Assess The Role Of Milk Screening For Disease Within The Development Of An Effective Herd Health System

NUFFIELD IRELAND
Farming Scholarships

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Date: March 2020

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1. Executive Summary

The agricultural landscape has changed significantly over the past five years as milk production increased after the ending of milk quotas in 2015, and with much greater consumer interest and scrutiny in how food is produced. Food processors are actively taking steps to guarantee the integrity of their products to avoid any repeat of food and health scares which occurred in some countries.

There is increased attention from regulatory authorities and consumers on animal health and welfare, food safety and concerns about antimicrobial resistance and climate change. In addition, social media provides access to a wider audience for accurate and inaccurate stories about food production methodology. Therefore, it is vital that herd health is put to the top of the farming agenda.

One of the ways to determine herd health is through milk surveillance or milk screening for disease. The objective of the report is to provide an overview of what milk surveillance schemes exist across the world and examine how such an approach can encourage farmers to be more proactive in managing herd health. Options are explored on how various stakeholders can work together and engage to achieve better herd health outcomes. A more pro-active risk-based approach like the United Kingdoms' National Johne's Programme, is testament that through collaboration between the farmer, veterinarian (vet) and the dairy industry an improvement in herd health is attainable.

Streamlined capture and use of data is an essential component in milk and herd surveillance and this was effectively demonstrated in Denmark utilising the national Danish Cattle Database. Evidence-based decision support is a core element to enable farmer and vet to develop coherent action plans, the value and merit of this was illustrated through My Healthy Herd.com. An aim is to address how milk surveillance schemes can make the best use of advanced digital communications, precision and new generation testing technologies.

The over-riding objective is to learn from best practice in herd health in other leading dairy countries and through focused independent travel on good standards for public health and well-developed dairy industries useful case studies have been incorporated within the report which can demonstrate insight into effective herd health systems.

2. Personal Introduction and Background to study topic

Coming from a farming background in West Limerick, working at home on the farm in County Kerry and working as Milk Quality Manager for Kerry Agribusiness I have opportunity to meet with farmers regularly and I am very immersed in agriculture. I am married to Paddy and we have two children Padraig and Aoife and live on the farm in beautiful, picturesque Annascaul, Co. Kerry. I qualified with a Bachelor of Science (Honours) in Food Technology from University College Cork and returned to college to complete a Master of Business Administration in 2011 at the Institute of Technology Tralee.

The rationale behind my chosen study topic is to provide insight and information on disease prevention and determine how to be proactive rather than reactive to animal health. Lack of clarity can often exist regarding poor health causes and it can be extremely frustrating to identify if an underlying herd health issue exists. One of the tools which could potentially detect such issues is bulk and individual milk screening for disease.

Within Ireland no specific published data is currently available outlining the level of participation in milk screening for disease but my initial research has signified that varying levels of participation exist within the industry. A portion of herd health schemes are completed by integrated service providers, others are centrally managed by milk processors themselves, while some schemes are driven by private veterinary practitioners who outsource testing.

My Nuffield scholarship has taken me to Iowa, USA for the Nuffield Contemporary Scholars Conference, to Singapore, Philippines, Hong Kong, China, Germany, Ireland, Washington and Texas as part of my Global Focus Program. For my personal travel I tried to be very specific in the countries to visit so I targeted countries which I felt were leaders in herd health monitoring and surveillance, so I travelled to the Netherlands, United Kingdom, Scotland and

Denmark. Within the countries I visited and all the influential people I have met this has given me the foundation and inspiration for my report.

3. Objectives

The study's aim is to assess the role in using milk screening for disease within the development of an effective herd health system. The overall objective is to enable the herd owner to become more proactive in managing herd health. The task is to explain the rationale behind the chosen study topic, give a brief overview of milk screening for disease and investigate best practice internationally in milk screening for disease and herd health management. The objectives align with the United Nations Sustainable Development Goals: 3-Good Health, 12-Responsible consumption and 15- Life on land.

Identified objectives for the study:

- Proactive Herd Health Management
- Acknowledging on-farm roles and responsibilities
- Adding Value to the Dairy Industry
- Efficient Capture & Use of Data
- Evidence Based Decision Support
- Future Direction of Milk and Animal Health Screening.

4. Proactive Herd Health Management

Building on one of the key enabling principles of the National Farmed Animal Health Strategy (NFAHS) 2017-2022 – "prevention is better than cure" is an initiative aimed at improving animal health. Preventing disease at their animal source is crucial to protecting human health. Sub-optimal animal health, whether associated with dramatic clinical disease or undiagnosed sub-clinical disease can destroy value. This prevention principle seeks to change the focus from one of post event response management/ treatment of disease to one that promotes animal health as a driver of optimised production, improved margins for producers and providing the best quality food for consumers (Blake 2019).

Prevention rather than cure is additionally of significance beyond the farm gate- in the context of two major societal issues- climate change and the increased focus on antimicrobial resistance. These challenges aim to be addressed comprehensively within The Farm to Fork Strategy which is at the heart of the Green Deal. This strategy recognises the obstacles within sustainable food systems and the inextricable links between healthy people, healthy societies and a healthy planet. There is an urgent need to reduce dependency on pesticides and antimicrobials, reduce excessive fertilisation, increase organic farming, improve animal welfare and reverse biodiversity loss. Better animal welfare can help improve animal health and food quality, reduce the need for medication and help preserve biodiversity (Farm to Fork Strategy 2020).

Healthy animals are more efficient, productive and they have less environmental impact than those animals whose health is compromised. Progress has been made in recent years in the area of disease prevention, with increased use of vaccines to protect against certain animal disease threats and elimination of certain diseases e.g. Bovine Brucellosis. Biosecurity is the core element of 'prevention' – serving to minimise risks and thus protect the health of animals (National Farmed Animal Health Strategy 2017-2022).

An ongoing challenge in the prevention of disease, is the need to effectively and consistently implement required management practices while being conscious of the requirement to educate and motivate individuals within an integrated farm system, this is where the complexity can exist (LeBlanc et al. 2006). As part of Ireland's National BVD eradication and Johne's Control programme a Veterinary Risk Assessment and Management Plan (VRAMP) is in place. A trained veterinary practitioner can provide up to three hours of advice to a farmer involved in a programme whereby they can identify the source of BVD infection if applicable or identify the risk factors associated with Johne's disease. Only vets who have undertaken Targeted Advisory Service on Animal Health (TASAH) training delivered by Animal Health Ireland (AHI) in relation to the relevant disease are eligible to provide the service. TASAH is funded by the Department of Agriculture Food and Marine, in conjunction with the European Union as part of the Rural Development Plan 2014-2020. An important step towards proactive health management in dairy herds is early detection of infections to allow timely decisions on control strategies to take place (Hanks et al. 2014).

4.1 Antimicrobial Resistance

The matter of antimicrobial resistance (AMR) is now universally accepted to be a major strategic global public health risk. AMR is estimated to be responsible for 33,000 deaths per year in the EU alone and 700,000 deaths globally (Blake 2019). A 'One Health' approach has been adopted in Ireland which recognises that human, animal and environmental health are all interconnected. A 'One Health' approach is recognised by the World Health Organisation and the European Commission as key to tackling AMR with the Commissions' objective to reduce overall EU sales of antimicrobials for farmed animals and in aquaculture by 50% by 2030 (Farm to Fork Strategy 2020). The establishment of *i*NAP (Ireland's National Action Plan on Antimicrobial Resistance 2017-2020) aims to implement policies and actions to prevent, monitor and combat AMR across health, agricultural and environmental sectors (Blake 2019).

New regulations on veterinary medicines (Regulation (EU) 2019/6) and medicated feed (Regulation (EU) 2019/4) will enter into force within the European Union from 28 January 2022. These regulations include several measures to fight antimicrobial resistance, will result in reduced availability of antibiotics and a greater reliance on prevention and will offer an important springboard for further progress.

New measures to fight antimicrobial resistance as outlined in Regulation (EU) 2019/6 (veterinary medicines) and (EU) 2019/4 (medicated feed) (More 2020):

- A ban on the preventative use of antimicrobials, both in groups of animals and in medicated feed
- Restrictions on metaphylactic use of antimicrobials
- A reinforced ban on the use of antimicrobials to promote growth and increase yield
- The possibility to reserve certain antimicrobials for humans only
- The obligation for Member States to collect data on the sale and use of antimicrobials
- For imported animals and products from outside the EU, a ban on antimicrobials for growth promotion and restrictions on antimicrobials reserved for human use

The prudent use of antimicrobials is a cornerstone in addressing antimicrobial resistance. Vets have a crucial role in communicating to their clients in the delivery of individual and national animal health programmes and antimicrobial veterinary medical products should only be authorised following careful scientific benefit risk assessment (Regulation (EU) 2019/6

Veterinary medicines (2018)). Antimicrobial selection should be based on proper diagnosis preferably confirmed by susceptibility testing. Progress can be monitored through collection of data from sales or recorded antibiotic use by farmers. Milk purchasers and supply chain have a considerable influence and through on farm antimicrobial stewardship can incentivise improved health on farm or where necessary impose tighter restrictions. Many have implemented training programmes to increase biosecurity, improve health and welfare and overall reduce antibiotic use (Armstrong et al. 2018).

4.2 'Predict and Prevent' Disease

To truly predict and prevent disease, a thorough understanding of the risks that redispose livestock to health threats is required. A structured system to identify such risks on farms and a need to construct a programme of risk management which can pre-empt and prevent herd health issues before they arisen is required. The concept of risk management in the prevention and control of endemic infectious diseases and production diseases such as BVD, Johne's disease, lameness and mastitis have been well accepted by vets and farmers in regional health schemes throughout the UK. Through My Healthy Herd.com it uses a principle of herd-disease management based on four pillars of control: biosecurity (risk of disease introduction); biocontainment (risk of disease spread within the herd); resilience (immunity, vaccination) and surveillance (Orpin & Sibley 2014).

THE FOUR PILLARS OF DISEASE SUPPORTING THE DISEASE STATUS OF THE HERD

Figure 1: The four pillars supporting the disease status of a herd
(Source: Adapted Orpin 2019)

Vets and farmers must adopt a "risk mindset" and much more focus must be placed on risk assessment and management (Orpin 2019). Traditionally infectious disease control had a strong emphasis on surveillance whereby only concentrating on one pillar of disease with the other three pillars given less priority. In order to build an effective herd health system all four pillars must be considered and if regulated correctly this can lead to the decline and the eventual eradication of disease through predicting and preventing its spread (Orpin & Sibley 2014).

For animal health to change from a curative to a more preventative approach, whereby reducing antibiotics and vaccines, the need to identify and quantify risk factors is necessary. The farmer should be advised which preventative or control measures take priority. In order to improve animal health substantially the farmer must be systemic in their approach to risk management – this can ultimately lead to reliable health certificates which has the potential to enlarge the markets for animals and products and further add value to the industry (Noordhuizen & Welpelo 1996).

5. Overview of Milk Screening for Disease

Laboratory testing for infectious, endemic and parasitic disease involves a variety of methods to determine the causation of the disease. The systems which are commonly used are generally broken down into direct (detecting the presence of an infectious or parasitic agent) or indirect tests using serology / antibody detection (Gilmore 2016). The scope of the report will concentrate predominately on bulk and individual milk screening for disease using ELISA (enzyme-linked immune sorbent assay) while also referring to PCR (polymerase chain reaction) testing methodology.

The ELISA is an immune assay which relies on the detection of the host antibody as an indicator of infection. Bulk milk ELISA can be an attractive option for monitoring or establishing infection status in a dairy herd as it can provide automated, rapid and relatively inexpensive method of assessing herd-level status with regard to various pathogens including Bovine Viral Diarrhoea (BVD) virus, Infectious Bovine Rhinotracheitis (IBR), Salmonella and parasites such as Liverfluke, Ostertagia (Stomach Worms) and Neospora (Sekiya et al. 2013). For vaccinated animals like in the case of IBR vaccine it may be necessary to use the IBR gB ELISA test which detects antibodies in animals which have previously been exposed to the virus (both vaccinated and infected) or the IBR gE ELISA test which detects antibodies produced but not by animals which have received a marker vaccine (DAFM).

Paratuberculosis (caused by bacterium Mycobacterium Avium Paratuberculosis) or Johne's disease requires individual animal milk screening to occur as antibody testing has poor sensitivity. Individual animal screening may also take place reactively as a result of disease incidence or whereby further investigation on positive bulk milk results are required (Gilmore 2016). It is essential to consider the ELISA test characteristics when interpreting the results, i.e. sensitivity, specificity and predictive values.

Table 1: Definitions important when interpreting test results

Term	Explanation
Sensitivity	The proportion of infected animals testing positive
Specificity	The proportion of non-infected animals testing negative
Positive predictive value	Probability that the animal / herd is diseased, given a positive result
Negative predictive value	Probability that the animal / herd is not diseased, given a negative result

(Source: Dufour and Hendrix 2009 cited in Wapenaar et al. 2017)

Testing may yield false-positives or false-negatives results which may be due to reasons such as reporting errors or cross-section of antibodies. Repeating a test or using an additional test using a different methodology i.e. PCR can improve the reliability of the aggregated test outcome (Wapenaar et al. 2017). False-positives results are known to occur, but with frequent testing combined with experience, the understanding of the false-positives can improve (Nielsen 2009). Bulk milk ELISA may be further biased because it does not include contributions from non-lactating animals and those which are withdrawn from the milk pool due to treatment for disease.

With bulk and individual milk testing there can be a significant delay in the onset of an infection and detection of the antibody and/ or lag between the elimination of the parasite and the corresponding reduction in the concentration of the antibody (Sekiya et al. 2013). A variety of milk screening tests can be conducted on bulk and individual samples and this schedule may be dictated by a laboratory, a vet, milk processor, milk purchasers i.e. retailers or as part of a regulatory eradication scheme. Appendix B outlines a list of potential diseases which can be milk screened for disease (Gilmore 2016).

6. Acknowledging on-farm roles and responsibilities

Whilst farmers have the primary responsibility for the health of their animals, it is acknowledged that there are factors, outside of their direct control which can impact on and influence animal health on farms. (NFAHS 2017-2022). Two of the major stakeholders which can impact herd health on-farm are the farmer and their vet. Effective herd health management requires three key elements (Bradley 2019).

Figure 2:
Three Key Elements Required for Effective Herd Health Management
(Source: Bradley 2019)

The strength of the relationship between the vet and the farmer is a significant predictor for participation in veterinary herd health management programs on dairy farms. Farmers who allow their vets to have access to their farm data are more likely to be more open and discuss more topics (Derks et al. 2013). Vets should always attempt to involve farmers in the decision-making process, ensuring that their decisions are aligned with the farmers own goals and aspirations (Orpin 2019). Farmers who stated that they had frequent table discussions with their vets felt they were more prepared to adopt veterinary advice. Vets should incorporate this aspect as part of their herd health management meetings with the farmers. It was also concluded that vets need to balance between providing information and giving farmers the opportunity to express their own viewpoints (Ritter et al. 2019).

To promote buy-in and adoption from vets in herd health management and specifically milk screening for disease it is critical to engage and give them a certain amount of control in the process (Atkinson 2019). On-farm testing programmes should be designed by the attending vet in consultation with the farmer to enable a bespoke programme to be developed for each individual farm. This could vary accordingly depending on i.e. biosecurity / vaccination policy on the farm, disease history and farm size. The vet plays an essential role in the transfer of data and interpretation of results from the laboratory to the farmer, this involvement can ultimately lead to an overall improvement and sustainment in herd health (Gilmore 2016).

6.1 Changing Farmer Mindset – A 'RESET' Model

The challenge exists to promote engagement and adoption by the farmer in herd health programmes and specifically milk screening for disease. In the Netherlands to successfully change farmer mindset and ensure that an overall reduction in antibiotic use a 'RESET' Model was used (Beldman 2019). The model recognised that in order to change behaviour towards antibiotics, not alone did the knowledge of farmers and vets need to improve but also their mindset toward the subject. Two requirements had to be fulfilled, to understand the optimal behaviour and to ensure that a person was motivated enough to implement this behaviour.

Five important cues to actions were formulated: Rules, Education, Social Pressure, Economics and Tools. People can be motivated to change their behaviour based on one or more of these cues. The adoption of the RESET model demonstrated that through using multiple communication strategies peoples' motivation and ingrained behaviour patterns could be changed (Lam et al. 2017).

Table 2: The most important simultaneous RESET actions taken by involved stakeholders to decrease antibiotic usage in dairy cattle in the Netherlands

Rules	Education	Social Pressure	Economics	Tools
One-to-one relationship dairy farmer and vet No preventive antibiotic usage (no bDCT) Herd health plan Transparency on antibiotic usage Limitations on use of specific antibiotics Action plan when antibiotic usage too high	Publications in scientific and farmer journals Press releases Guidelines on antibiotic usage Specific courses for veterinarians on herd health plans Study groups on antibiotic usage for farmers Lectures, meetings, symposia	Public opinion on responsibility towards human health Initiation of the 'antibiotic number' DDDA Benchmark on DDDA for farmers and veterinarians - Discussions on alternative (preventive) approaches with different herd health advisors	Costs of dry cow antibiotics Imminent threat of sanctions when failing to commit - Indirect threat of losing customer trust, national and international	Herd health and treatment plan Medi-Rund Standard treatment protocols Colour codes for passing signalling and action thresholds on antibiotic usage Setting signalling and actions thresholds on antibiotic usage

(Lam et al. 2017 cited in Armstrong et al. 2018)

In order to elicit change the Health Belief Model (Rosenstock 1974; Janz and Becker 1984 cited in Ritter et al. 2016) can be used. It is important for the farmer to perceive the threat of disease on the farm and in order to be proactive the farmer must believe in the proposed management solutions (Ritter et al. 2016).

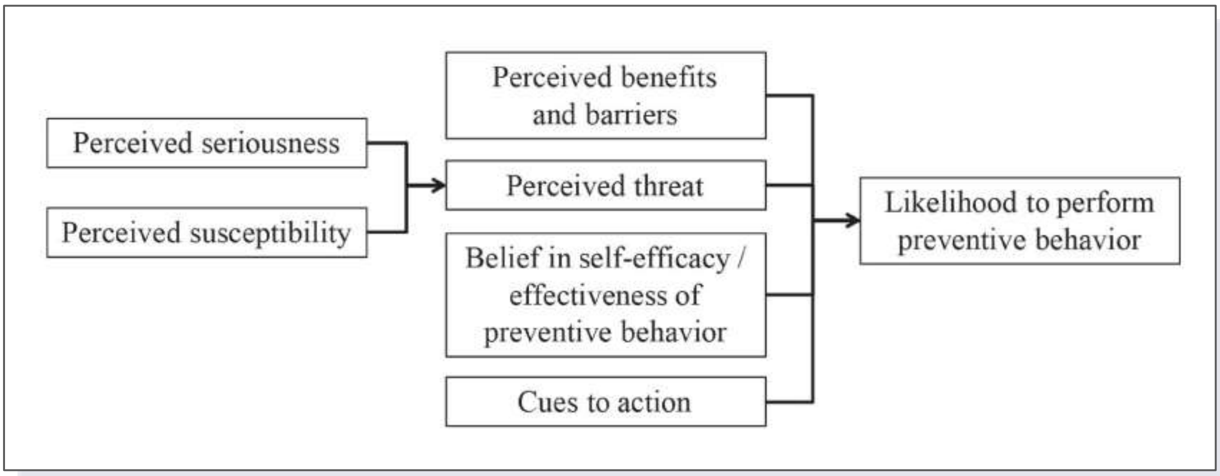


Figure 3: Psychological framework of the Health Belief Model
(adapted Ritter et al. 2016).

6.2 Case Study: Healthy Partners

Traditionally the relationship that existed between farmer and vet was one of reactive veterinary care whereby the vet's income predominantly came from the treatment of sick animals. Utrecht University in collaboration with 'Courage' set out to change this and an innovative project 'Healthy Partners' was developed. The objective of the initiative was to see an overall improvement in animal health and welfare and an increase in the social appreciation of the sector (Hooijer 2019).

Together the farmer and vet set specific targets, for example improvement in udder health and somatic cell count. If the goal was reached the vet gets 100% of their visit and advisory costs. If the target is not achieved the vet would only get two-thirds of their costs.

This co-operation between farmer and vet can guarantee that the vet has more of a vested interest in the farm and this shared responsibility can lead to an improvement in herd health. What is critical to fostering this relationship is that the vet takes part in round table discussions, is a key partner in decision making and recognised as part of the team. Marten Knol a farmer who is a major advocate of 'Healthy Partners' experienced a decrease in new udder infections going from 10% to 5% and through monthly meetings collectively Marten and his vet decided and agreed new targets and key performance indicators to work on (Knol 2019).

6.3 Case Study: The Danish Model

The social norm and culture of Denmark is to eradicate and control disease with this long tradition associated originally with bovine tuberculosis and brucellosis which were eradicated in Denmark in the mid-1900's so called 'The Danish Model'. Denmark has also successfully eradiated IBR, Bluetongue and BVD. Eradication programmes are ongoing for Salmonella Dublin and a voluntary programme is in place for Paratuberculosis (Rattenborg 2019).

All dairy herds which have greater than 100 cows must have a mandatory health consultancy agreement – Veterinary Advisory Service Contracts (VASC'S). This business model is based around routine visits and herd health monitoring. Depending on herd size there are different frequencies of veterinary visit, options and responsibilities expected of the farmer and the vet. This model enables one-to-one relationship building between the farmer and the vet. Legalisation in Denmark states that a vet can only make a handling charge on antibiotics and they are only authorised to supply or prescribe antimicrobials for farmer administration for up to 5 days, if extra treatment is necessary a revisit must occur. All herds must focus on animal welfare twice a year (Armstrong et al. 2018).

One visit must incorporate a biosecurity plan, within this the farmer and vet must identify areas for improvement and implement action points accordingly (Pederson 2019). The most important aims of the VASC are to focus on advice and prevention of illness rather than treatment, to optimize the use of antimicrobials in order to minimize AMR and to improve animal welfare (Danish Veterinary and Food Administration 2018).

7. Adding Value to the Dairy Industry

To optimise outcomes for farmers and the relevant sectors within agri-business there is an absolute need for all players to work in partnership towards delivery of an overall outcome which best serves the industry (NFAHS 2017-2022). Milk Purchasers and the supply chain have considerable influence – either through incentivising better health on supply farms or imposing tighter requirements on the less performing farms. Some companies are particularly pro-active in initiating education and knowledge exchange programmes for farmers that aid to increase biosecurity, improve animal health and welfare and enable an overall reduction in antibiotic use (Armstrong 2019). Equally farmers can source support from government or other stakeholder groups i.e. levy boards, pedigree associations etc. which can engage the whole sector in disease control and send out clear, concise and consistent messages to the industry and general public (Wapenaar et al.2017).

The drive to improve technical efficiency, while producing safe, healthy wholesome food for which the consumer is willing to pay a premium price, has driven the retail and processor groups particularly in the United Kingdom to take a robust interest in animal production, health and welfare (Orpin & Sibley 2018). The challenge sometimes for milk processers is they need to be customer and farmer facing and it is important to get the balance correct and within this it is vital that the farmer understands that the milk processor is not the enemy (Hampton 2019).

One key area of interest has been Johne's disease within the dairy sector, not least due the potential human-health issues. This has led to the creation of the UK National Johne's Management Plan (NJMP) with a clear focus to reduce the incidence of the disease nationally (Oprin & Sibley 2018). Equally through the introduction of 'Johne's-free' milk certification scheme this can counteract potential demand and losses from an infected herd (Barratt et al. 2018).

Different attitudes to the NJMP are apparent with some niche suppliers with export contracts driving the initiatives, with some demanding 100% compliance for the farmers contract to be retained. 74% of milk processors engaged with the NJMP plan committed to ensure their member farms complied by 31st Oct 2018 (Orpin & Sibley 2018). Since October 2019 the need to comply with the NJMP has been incorporated into the Red Tractor standards and it is expected by end of 2020 95% of national milk suppliers will be on board (Oprin 2019).

Red Tractor is one of the UK's largest food standards scheme which covers animal welfare, food safety, traceability and environmental protection. Independent assessors' complete yearly audits with over 46,000 British farmer members. In October 2019 Red tractor revised its standard whereby it is now mandatory that a Livestock Health Plan is written in conjunction with the farm vet and the farmer must demonstrate that health and welfare is proactively established and implemented on the farm. The farmer must demonstrate how they are managing disease risk posed by Johne's and BVD. The NJMP and appropriate disease strategy must be implemented on the farm with a declaration signed and completed by a British Cattle Veterinary Association accredited Johne's Veterinary Advisor. BVD must be managed through a BVD eradication programme designed also in conjunction with the farm vet. This must include participation in national schemes such as BVD Free England, Scottish BVD Eradication Scheme or be a member of CHeCS accredited scheme (Red Tractor 2019).

Tesco one of the largest retailer groups has made quarterly individual milk testing for Johne's compulsory (Atkinson 2019). Quarterly bulk milk testing for BVD using PCR, IBR and Leptospirosis are also mandatory whereby the farmer is advised to review test results and their action plan with their vet (Graham-Brown 2019). The Evidence Group is a specialist veterinary consultancy company within the UK, and they manage Sainsbury's and Arla 360 portfolios. Each year an Evidence Group veterinary consultant will visit the Sainsbury's supplier farm and conduct an audit with herd health being of huge importance. Before the visit the consultant will have access and visibility of the farm's animal health data. A condition of purchase is the supplier must be completing quarterly bulk milk screening for disease for IBR, Leptospirosis, Neospora and involved in the NJMP programme and be part of a national BVD eradication scheme. The Evidence Group consultant invites the farmer's local vet to the audit, this is generally not seen as a threat to the local vet but can help endorse the local vet. Both vets generally have the same consistent message to the farmer which can reinforce the health goals and objectives for the farm. The cost of the Evidence group audit is covered by Sainsbury's and Arla (Burgess 2019).

7.1 Case Study: CHeCS scheme

Cattle Health Certification Standards UK (CHeCS) is the regulatory body for cattle health schemes in the UK and Ireland. It is a non-trading organisation established by the British cattle industry for the control and eradication of diseases. CHeCS aim is to identify herds free from certain diseases and offer control programmes for herds which have identified disease. CHeCS is a stamp of approval and quality mark signifying conformity to an industry standard.

CHeCS can be used as a framework for routine monitoring, for disease reduction, disease eradication and certification of freedom from diseases. Programmes exist for the five most important non-statutory diseases - IBR, Leptospirosis, Johne's disease, BVD and Neospora. Monitoring can be limited to quarterly bulk milk antibody testing while herds can achieve elite status by reaching Level 1 for Johne's disease and being accredited free for BVD, IBR and Leptospirosis.

Completion of a health plan is compulsory for the Neospora and Johne's programme. Herd owners are advised to consider a herd health visit by their own vet to discuss the interpretation of results and future plan for the herd. There is no mandatory requirement for biosecurity, but all farmers are advised to have an active biosecurity plan in place (CHeCS 2018a).

A survey stated that vets remain the biggest driver of scheme awareness and uptake. 45% of participants joined the CHeCS scheme to obtain official accreditation with another 45% joining for a combination of reasons relating to improvement in herd health, getting targeted advice, obtaining access to testing protocols and saving money on testing. There was a definite bias towards membership from pedigree herds with dairy herds potentially less clear about the benefits involved (CHeCS 2018b).

The farmer pays the cost of the Premium Cattle Health Schemes and through disease status being displayed in sales cards, markets etc. this is where the farmer can see the value and return on investment. Disease status is also visible on the CHeCS database (McDiarmid 2019).

Figure 4: The author with Julie McDiarmid & the team at CHeCS, St Boswells, Oct 2019

7.2 Case Study: Friesland Campina

Friesland Campina is owned by a cooperative of member dairy farmers in the Netherlands, Germany and Belgium who supply the organisation with their milk. The cooperative and organisation have made agreements on the quality, safety and sustainability criteria which dairy farmers must meet. These agreements are set out in Foqus Planet – 'Quality and Safety from Grass to Glass'. In Friesland Campina the farmer can choose between three types on animal health checks on farm, this is a compulsory condition of purchase.

1. Four Periodic Visits – the farmers' own vet visits the farm in four pre-indicated months. The health of the dairy cows is examined including body condition score. If a certain percentage of cows require special attention a veterinary check must be completed
2. Continuous Animal Health Monitoring – This is based on available data on animal health such as mortality, animal health status for Johne's, BVD, Salmonella etc., milk recording information like somatic cell count, new udder infections etc. The farmer is benchmarked against the province and national average - this can motivate the farmer to improve. Two vet visits are obligatory in the scheme
3. Cow Compass – During two vet visits, the farmer and the vet make an analysis using the Cow Compass instrument. This measures the health and welfare of the dairy cows and can provide insight into the steps which need to be taken to optimise health and welfare of the herd.

If either of the animal health checks do not meet the required standards and no improvement is made after completion of the animal health check then Friesland Campina will not collect milk from that farm. The farmer must compile an Animal Health and Treatment plan in consultation with the vet, this is evaluated on an annual basis. A calf rearing quality score system – KalfOK also exists, this was developed to evaluate and monitor the quality of young stock rearing on the farm and provides guidance where rearing management might need to be adapted to lead to an improvement in calf and young stock health (Friesland Campina 2020).

One critical component necessary to manage and oversee the different components of the animal health checks and plans is a central data point which can bring all the systems together. This is one area which Friesland Campina want to focus on – ideally a database which could signify "Cow Alerts" to indicate where breaches of standards have occurred (Kock 2019).

One of Friesland Campina unique selling points is that it has always focused on and prioritised animal health and welfare, this strategy has added value to the brand particularly in relation to its export market. A zero-tolerance attitude is evident whereby Friesland Campina will not accept milk from IBR, BVD and Johne's positive herds (Keurentjes 2019). GD Deventer complete the bulk milk screening for Friesland Campina suppliers. GD Deventer mindset is to not continue to test positive samples, but the farmer must step up and take responsibility and demonstrate disease free status themselves (Van Duijn 2019).

Figure 5: The author with Petra Kock, Friesland Campina & Anouk Veldhuis GD Deventer April 2019

7.3 Case Study: Thise Dairies

Thise
DAIRY WITH PASSION

Thise is a Danish organic co-operative which was founded in 1988. Thise working in collaboration with their farmers have successfully eradicated Johne's disease. A control programme was designed on each farm with the assistance of a Thise representative and Thise paying for the cost of the individual milk screening test. Working in groups with other farmers within the same area, the farmers met regularly to trouble – shoot and discuss progress with disease eradication. Any 'Red' (infected) cows were culled and once Johne's disease was eradicated on the farm the producer was paid a bonus for their milk (Bonde 2019).

Working with a group of like-minded individuals and the co-operative mindset has acted as catalyst to further promote engagement and buy in into the programme (Bonde 2019). Having successful adopted the protocols and management strategy to eradicate Johne's disease most farmers have made significant progress on the eradication of Salmonella Dublin, with the risk factors being quite similar for the two diseases particularly in relation to colostrum / housing / biosecurity (Tvistholm 2019).

Figure 6: The author with Erling Bonde and Betina Tvistholm (Seges) on Erling's farm Denmark October 2019

8. Efficient Capture and Use of Data

To inform decisions regarding disease priorities and suitable control programs and to allow for monitoring of disease trends over time reliable and up to date information on disease prevalence is highly desirable (Velasova et al. 2017). Vets have been major contributors to the development of farm dairy data management and herd analytic software. The ability to integrate and analyse farm-specific data has led to the earlier detection of health problems, however standardised, valid and systemically recorded health data at herd level can be non-existent. More streamlined data capture and better incentives for producers may be necessary so that data can be recorded faithfully and accurately. The optimum strategies for collection, interpretation and application for this data is still being developed and when it happens it will be a significant contributor to improvement in preventative health management (Le Blanc et al. 2006).

Effective herd health management requires three elements, one being “Good (Consistent) Data”. Keeping good farm records is crucial and software has been developed which can tabulate, store and disseminate all relevant data into an integrated reporting system which can minimise time wasted in collation and formatting of reports. Once such software system is ‘Total Vet’ which is dairy herd data analysis software which is designed to be used by vets and consultants who have an interest in herd health. Electronic data is accepted from a variety of on-farm and central databases, this data is rapidly and consistently analysed while providing ongoing monitoring of herd health and production. The system is designed to infer errors and identify outliers which can then be flagged to the vet whereby further investigation and examination may be necessary. The vet purchases the software and the farmer owns the data and what is essential is that the vet and farmer sit down together and review results etc. so they can formulate specific herd health and actions plans accordingly (Bradley 2019).

Another user-friendly, web-based system is Sheep and Suckler Cow, Animal Health Planning System (SAHPS). This health planning system has been funded by the Scottish Government and created by Scotland’s Rural College (SRUC). A concise yet comprehensive health plan can be developed. The system enables the vet and the farmer to manage herd health and production in real time as the system gets updated when production and disease data becomes available. Production and disease data can be compared year and year while also benchmarking similar enterprises locally and nationally. The farmer can view and update a calendar of events i.e. planned vaccine / dosing regimes etc. Uptake for the system has been quite low at less than 20% so now SRUC is developing an App so they hope that this will boost engagement and participation in the scheme (Manolaraki 2019).

In 1998 Irish industry had a vision to increase farm profitability through genetics and data integration. It established Irish Cattle Breeding Federation (ICBF) as a non-profit 'industry good' organisation to increase the rate of genetic gain in the national herd and to remove duplication in record keeping for both farmers and industry. This has resulted in one of the most integrated animal databases in the world and the emergence of Ireland as a global leader in animal genetics. It is an independent, farmer led organisation providing services to Irish farmers and industry. Its shareholders consist of farmers, milk recording, artificial insemination (AI) and herd book organisations.

The flow of data to and from this national database represents data acquired from milk recording, AI companies, milk co-operatives, genomic laboratories, vet labs, marts and animal identification and movements. This database has the capability to hold information on practically all animals registered nationally and the team have a heavy technical focus covering information technology, genetic evaluation skills and agricultural science. Information services are provided back to the farmers and the industry and now the farmer can access data from within the database relating to participation and results from the national BVD eradication and Johne's Control Programme.

8.1 Case Study: Danish Cattle Database

The Danish Cattle Database is a central database of all cattle in Denmark. It is managed by Seges, a private non-profit advisory, test and research association owned by 30,000 Danish farmers. The organisation collects huge volumes of data from farmers across the country covering everything from crop and livestock production, environment and climate, to accounting and financial expenditure. The farmer is the owner of the data in the cattle database and the farmer legalizes vets, livestock and breeding consultants, hoof trimmers, dairy factories, abattoirs etc. to access and use the data (Seges).

Within the database milk screening requests are entered, this could be Salmonella Dublin milk screening samples. If the farmer is involved in an eradication programme the sample request will be generated automatically but the farmer and advisory have the option within the database to request extra bulk or individual cow samples. All antibody testing results are entered into the database and the farmer and vet can view current and historic test results and visualise if antibody levels have increased or decreased within the last test period. Milk recording data and milk quality assessment information i.e. fats, proteins, somatic cell counts, bacterial counts are all stored within the database. (Nielsen et la. 2006)

Regarding cattle movements if a farmer wishes to move or sell a cow it is compulsory that she is tested for Johne's and the results of this test are updated on the Danish Cattle Database. Here any perspective buyers can access this results and data. Knowledge sharing through other farmers, vet and artificial insemination companies has been a huge contributing factor to the overall success of the database. The cattle database is of huge asset in the overall management of the farm whereby the farmers has one central portal to base and make decisions on the overall effectiveness and profitability of the farm (Bonde 2019).

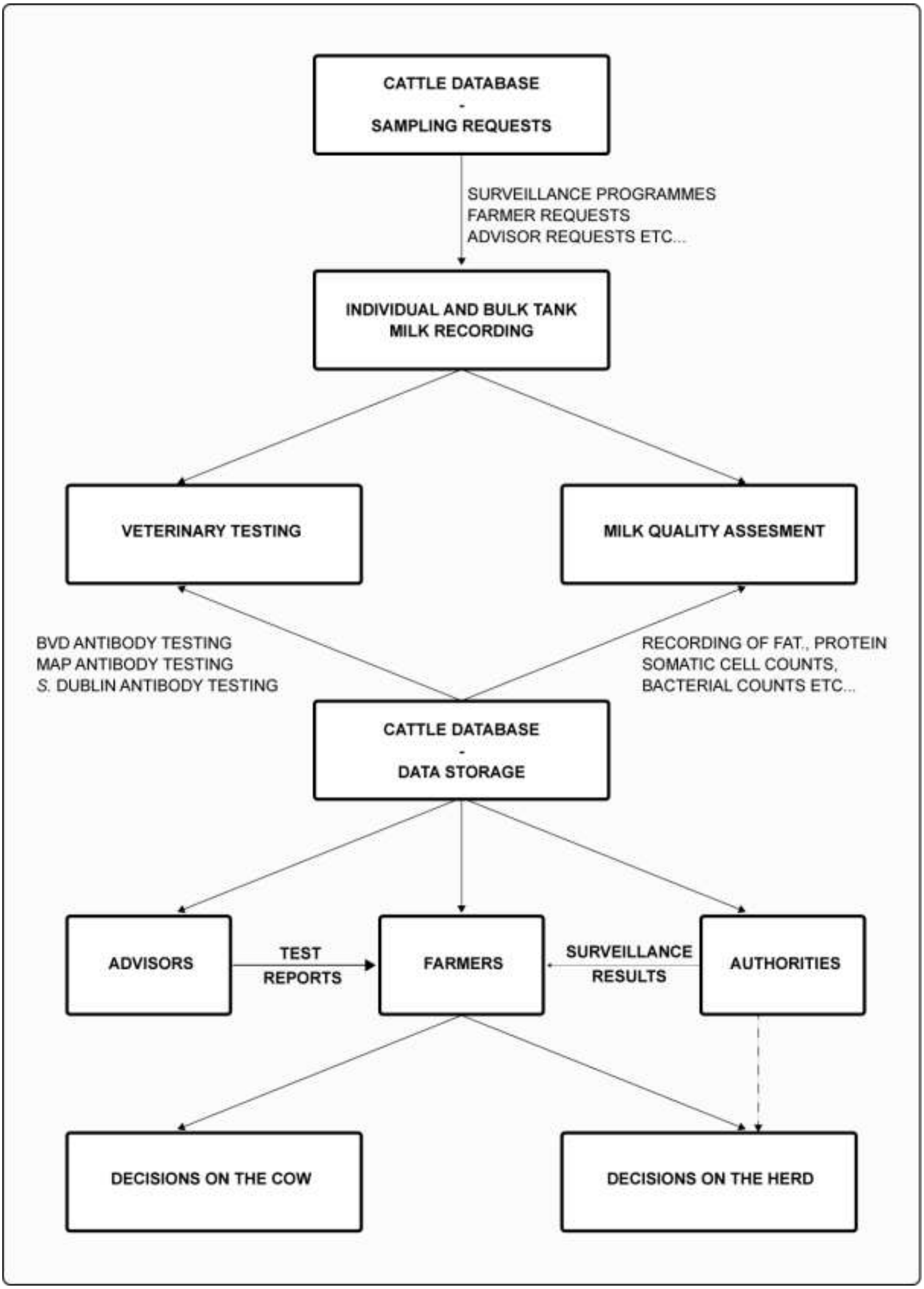


Figure 7: From Data to Decision-Chart on Selected Data flow in the Danish Cattle Database
(Source: Houe, Nielsen & Nielsen 2014)

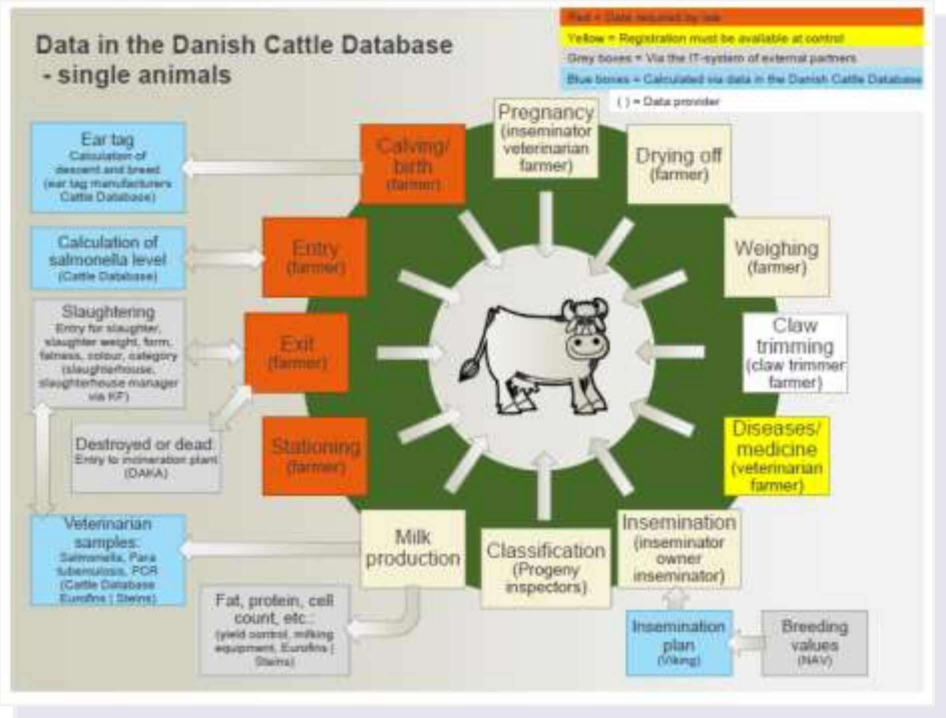


Figure 8: Single Animal Data in the Danish Cattle Base

(Source: Danish Platform for Dairy Management – Barrett, T 2014)

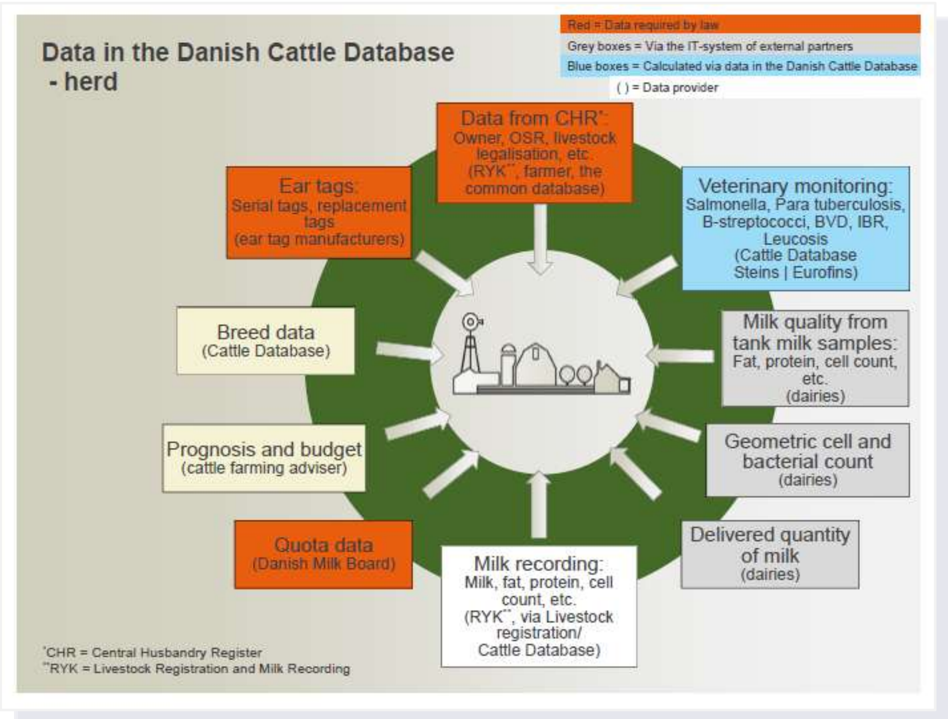


Figure 9:

Herd Data in the Danish Cattle Base

(Source: Danish Platform for Dairy Management – Barrett, T 2014)

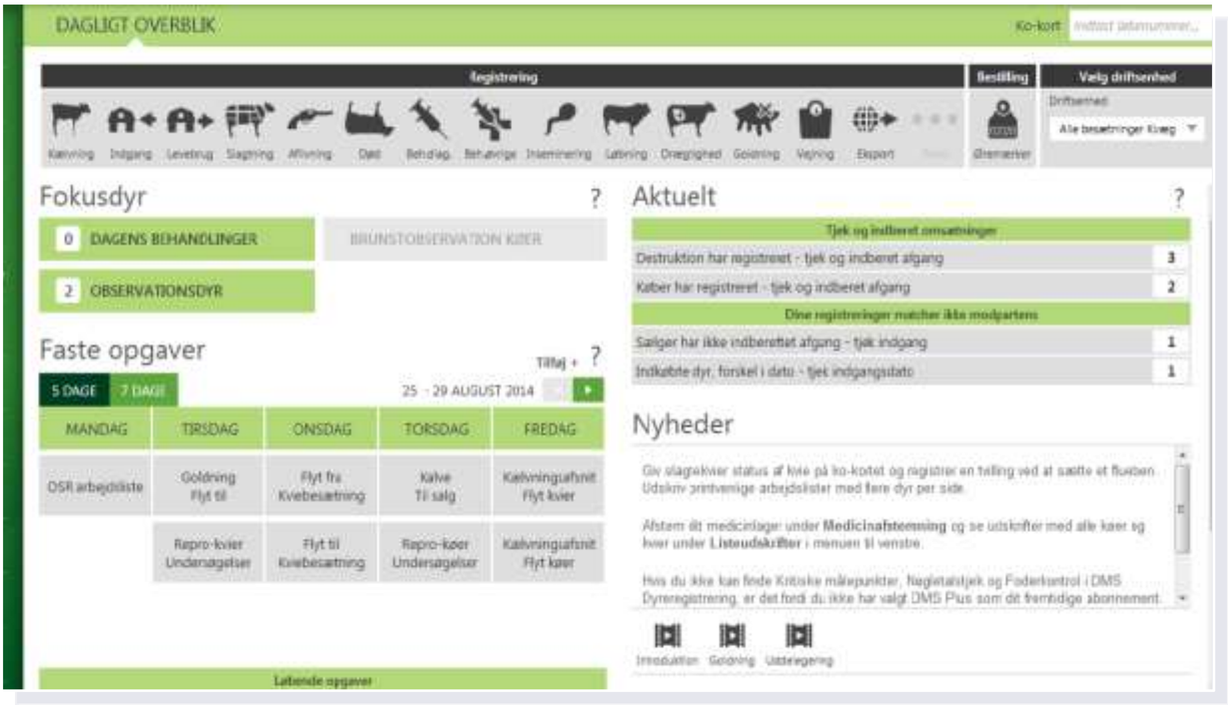


Figure 10: Danish Cattle Data Base Home Screen
(Source: Danish Platform for Dairy Management – Barrett, T 2014)

8.2 Case Study: Trend Analysis Surveillance Component (TASC)

Since 2002, a national cattle health surveillance system is in place in the Netherlands. This system combines enhanced passive reporting, diagnostic and postmortem examinations, random surveys of prevalence estimation of endemic disease and quarterly data analysis. The aim of the TASC is to monitor trends and developments in cattle health using routine census data. The key monitoring indicators that are analysed as part of the TASC all relate to cattle health and involve parameters such as mortality, fertility, udder health and antimicrobial use. The flexibility of the system allows for additional analysis to be completed especially if anomalies in trends in cattle health occur. The TASC can offer insight in the general cattle health in the Netherlands and provides information to support signals of changes in cattle health (Santman-Berends et al. 2016). The TASC is managed in a central location GD Deventer.

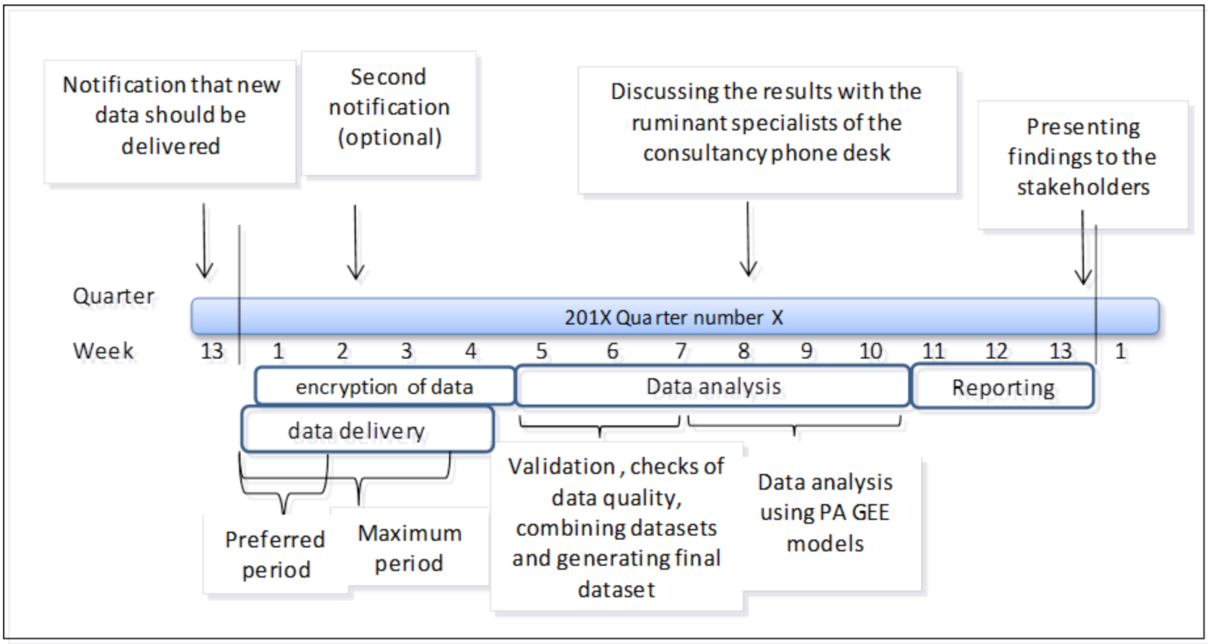


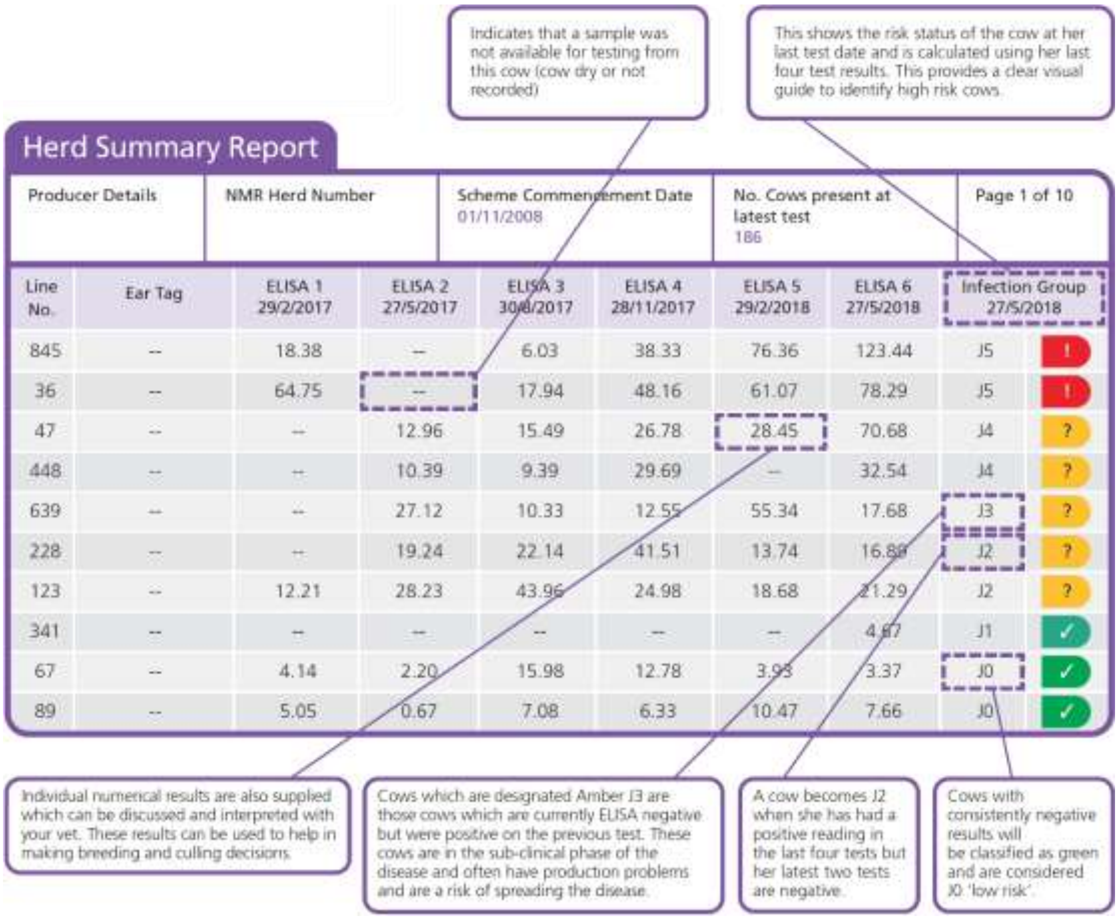
Fig 11: Overview of the process of the quarterly trend analysis surveillance component on the cattle census data
(Source: Santman-Berends et. al 2016)

The TASC is a crucial component in ensuring proactive disease monitoring and surveillance. Within the Netherlands clusters of farms with lower than expected milk yield can be quickly identified and triggers sent to GD Deventer who can then authorise further investigation where necessary. Retrospective investigation of the Bluetongue outbreak in the Netherlands in 2006 concluded that if a TASC system had been in place this would have identified the disease quicker and reduced the spread of disease. The presence of the TASC can pre-empt and contain disease outbreak (Veldhuis 2019).

9. Evidence Based Decision Support

In some way's completion of the milk screening tests can be easy but it is the interpretation and decision support of these which can be more challenging. A lot of farmers who pay for the milk testing fail to the exploit the full value of their investment (Armstrong 2019). A large amount of results can be generated with nothing being done with these results with "far too much testing done for testing sake". Once results are available these should be interpreted with agreed actions being implemented – this should involve discussion with the farmer and the vet. Younger vets can be less technophobic so this should improve interpretation and review of results (Bradley 2019).

It is vital that the test results are consolidated and put into a format which is actionable. Having easy to use, visual reports can be beneficial in the interpretation of results, something like a traffic light system or risk classification. It is important that historical results and data is available so outliers/ trends can be identified.



Line No.	Ear Tag	ELISA 1 29/2/2017	ELISA 2 27/5/2017	ELISA 3 30/8/2017	ELISA 4 28/11/2017	ELISA 5 29/2/2018	ELISA 6 27/5/2018	Infection Group 27/5/2018	
845	--	18.38	--	6.03	38.33	76.36	123.44	J5	!
36	--	64.75	--	17.94	48.16	61.07	78.29	J5	!
47	--	--	12.96	15.49	26.78	28.45	70.68	J4	?
448	--	--	10.39	9.39	29.69	--	32.54	J4	?
639	--	--	27.12	10.33	12.55	55.34	17.68	J3	?
228	--	--	19.24	22.14	41.51	13.74	16.89	J2	?
123	--	12.21	28.23	43.96	24.98	18.68	21.29	J2	?
341	--	--	--	--	--	--	4.67	J1	✓
67	--	4.14	2.20	15.98	12.78	3.93	3.37	J0	✓
89	--	5.05	0.67	7.08	6.33	10.47	7.66	J0	✓

Figure 12: Example of Herd Summary Report Utilised on NMR / Herdwise for National Johne's Programme
(Source: Kind permission Watson 2019)

Risk Classification Table

Risk level	HerdWise classification	Johne's infection group	Definition	Infection status
LOW	Green	J0	Repeat ELISA negative – minimum two tests.	**Low risk** - no evidence of infection.
	Green	J1	ELISA negative - one test only.	
HIGH	Amber	J2	ELISA negative but positive within previous three tests.	**Moderate risk** - evidence of infection and may be shedding MAP. Should be managed as a risk for calving and milk/colostrum.
	Amber	J3	ELISA negative but positive on previous test.	
	Amber	J4	ELISA positive – first positive test.	
	Red	J5	Repeat ELISA positive - minimum two tests. **Two or more positive results in any four consecutive tests at any time in individual cow test history.**	**High risk** - evidence of infection and highly likely to be shedding MAP (i.e. high level of infectivity).

Figure 13: Risk Classification Table utilised on NMR / Herdwise for National Johne's Programme
(Source: Kind permission Watson 2019)

Being pre-armed with data can aid decision making but it is also important for the vet to spend time on the farm engaging with the farmer (Watson 2019). The correct information must be captured pre-milk testing, this should include vaccination status at a minimum. A multi-disease report can be overwhelming so it might be more beneficial to concentrate on three or four endemic diseases (Orpin 2019). Results generated is just a monitoring tool which provides evidence and information on what pathogens / antibody levels which are present within the herd. This information should enable the farmer and vet to develop a herd specific health plan on the farm. It is vital to get vets on board and it may be necessary to offer them continuous professional development (CPD) so they can see value in the testing. To further capitalise on the diagnostic results - these could be interlinked to a dosing / vaccination calendar which would be a beneficial tool for the farmer (Williams 2019). There is merit in being more proactive in the use of economics in generating data and information on burdens and costs associated with disease, this could aid decision making (Rushton 2016).

9.1 Case Study: My Healthy Herd

myhealthyherd

In 2007 a web-based health management program My Healthy Herd was launched in the UK by Pete Orpin and Dick Sibley. The program measures and analyses disease specific risks using algorithms to create a traffic-light system of categorisation and then ranks individual risks to enable prioritisation of control. A prevalence – prediction tool has been added which allows current test prevalence to be converted to a predicted true herd prevalence to drive further engagement. Testing alone does not cure disease so testing without regard to biosecurity, biocontainment and resilience can fail to control disease like Johne's etc. (Oprin & Sibley 2018)

Figure 14: My Healthy Herd.com Overview Screen
(Kind Permission Oprin 2019)

Figure 15: Disease Manager Framework My Healthy Herd.com
(Kind Permission Oprin 2019)

Figure 16: Disease Prevalence & Biosecurity Risk Screen My Healthy Herd.com
(Kind Permission Oprin 2019)

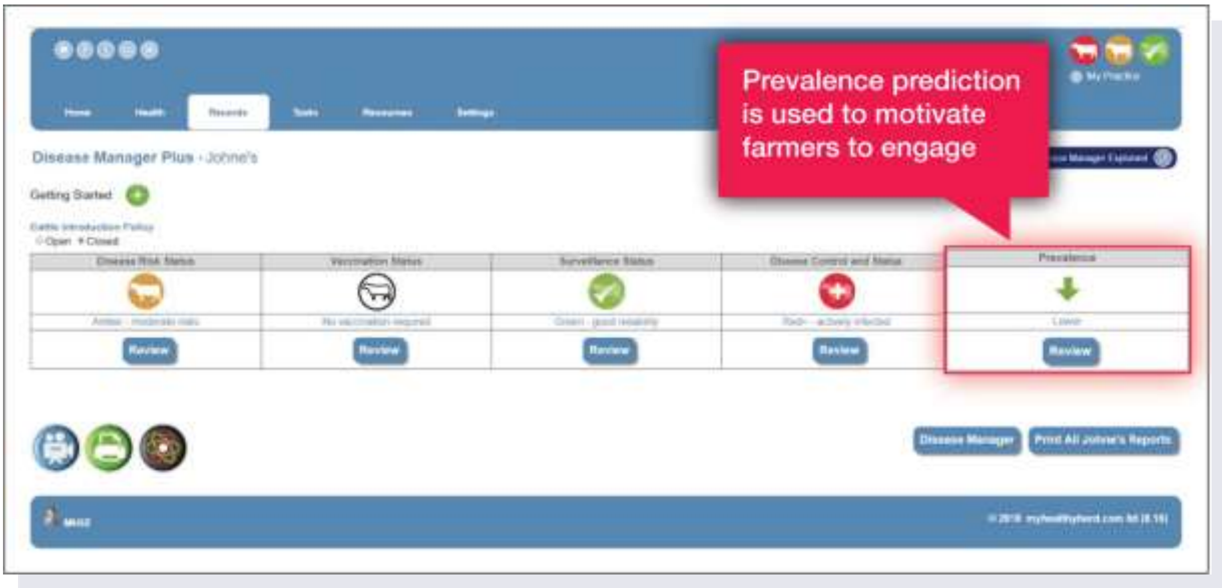


Figure 17: Disease Prevalence and Risk for Johne's Screen My Healthy Herd.com
(Kind Permission Oprin 2019)

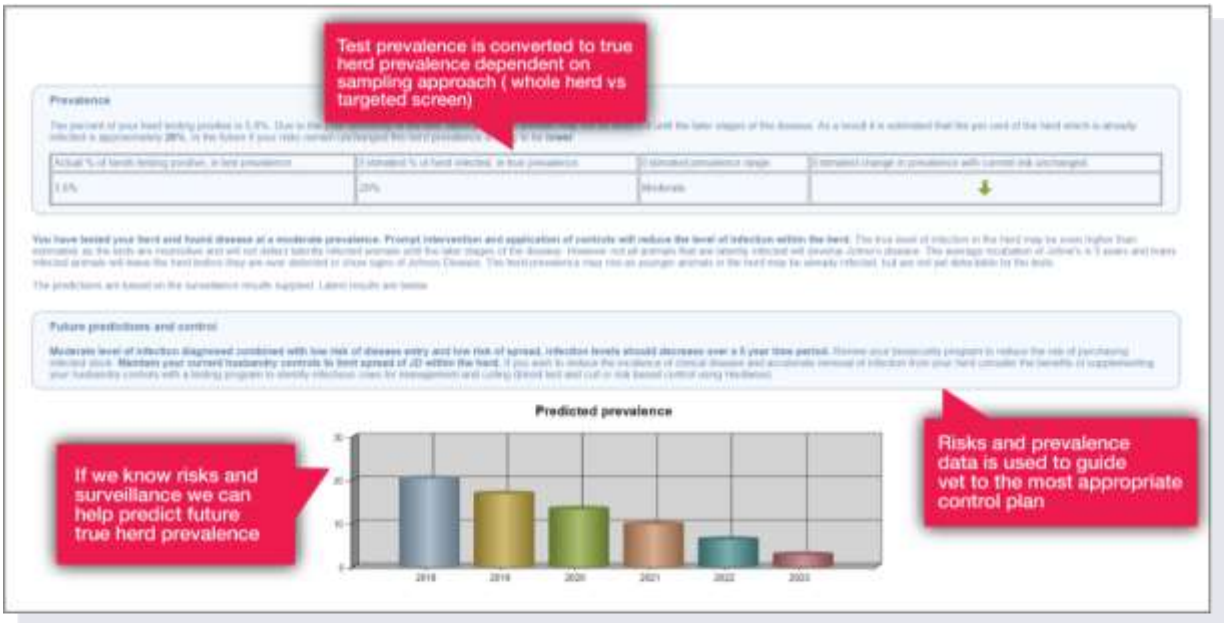
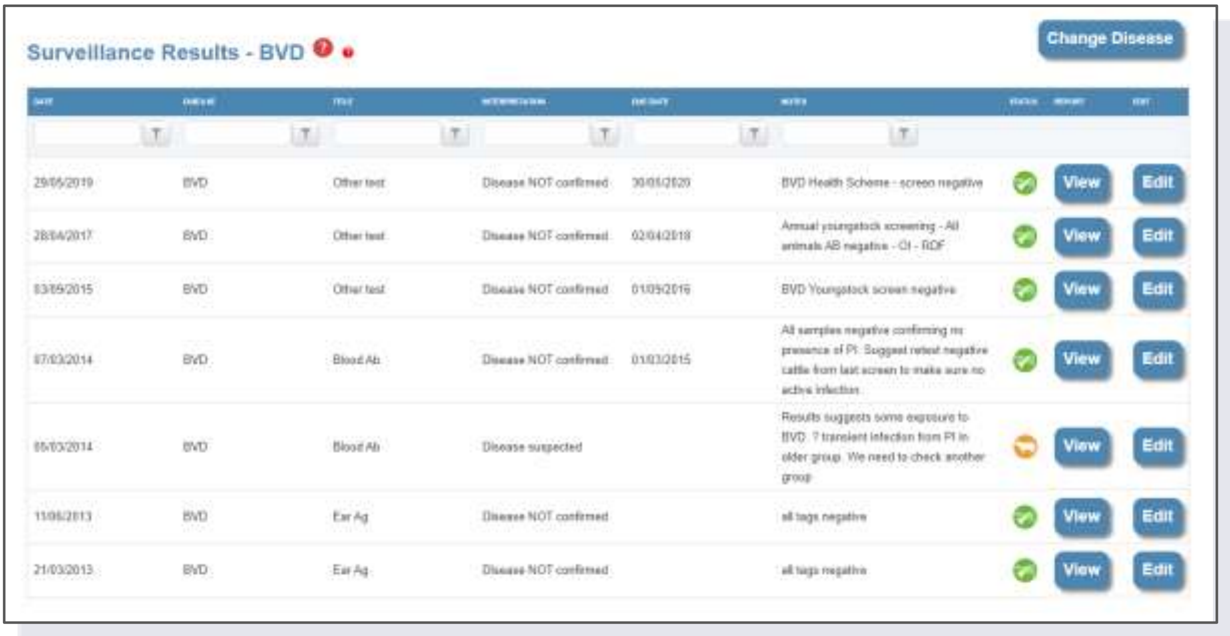


Figure 18: Predicted Prevalence Screen My Healthy Herd.com
(Kind Permission Oprin 2019)



29/05/2019	BVD	Other test	Disease NOT confirmed	30/05/2020	BVD Health Scheme - screen negative		View	Edit
28/04/2017	BVD	Other test	Disease NOT confirmed	02/04/2018	Annual youngstock screening - All animals AB negative - OI - RDF		View	Edit
03/09/2015	BVD	Other test	Disease NOT confirmed	01/09/2016	BVD Youngstock screen negative		View	Edit
07/03/2014	BVD	Blood Ab	Disease NOT confirmed	01/03/2015	All samples negative confirming no presence of PI. Suggest retest negative cattle from last screen to make sure no active infection		View	Edit
05/03/2014	BVD	Blood Ab	Disease suspected		Results suggests some exposure to BVD. ? transient infection from PI in older group. We need to check another group		View	Edit
11/06/2013	BVD	Ear Ag	Disease NOT confirmed		all tags negative		View	Edit
21/03/2013	BVD	Ear Ag	Disease NOT confirmed		all tags negative		View	Edit

Figure 19: Overview BVD Surveillance Results My Healthy Herd.com
(Kind Permission Orpin 2019)

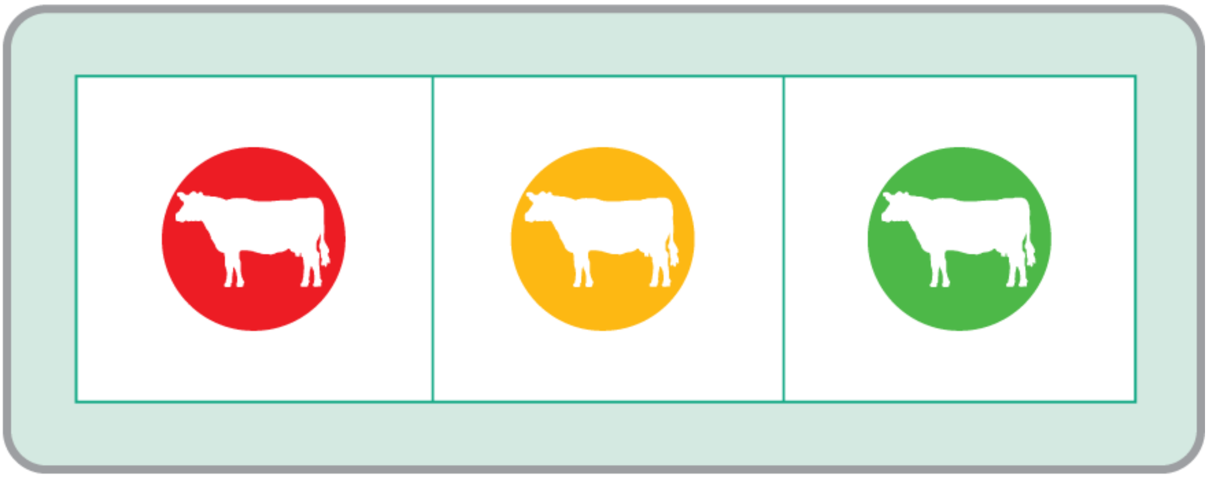
This system allows vets, farmers and monitoring organisation to create and share dynamic health programs. The vet purchases the program from My Healthy Herd with the farmer controlling the permission and linking it to their vet practice. Some restrictions apply on certain aspects of the programme which have vet access only. The milk and serum laboratory test results are uploaded on the system, but the vet must include the clinical assessment of results before the farmer can access these. The system allows for both a lab interpretation i.e. positive, inconclusive or negative but also allows for the vet to clinically interpret this result within the context of the herd.

This allows for instance for a herd with a positive bulk milk result for a disease such as BVD to be assigned a 'No Disease Present' assignation based on further tests demonstrating the absence of the disease.

The risk assessment is completed by the farmer and the vet with the system generating control strategies required. The vet would have received specific training of completion of the risk assessment. The farmer can choose one of the six control strategies which can be printed with individual task assigned. Generally, three-four key actions are agreed but this would be designed to match the aspirations, resources and needs of the farmer (Orpin 2019).

Figure 20: The author with Pete Orpin in Pete's Garden, Leicester UK September 2019

9.2 Case Study: Operation Paratuberculosis



The Danish eradication and control program for Johne's disease Operation Paratuberculosis has been running in a voluntary basis since 2006 and is currently managed by Seges. Once a farmer is signed up, individual milk samples are automatically collected four times a year. The results are transferred to the Danish Cattle Database and are immediately made available electronically to the farmer and to the advisors which have been granted access i.e. the vet. The testing system is relatively robust as results are achieved four times a year (Nielsen 2009). Care should be practised in the decisions based on the test result, because not all cattle with a positive test results could be diseased, either due to false-positive reactions or infections that never result in evident disease. However, test positive animals are in general a greater risk for transmission of the pathogen than are negative animals. The positive animals should be managed so that the risk of transmission is eliminated or reduced.

Specific risks are addressed depending on the possibilities. In relation to calving:

- 'Red' cows – should be culled prior to next calving and should not be allowed near the calving area
- 'Yellow' cows – can calve, calving pens should be cleaned after each calving and the calves born should be removed immediately. Any calf born from a 'yellow' cow and if the calf is to remain in the herd it should be isolated from other calves which will remain in the herd for more than one year

- ‘Green’ cows – are regarded as test-negative cows, on the test date they are non-infectious and are therefore considered low risk cows. These can calve with other ‘green’ cows and preferably not with ‘yellow’ cows
- Regarding milk feeding, any colostrum should not be used from ‘red’ or ‘yellow’ cows but can be used from ‘green’ cows.

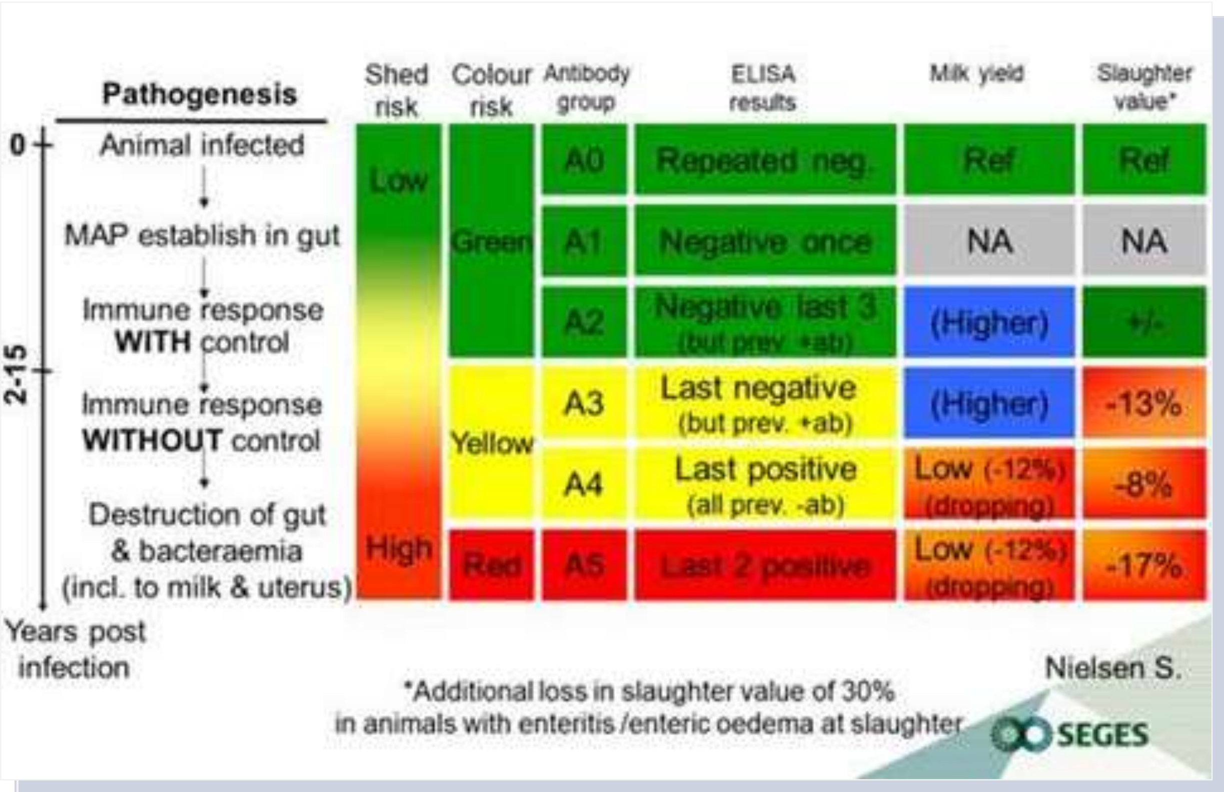


Figure 21: Operation Paratuberculosis Risk Categorisation
(Source: Nielsen given by kind permission Pederson 2019, Seges)

Although ‘red’ cows are suggested to be culled, a specific culling strategy is recommended for each farm dependent on level in antibody ELISA test, deviations in milk yield, diarrhoea, high SCC, within herd prevalence of ‘red’ and ‘yellow’ cows and other factors such as lameness, age and performance in general (Nielsen 2007).

Potential deficiencies exist with using ELISA to detect Johne’s disease antibodies in milk. Chronicity of the infection associated with varying sequences of immune response and shedding of the organism on the course of the infection can complicate diagnosis. The sensitivity of the test is not optimal until cows are in the second or third parity due to the chronic nature of the disease and the time taken for an immune response to develop. Changes may also occur across lactation because the infected cow concentrates antibodies at certain times in lactation (Nielsen 2002 cited in Hanks et al. 2014). There is no recommendation to do confirmatory testing with faecal culture, but some farmers may opt to choose to do this (Nielsen et.al 2006).

By January 2016, about 25% of dairy herds were enrolled in the programme covering 29% of dairy cows in Denmark. In 2019, 20% of herd covering 22% of dairy cows were enrolled in the programme with the governments objective to get 50% dairy herds involved (Pederson 2019). A survey was completed with farmers in 2015 with two main reasons given for leaving the programme - poor economy and very low prevalence of Johne's disease. Based on these findings a recognised need for adjustments to the existing program had to occur, both in terms of making it more cost effective to participate and providing farmers with very low prevalence the right incentives to stay enrolled (Pedersen et al. 2016). A Dynamic programme is being developed which is like a monitoring strategy. Less tests are required but the farmer can still get an overview on the disease and can specify extra tests in the high-risk period – pre-calving. The number of tests required can be cascaded up or down accordingly and appropriate action can be quickly taken if results start to increase i.e. improvement in biosecurity. Through the development of the Dynamic programme Seges feels that it can keep oversight and surveillance of the disease and this can keep more farmers engaged within the programme. Through completion of a risk assessment this can determine the herd test schedule required (Pedersen 2019).

9.3 Case Study: Cow Compass

Cow Compass is a system that involves evaluation of the risk factors for milk production, such as milk process, feeding and water, housing and husbandry, animal welfare, animal health routines and young stock. It originates from projects on farm level into quality systems on dairy farms. Studies were carried out by Utrecht university into hazard management and quality assurance on dairy farms and it was concluded that process control and product control according to Hazard Analysis Critical Control Points (HACCP) concept could provide opportunities to preventative health action and risk management. The objective was to develop practical tools that could support farmers and vets in analysing risk factors for the milk production process on dairy farms. The Cow Compass is a dynamic system for monitoring several farm management issues with a central role for the local vet, who must be certified to conduct the analysis to advise the farmer accordingly. This septagram is a very informative way of showing the results.

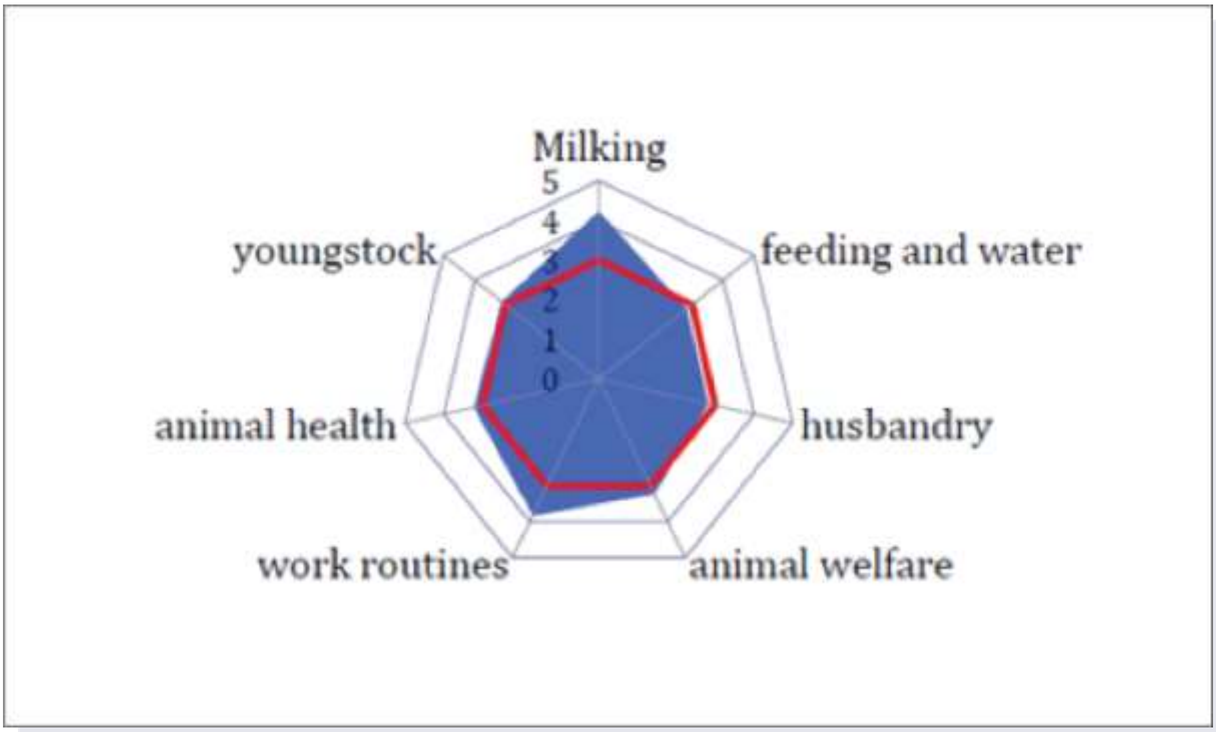


Figure 22: Example of a Cow Compass Report, the line represents a medium risk level, the more a blue surface the less risks were determined in the milk production process
(Source: Cow Compass Hooijer 2015)

For the dairy industry it provides a substantial advantage to ensure less hazardous milk production and for the farmer economic profits may increase due to an improvement in animal health and welfare (Hooijer 2015). Friesland Campina suppliers can use the Cow Compass as one of the three mandatory health checks on farm (Kock 2019). Feedback from farmers is that reporting style is very visual, unbiased and can provide clear insight into the two or three areas that the farm is performing poor on and what areas need improvement (Mensink 2019).

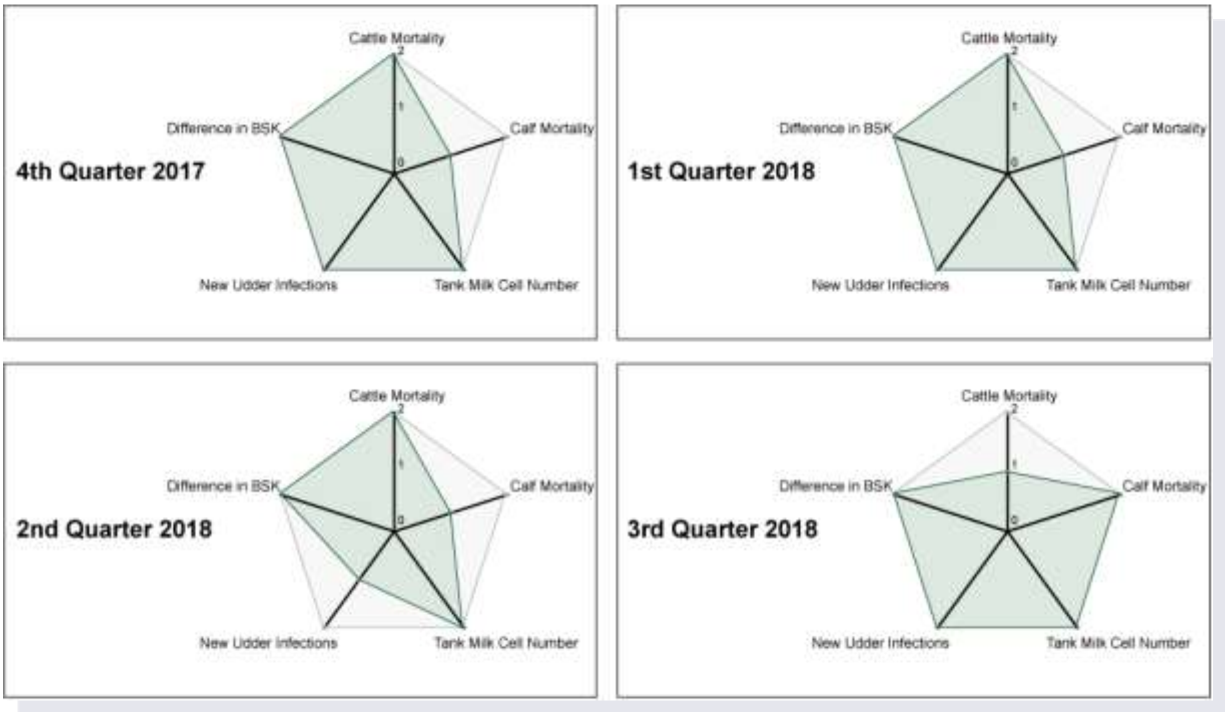


Figure 23: Example of Cow Compass format within Continuous Animal Health Monitor for Friesland Campina Supplier (Anonymous 2019)

10. Future Direction of Milk and Animal Health Screening

In recent advances the mid-infrared (MIR) analysis of milk performed within milk recording can deliver more information than used traditionally. Beside the established milk recording parameters of fat, protein and lactose the spectra can provide additional information on cow's status for a range of characteristics such as fertility, health and energy balance. MIR can potentially offer a possibility to develop novel, cost-effective tools which can enable milk producers to improve management of their dairy herd and in turn reduce the cost of milk production (Friedrichs et al. 2015). MIR has been studied as a potential tool to predict several milk traits related to cow health and robustness – this is the case for ketosis, a metabolic disorder that affects high producing cows and causes loss of production and infertility (De Marchi et al. 2014). MIR can be used to predict body energy status, enabling accurate, routine and freely available information to farmers so they can identify cows which have a greater likelihood of succumbing to health problems. MIR could also provide useful information for inclusion in genetic evaluations (McParland et al. 2010).

Work is currently ongoing in SRUC where researchers are looking at an early and accurate prediction of which animals may fail a bovine tuberculosis (TB) test. The existence of significant genetic variation among animals for bovine TB resistance have been identified and researchers are using routinely collected data from MIR on milk samples to predict the bovine TB skin test status of cows using digital imaging. This technology has the potential to alert a cow who may have been exposed to infection, this can allow farmers to take remedial action long before the normal testing regime is undertaken. Using good quality phenotypes and spectra data - immune associated traits have the potential to be identified. Through deep learning technology MIR could be used as a predictor of herd health (Denholm 2019).

The decision-making landscape of dairy farmers could change dramatically within the next five to ten years. Precision Dairy Farming may help support this change, this is generally defined as information and technology based farmed management systems which can be used to identify, analyse and manage variability within the farm. The management level of the dairy farmer plays a critical role in determining returns from investing in Precision Dairy Farming technology (Meijer & Peeters 2014). Precision technologies have the capacity to transform the management of animal health and more precisely forecast animal health disease challenges, facilitating more rapid and effective control. “Cow Fitbit” – a tracking device or sensor could be placed on the cow’s collar, ear, leg etc. which could track the cow’s activity level, temperature, health and other key behaviours. This captured data could tell and enable disease to be forecasted. Developments in animal breeding could also impact animal health – data could be extracted from the gene pool with the animal’s immune response to infectious disease identified (Armstrong 2019). More focus will be placed on genetic resilience in the future and there is an objective to develop a bulk milk “happiness test”. Biomarkers could translate into identifying chronic lameness or somatic cell count issues within the herd. Will the customers demand and want proof that cows within the herd are happy? (Watson 2019).

11. Conclusions

The need to be proactive in herd health management has never been more important particularly with the significant challenges in relation to two major issues – climate change and antimicrobial resistance. Much more focus must be placed on risk management and assessment, this can enable a shift from a reactive to more preventative approach to herd health. Milk screening for disease may have limitations but through having very clear, concise troubleshooting guidelines these can be overcome. Milk screening can have benefits, it can provide an initial impression of herd health and through identifying trends and triggers it can alert the farmer and the vet to potential herd health issues on the farm. There can be merit in continuing to protect the negative and naïve herds.

The strength and importance of the farmer-vet relationship cannot be underestimated. Through the farmer sharing herd health information and the vet involving the farmer in decision making this could foster and develop the relationship. The vet can play a crucial role in the design, interpretation and communication of the on-farm testing programme. To promote buy-in and adoption a need exists to be conscious of social science in relation to ensuring farmers and vet are engaged and motivated in herd health schemes.

In order to protect and enhance farmer's ability to sell milk products into global markets the industry could adequately demonstrate that animal health is a priority on farms. Each stakeholder within the supply chain can play a role in demonstrating this, this could be in relation to educating and supporting suppliers to implement more effective herd health systems on farm.

Software tools are available which can enable streamlined capture and use of data, our European counterparts have demonstrated leadership and best practice in this field. Decision support can improve, templates are available which can stimulate modification in reporting style and format so that results can be actionable and accountable. The future direction of milk and animal health screening will change, with milk-infrared spectrometry and precision technology being at the forefront. It is important to acknowledge that we all have roles and responsibilities to collaborate, lead, drive and empower in order to protect herd health and the sustainability and profitability of dairy farms and industry.

12. Recommendations

I. All stakeholders – the committed farmer, the dairy industry and the engaged vet need to be 'at the table' and co-design proactive herd health management programmes. While the early adopters in the veterinary community have started to lead the way in terms of a collaborative, knowledge share approach, the wider community of vets must come on board with this approach and there is a need to create further buy-in and adoption. The vet can become a key influencer of scheme awareness and uptake. Continuous professional development (CPD) should continue to be developed and offered to all

II. All stakeholders should be vested. A clear concise financial business model must be identified – this should be **co- funded** between the farmer and TASAH (Targeted Advisory Service on Animal Health). Through self-contribution and investing in herd health the farmer may reap more value and benefits from the various herd health initiatives

III. Animal Health Ireland - Veterinary Risk Assessment and Management Plan **(VRAMP)** should be launched and become mandatory on all farms. This template has been successfully used for Irelands' National BVD eradication and Johne's Control programmes. Every farmer should complete this risk assessment and evaluate biosecurity and disease status on farm, this should be completed by the farmers' own vet

IV. The Risk Assessment would determine what milk screen tests are required. A herd specific schedule and action plan could be formulated – this would cascade up or down accordingly depending if extra milk screening/ young stock serology is required

V. All stakeholders within the dairy supply chain must work together, they must lead & empower farmers and vets to achieve better herd health outcomes. Milk Purchasers could support on-farm risk assessments or could subsidise the cost of milk screening or pay a higher milk price to the elite farmers who is excelling in herd targets

VI. It is necessary to put extra context and operational decision support around milk screening results, through consolidating and communicating interpretations into effective simple user-friendly format the reports may be more useful. Through setting two or three specific targets or areas for actions and ensuring follow through this could provide the cornerstone for effective herd health management

VII. Ireland is the only country in the world with a farmer owned national herd database, hosted by ICBF. It provides the industry with critical trends to inform sector and individual farmer decision making. All service providers within the industry must consistently promote this service and encourage more farmers to engage with the on-farm analysis to support timely, effective decision making

VIII. New technologies like MIR and Precision Technology will evolve and the Irish dairy industry should take the lead in using these innovations to make a significant contribution, while ensuring that effective herd health management is always at the core

13. Acknowledgments

Firstly, I would like to thank my family and especially my husband Paddy and children Padraig and Aoife for all their love, patience, support and encouragement over the last two years. I would especially like to thank my work colleagues at Kerry Agribusiness, they were fantastic at holding the fort while I was away on my travels and a special thank you to James O'Connell for being my sounding board.

I would like to thank Nuffield Ireland John Tyrrell, Geoff Dooley, Karen Brosnan and my mentor Finola McCoy for their support and encouragement throughout the whole scholarship. I would like to thank the Nuffield Farming Scholarship sponsors as without them this scholarship would just not be possible. It has been a real honour to share this journey with my fellow Nuffield Ireland 2019 scholars Alison Holmes, Ciara O'Halloran, Karina Pierce and Pat O'Meara - we will remain friends for life. I was privileged to share the China Global Focus programme with Johanna, Claire, Ingrid, Tom, Duncan, Henrique, Ellen, Frank and Hamish.

Regarding my independent travel to the Netherlands, UK, Scotland and Denmark, I was overwhelmed by the welcome I received and thank you all for sacrificing your time, being so open and so forthcoming with your advice and information. You challenged my ideas, opened my mind and these insightful engagements gave me the inspiration and motivation to complete this report. A special thank you to all the people here in Ireland who have taken the time to meet and discuss my study topic with me, you all have been so helpful. I have no doubt the future of effective herd health management is in save hands!

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Appendix A Interview List

Ireland*:*	**2019-2020**
Lorna Citer	Animal Health Ireland
Maria Guelbenzu	Animal Health Ireland
John Quille	Castle Veterinary Centre
John Martin	Centenary Thurles
Ger Cusack	Comeragh Vets
Martin Kavanagh	Cow Solutions
Denis Guiry	Dairygold
Martin Blake	Department of Agriculture, Food & Marine
John Roche	Down to Earth Advice (based in NZ)
John Gilmore	FarmLab Diagnostics
Fionnuala Malone	Glanbia
Joris Somers	Glanbia
Gary Landers	Mid Kerry Veterinary
Donal O'Riordan	Irish Cattle Breeding Federation (ICBF)
William Minchin	MSD
Fergal Morris	MSD
Cara Sheridan	MSD
Donal Murphy	Sliabh Luachra Vets
Geoff Dooley	Strategic Advisor
Emma Dillon	Teagasc
Catherine McAloon	University College Dublin

Netherlands:	**April 2019**
Tonnie Vissers	Crv4all
Marten Knol	Farmer
Marten Dijkstra	Farmer & Nuffield Scholar
Kees Hemminga	Farmer & Nuffield Scholar
Guus Mensink	Farmer & Nuffield Scholar
Jet Mars	GD Deventer
Linda van Duijn	GD Deventer
Anouk Veldhuis	GD Deventer
Frans Keurentjes	Friesland Campina
Petra Kock	Friesland Campina
Gerrit Hooijer	Utrecht University
Alfons Beldman	Wageningen University & Research
Britain & Scotland:	**September/ October 2019**
Derek Armstrong	Agriculture & Horticulture Development Board (AHDB)
Tim Hampton	Arla
Rob Burgess	Evidence Group
Tom & Karen Hampton	Hampton Farm
Pete Orpin	My Healthy Herd
Karen Bond	National Milk Laboratories (NML)
Eamon Watson	National Milk Laboratories (NML)
James Breen	Nottingham University (Phone)
Julie McDiarmid	Premium Cattle Health Scheme (CHeCs)
Andrew Bradley	QMMS

Owen Atkinson	The Webinar Vet
Scott Denholm	Scottish Rural College (SRUC)
Foteini Manolaraki	Scottish Rural College (SRUC)
John Graham Brown	University of Liverpool
Diana Williams	University of Liverpool
Denmark:	**October 2019**
Per Svane Knudsen	Danish Crown Beef Company
Jorgen Katholm	DNA Diagnostics
Michael & Lynn Bruhn	Farmer
Erling Bonde	Farmer & Thise supplier
Jaap Boes	Seges
Henrik Læssøe Martin	Seges
Lars Pederson	Seges
Erik Rattenborg	Seges
Betina Tvistholm	Seges
Lone Holler	Eurofins
Anne Sofia Ladekjoer Mikkelsen	Eurofins

Appendix B

Some Commonly Used Screening Methods in Herd Health Screening

Disease/infectious agent		Direct tests	Indirect tests
Respiratory disease	Virus		
	Infectious bovine rhinotracheitis (IBR)	Polymerase chain reaction (PCR)	Serology/BTM/IM*
	Bovine viral diarrhoea (BVD)	PCR	Serology/BTM/IM
	Respiratory syncytial virus (RSV)	PCR	Serology/BTM/IM
	Coronavirus	PCR	
	Bacteria		
	Mannheimia haemolytica	PCR/culture	Serology
	Histophilus somni	PCR/culture	Serology
	Mycoplasma bovis	PCR/culture	Serology
	Parasite		
	Dictyocaulus	Faecal Baermann tests	
	Tickborne fever	PCR	
Infertility	Virus		
	IBR	PCR	Serology/BTM/IM
	BVD	PCR	Serology/BTM/IM
	Bacteria		
	Leptospira spp	PCR/ IFAT	Serology
	Salmonella spp	PCR/culture	Serology
	Parasite		
	Neospora caninum	PCR/histopathol-ogy	Serology
Johnes disease	Mycobacterium paratuberculosis (MAP)	Faecal culture/ PCR	Serology/IM
Mastitis	Bacteria		
	Many agents eg. Staphylococcus spp, Streptococci Mycoplasma	Culture PCR	
	Fungi	Culture	
Parasitic Disease	Gutworm	Faecal analysis	Ostertagia BTM antibody
	Lungworm		
	Liver fluke		BTM antibody test
	Rumen fluke		

Table 1: Some commonly used screening methods in herd-health screening
*BTM= bulk tank milk; IM= individual milk sample.

(Source: Gilmore 2016)