perceived this dashboard to be somewhat useful (*n* = 48, 32%), and useful (*n* = 59, 39%), to manage infectious respiratory disease. The remaining stakeholders either rated it as not useful or were unable to determine its usefulness (*n* = 45, 29%). However, some Spanish stakeholders thought it was labour-intensive and costly to apply such a tool in a big pig farm. Some Irish stakeholders stressed that received alarms from the dashboard for respiratory diseases might come too late for effective treatment. Additionally, they pointed out that this dashboard could not replace manual observations of pigs and it lacked contextual information, such as environmental parameters or pathogen infection status. One Dutch stakeholder who owns a small farm was adept at visually observing pigs and didn't necessitate a data tool for cough counting.

3.3 Focus group discussion with pig farmers (Sweden)

The Swedish case is following a Living Lab approach similar to the approach in the cattle group. For the explore phase of the concept stage of the Living Lab, farmers' needs were investigated through focus groups. The results of the Swedish pig farmer focus groups were reported in combination with the Swedish dairy farmer groups, and therefore can be found in section 2.

3.4 Needs for the pig data tool

The following needs for the pig data tool were uncovered:

- General needs for the data tool:
    - Target group: farmers and veterinarians.
    - Linking of different data sources and standardisation of collection and reporting.
    - User-friendly, intuitive interface.
    - Aligns with farmers existing technology competencies.
    - Provides opportunities for feedback and communication of the data.
- Needs regarding the functionality of data tool:

- Remote monitoring of the farm data and slaughterhouse data for stakeholders who have limited chances for in-person farm visits (particularly for independent veterinarians).
- Visualisation of historical data with time series e.g., weekly and/or monthly (need contextual information such as the location of farm, mortality reason, production system).
- Visualisation of endemic disease maps including the cause of disease (particularly for Spanish veterinarians).
- Anonymous benchmarking against other farms (particularly for Irish users).
- Early-warning tool for detecting infectious respiratory and digestive diseases (e.g., cough count, environmental parameters, weight, feed and water consumption, mortality) with customisable reference levels based on the farm-specific context (the distribution of alarm should depend on stakeholders' specific needs and responsibilities. E.g., farmers may check the alarm first and then forward it to veterinarians; alarms about productive data may go to farmers and health alarms may be forwarded to veterinarians).
- Support in interpretation and decision-making through Artificial Intelligence (AI) through prediction of potential risk and solutions.

4 Potential of data tools for stakeholders in poultry farming

Several studies were conducted and are currently ongoing to investigate stakeholders' needs regarding poultry farming (ETHZ, GD, UU, SLW, AHI).

An anonymous online survey was shared with European stakeholders from the broiler industry (i.e., farmers/producers, veterinarians, retailers/buyers, managers of slaughterhouses, regulators, feed producers). The survey explored the status quo of data collection and decision making on broiler farms and the needs and challenges of stakeholders in decision making about broiler health and welfare. Unfortunately, the recruitment efforts did not lead to a satisfactory sample size that would allow for inferences and comparisons across stakeholders. In total, n = 23 producers, n = 66 veterinarians and n = 19 other stakeholders took part in the survey. Reasons for the low participation rate were manifold, among the most likely reasons were the length of the questionnaire, lack of incentive for participation, and environmental factors (i.e., Avian Influenza outbreak in Europe). For this reason, only limited insights could be drawn from the open response fields at the end of the survey.

Due to the low response rate in the survey, other means of collecting data on stakeholder needs are currently pursued. Namely, semi-structured interviews are currently planned and being conducted in Poland (health decision makers in the broiler industry). The objective of these interviews is to investigate the requirements and capacities of stakeholders in terms of data utilisation and data tools for health management and production management. The data collection is currently planned and no data is available yet.

Design, data collection, analysis and interpretation of the reviews are conducted in close collaboration with other WPs (WP1, WP3) and the poultry data leaders and data tool developers.

4.1 Online survey with stakeholders from the broiler industry in Europe

As stated above, only limited insights could be generated from the online survey due to the low response rate. Solely, from the open response fields, some useful data on the stakeholders' needs could be extracted. Some stakeholders explained that the data from the processors or slaughterhouses are available but are currently not used to inform and improve decision making at the farm level. Particularly, continuous environ-

mental data (i.e., temperature, humidity, noise, thermography) and on bird behaviour (i.e., sound and movement) were seen as potentially helpful for decision making. Other stakeholders were concerned that already there is an overreliance on technology on broiler farms and requested more observation.

4.2 Needs for the poultry data tool

The following needs for the data tool were uncovered (more insights are expected to emerge from follow-up studies):

- General needs for the data tool:
  - Current gap: transforming data into useful and usable information.
  - Prevalent health challenges: respiratory and gastrointestinal diseases.
  - Prevalent welfare challenge: footpad lesions.
- Needs regarding the functionality of data tool:
  - Continuous data on environment (i.e., temperature, humidity, noise, thermography).
  - Continuous data on bird behaviour (i.e., sound and movement).
  - Continuous data and feedback from the slaughterhouse

5 Potential of data tools for stakeholders in salmon farming

Fourteen focus group discussions and three interviews were conducted to explore stakeholders' status quo of data utilisation and their needs for data tools regarding salmon health management (ETHZ, NVI, SRUC, AHI). A total of 44 participants were recruited in Norway, Scotland and Ireland. Specifically, three types of stakeholders were included: health experts (i.e., veterinarians and biologist), health inspectors (i.e., stakeholders associated with government institutions and certification bodies), and salmon industry stakeholders (i.e., technical managers and health managers from the salmon industry). Publications on the insights generated in these focus groups (Zhou et al., 2023a) and a public survey on various sea lice management in the UK are under development (Zhou et al., 2023b).

5.1 Focus group discussions and interviews with salmon health and welfare stakeholders (Norway, Scotland, Ireland)

Stakeholders acknowledged the important role of data in salmon health management. The subsequent sections summarise the key insights into stakeholders' data utilisation.

(1) Timeliness of data updating is crucial to monitor salmon health. For instance, compared to in-house health experts and industry stakeholders, independent health experts and inspectors faced a delay of at least 1 month because they did not have access to company data directly but instead rely on open-source databases that all salmon producers in Norway and Scotland contribute to.

(2) "Reasons for mortality" data provide important information in addition to salmon mortality data. While there are many challenges in standardising "reasons for mortality" across companies, steps have been set in Norway and Scotland to collect and provide this data in open-source databases alongside mortality quantities, making mortality more transparent.

(3) Standardised case definitions serve as foundation for the quality of shared data. Independent health experts and health inspectors highlighted the necessity of standardised data collection and recording procedures before sharing and using data among multiple parties.

(4) Within-company inefficient data access and management is time-consuming and labour intensive for those needing it. This is perceived as barrier to the efficient utilisation of data for salmon health management.

(5) Independent health experts and inspectors have no direct access to data held by industry. In general, they acquired data through methods such as email, online open-source data platforms, or in-person data requests. This was a time-consuming process that was being perceived as making their jobs more difficult.

(6) Lack of a user-friendly and intuitive tool to analyse and interpret data. Stakeholders exhibited diverse opinions when using data tools for analysing and interpreting data. Health experts often use their own software to manually analyse and visualise data with time series for benchmarking and identifying the potential risk, but the majority of them perceived these tools as not being user-friendly. Some health inspectors lacked a user-friendly tool for efficiently and effectively visualising and analysing data. While industry stakeholders mentioned the use of data tools to visualise data for benchmarking and predicting mortality, there is currently no tool available that enables flexible data selection for specific purposes and prediction for environmental parameters.

(7) Data sharing between companies or between company and other stakeholders is not an easy process. Salmon industry stakeholders are hesitant towards sharing data although producers mentioned that relevant data and information (e.g., salmon mortality, environmental parameters, and plan for coordinate activities) were often shared within other salmon farms/companies or externally with neighbouring farms/companies. Most stakeholders expressed concern about sharing data, such as mortality, publicly available. Firstly, they mentioned that data is often considered a trade secret. Secondly, they noted that data without contextual information could be misinterpreted by the public and misused by non-governmental organisations (NGO) and interest groups. A constraint on sharing data from the salmon industry with governmental authorities is the presence of legislations and regulations. Freedom of Information legislations allow the public to request the officially recorded information.

5.2 Needs for the salmon data tool

The following needs for salmon decision support tools were among those uncovered (may not be universally applicable to all individuals or every country):

- General needs for data tools:
  - Linking of data from different sources and distributing such information through reports in a standardised way will be essential for ensuring data consistency and accessibility (particularly for health experts and health inspectors).
  - User-friendliness, intuitive interface.
  - Alignment with users' preference for data searching and data analysis.
  - Timely updates of data (e.g., mortality, environmental parameters, sea lice treatment).
- Needs regarding the functionality of data tool:
  - Remote and continuous monitoring of farm data, particularly for independent health experts and health inspectors).
  - Visualisation of historical data with time series, which requires contextual information such as the sea lice treatment, mortality causes (particularly for health experts and health inspectors).
  - Early-warning tool for detecting the potential risks when the mortality rate exceeded a predefined reference level (e.g., the reference level can be customised, particularly for health inspectors).
  - Support in reliable interpretation and decision-making through advanced data-science methods including Artificial Intelligence (AI), multiple health indicators should be considered such as environmental parameters.

6 General insights and conclusions

6.1 Variability in stakeholders' needs for data tools

This deliverable encompasses the views of multiple stakeholders originating from varying professional backgrounds and countries, manifesting diverse requirements regarding data tools for animal health and welfare management. To facilitate the development of prototypes targeting different users, it is required that WP5 discusses the potentials of data tools with data leaders from species case-studies, DECIDE partners involved in the tool development, and partners from other WPs. Workshops and meeting have been held by WP5 to share the social science insights into the stakeholders' needs for data tools with project partners, contributing the development of prototypes fitting countries, species and stakeholders. WP5 will continue to collaborate closely, as tools are developed, designed, evaluated and implemented.

6.2 User experience

The results of the Living Lab studies highlight the importance of the emotional responses to using technology and data. Therefore, it is important to investigate the user experience when using the developed data tools. Also, the potential unintended consequences of adopting data tools (e.g., unpleasant use experience, not adaptable to farm system) should be considered. Applying a Responsible Innovation approach to tool development (Rose and Chilvers, 2018) e.g., by including users throughout the development process and responding to their concerns, may address these issues.

6.3 Challenges of the recruitment of stakeholders

One prominent challenge of WP5 is the recruitment of participants, highlighting the difficulties in securing a diverse and representative sample in different countries. Tackling these recruitment challenges has proven to be a pivotal challenge for WP5, prompting the search for solutions to reach stakeholders (e.g., events, workshops), augment participation rates (e.g., providing incentives and through collaborations with partners outside of DECIDE) or find alternative avenues to collect data. Future studies in relation to the evaluations of the data tools will place more emphasis on smaller scale data collection (i.e., interviews, workshops) or on stakeholders, such as veterinary students and the public. Understanding how humans in general make decisions will provide valuable insights into the development of data tools for animal health and welfare management.

7 Next steps - evaluation of case-specific data tools

7.1 Next steps

Data collection for further stakeholder engagement studies are underway for all species. Next step of WP5 will be to conduct studies evaluating how data tools, choice framing and design choices impact stakeholders' risk perception, behaviours and decision-making for animal health and welfare management in collaboration with WP3 and other partners for species case-studies. Articles for salmon focus groups, pig veterinarian focus groups and pig farmer surveys will be prepared for publication in peer-reviewed journals based on the upcoming collected data. In addition, results of pig veterinarian focus groups and pig farmer surveys will be presented at international conferences (ESPHM & IPVS Congress 2024). The plan for forthcoming studies for specific species is shown in the following sections.

7.2 Cattle

The next stage of the cattle Living Labs was a researcher workshop. The workshop involved the researchers who are developing the cattle data tools and aimed to immerse them in the user needs that were generated from the farmer focus groups and qualitative survey with vets. Following on from this, workshops will be

conducted with stakeholders (e.g., farmers and vets) in Sweden, Ireland, and the UK to evaluate the concepts for the data tools and explore specific requirements.

7.3 Pig

An online survey with follow-up interviews is currently designed to evaluate the usefulness and usability of the Pig HealthCheck by current and prospective users (i.e., pig stakeholders) in Ireland, in collaboration with AHI and WP3 (SVA). The Pig HealthCheck programme is an Animal Health Ireland (AHI)-led programme co-funded by pig producers and Department of Agriculture Food and Marine (DAFM), seeks to enhance the profitability and sustainability of the Irish pig industry by improving animal health and welfare. Data will be analysed and discussed with AHI to improve the data tool for pig health and welfare management. The insights generated from this survey will be used to inform future evaluation studies of other data tools. The next stage of the Swedish pig Living Lab will focus on tool evaluation and feedback from stakeholders such as pig farmers and veterinarians. Evaluation studies for other data tools will be planned in collaboration with pig data tool developers within DECIDE.

7.4 Poultry

Evaluation studies for the developed data tools will be planned in collaboration with poultry data tool developers within DECIDE.

7.5 Salmon

An online experiment is planned with the public and veterinary students to investigate the impact of design elements in a mortality dashboard on judgment and decision making. Specifically, the experiment allows to explore how colour schemes (traffic light vs. gradient colour) for different levels of mortality (low vs. high) impacts people's risk perception and conclusions drawn from these visualisations. A sample from the public will be recruited, assuming similar mechanisms in judgment and decision making among humans. The sample of veterinary students allows to test for differences based on experience and knowledge about salmon health and welfare. Evaluation studies for other data tools will be planned in collaboration with salmon data tool developers within DECIDE.

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