



# **Exploring challenges to Bovine Viral Diarrhoea (BVD) eradication in the UK and Ireland**

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# Executive summary

## Introduction

Bovine viral diarrhoea (BVD) is an endemic cattle disease in the UK and Ireland which causes animal health and welfare problems and in turn economic losses for farmers (Gunn et al., 2005). BVD has been successfully eradicated in several European countries (Moennig et al., 2005) and eradication schemes were introduced in Scotland in 2010, Republic of Ireland in 2012, Northern Ireland in 2013, England in 2016 and Wales in 2017. The Irish, Northern Irish and Scottish schemes involve legislation while the Welsh and English schemes are in a voluntary phase. This report presents results from interviews with key stakeholders about key elements and challenges for BVD eradication in order to make evidence-based recommendations to policy.

## Methods

A total of 25 key stakeholders were interviewed: 5 from Ireland, 5 from Northern Ireland, 4 from Wales, 5 from England and 6 from Scotland. Interviewees included government employees, private vets, academics and representatives of agricultural organisations involved in the organisation and implementation of the eradication schemes.

## Results

### Key elements for BVD eradication

Stakeholders framed BVD as a relatively 'straightforward' disease from an epidemiological point of view which made eradication achievable. The primary aim of all the schemes was the removal of persistently infected (PI) animals. Other countries in Europe have eradicated BVD and there was a perception that BVD freedom may become a trade barrier in the future, creating additional motivation for eradication. All the schemes were industry led and the compulsory BVD schemes were viewed as a new form of animal disease governance because they involved industry-government partnerships in relation to a non-zoonotic, non-exotic disease. It was stated that effective government-industry collaboration was key to successful eradication, involving the enrolment of key stakeholders including livestock marts and veterinarians. Government involvement through funding and legislation was viewed as necessary for successful eradication. Farmers needed to be recruited in the voluntary phase of the scheme to gather a critical mass of involvement and convince government of the need for legislation. Movement restrictions were a crucial way in which farmers were enrolled to eliminate BVD from their farms in the compulsory phase. Integration of BVD test results with official cattle data was necessary. Integration of data between the schemes in different countries was under development. Interviewees described the interaction of legitimacy, compliance and epidemiological risks within the schemes. Legitimacy must be built not only with farmers but also with the government to ensure compliance. Compliance with the scheme leads to a reduction in epidemiological risk. A reduction in epidemiological risk builds legitimacy for the eradication scheme.

### Key challenges to BVD eradication

Interviewees stated there was a need to recruit farmers in the voluntary stage of the scheme to convince government that there was a need and appetite for compulsory BVD eradication measures. Actors that took responsibility for enforcing eradication measures risked losing legitimacy if the measures were unpopular or ineffective. There was disagreement about the distribution of benefits and responsibilities within the scheme – the extent to which BVD eradication is a public or an industry good. There was a perception that some farmers may stand to gain more

than others from BVD eradication, and the measures taken in the scheme. Government involvement was a challenge in Northern Ireland where there was no sitting government, and in England because of different government priorities. There were also difficulties with enforcing legislation in other countries because of government funding priorities and distribution of duties. The main gap in 'compliance' within the scheme was framed by interviewees as farmers retaining persistently infected (PI) animals.

There were different reasons for the choice of a blood test or a tag test within the schemes based on the desired level of control of different actors over the process and the specifics of the livestock industries. The tag test was viewed as expensive but had the advantage of being simple to communicate and could be done at the same time as farmers' existing tagging practices. Some interviewees stated the blood test was a less expensive option but there were concerns about the accuracy of blood testing a sample of animals within management groups and the long time period between tests. Animal trade across borders was framed as a challenge to achieving and maintaining BVD freedom. There were different possibilities of integrating schemes individually or through potential changes within the EU animal health law stipulating the criteria for BVD freedom.

## Policy Considerations

### Rethinking compliance

It may be useful for stakeholders to consider in more detail what compliance means in this new domain of industry-government partnerships for eradication of a non-zoonotic, endemic disease. Compliance may be understood in terms of following the epidemiological advice behind the scheme to remove PIs, or in terms of complying with legislation. Research has shown farmers have their own values and goals in relation to animal husbandry which may differ from epidemiological advice. And none of the schemes enforced compulsory removal of PI animals as it was viewed as too onerous and problematic for government to legislate for. This created a gap between what compliance was conceived of more broadly and how it was enforced more narrowly (if it was indeed enforced).

### Continued industry-government partnership working

Several interviewees stated that novel industry-government partnerships to govern the schemes were working well. However, there were tensions between a perceived need for government to legislate to enforce compliance but also a desire for industry to retain autonomy. Stakeholders may be working within a novel governance domain characterised by shared decision making with an understanding of command and control mechanisms by government as the ultimate source of legitimacy and compliance for the schemes. Given that industry-government partnership governance of disease eradication is a new departure in the UK and Ireland there is a need to keep negotiating roles and responsibilities as schemes evolve.

### Negotiating integration of the schemes

There was work underway to link up databases and animal statuses between schemes individually. The challenges in terms of technical difficulties, different testing methods and rules were also highlighted. There were also discussions of the benefits of the EU setting out a framework for what BVD freedom means within the animal health law which individual schemes would need comply with. The EU designation of what BVD freedom means will involve political choices which benefit and disadvantage different countries and different types of farmers within those countries. Integration of schemes individually or at the EU level will also involve trading of responsibility and autonomy between different organisations.

# Introduction

Bovine viral diarrhoea (BVD) is an endemic cattle disease in the UK and Ireland causing animal health and welfare problems and in turn economic losses for farmers (Gunn et al., 2005). Animals with BVD carry a range of signs that include scouring, infertility, abortions, respiratory illness, infections and reduced growth (Evermann and Ridpath, 2002). According to the epidemiological account of BVD, it is primarily spread by persistently infected animals (PIs) which were infected with the disease in utero and as a result have not developed immunity to the disease (Houe, 1993). PIs shed the virus throughout their lifetime and cannot be cured and are more likely to have health problems, fail to thrive and have higher mortality rates (Houe, 1993). According to veterinary economics the eradication of BVD from Scotland is beneficial for individual animals, farms, the industry as a whole and consumers (Weldegebriel et al., 2009).

A thematic network funded by the European Commission produced a report in 2005 stating that the technology and knowledge existed to eradicate BVD through what they called a 'systematic' approach involving biosecurity; eliminating PIs; and surveillance to monitor progress and prevent reintroduction of the disease (EU thematic network on the control of BVDV, 2005). Norway, Denmark, Sweden and Finland embarked on BVD eradication programmes in the 1990s and achieved "freedom from the disease" after 10 years (Moennig et al., 2005). Austria, Germany and Switzerland introduced schemes in the 2000s (Lindberg et al., 2006; Presi et al., 2011; Wernike et al., 2017). Eradication schemes were introduced in Scotland in 2010, Republic of Ireland in 2012, Northern Ireland in 2013, England in 2016 and Wales in 2017. Work is underway to assess BVD freedom across heterogeneous control programmes (van Roon et al., 2019). Schemes have used an antigen test which tests for the presence of the virus by taking a tissue sample from the animal's ear through the application of a tag, or a blood test which tests for antibodies to the virus in a sample of calves (EU thematic network on the control of BVDV, 2005).

The term 'United Kingdom' designates the political union of England, Scotland, Wales and Northern Ireland; the term 'Great Britain' refers to England, Scotland and Wales but not Northern Ireland; and the Republic of Ireland will be henceforth referred to as Ireland. Ireland has been an independent country separate from the United Kingdom since 1922. A summary of the BVD eradication schemes in the UK and Ireland is shown in table 1.

This report first describes the BVD eradication schemes by country then presents results from interviews with key stakeholders about key elements and challenges for BVD eradication in order to make evidence-based recommendations to policy.

## Methods

This report is based on interviews with key BVD decision makers, practitioners, and technical experts. Qualitative interviews with key stakeholders involved in the organisation and administration of the BVD eradication schemes were carried out in the 5 countries. Ethical approval for the study was obtained from the James Hutton Institute research ethics committee. Qualitative interview data is not taken as representative of the attitudes or behaviours of a group of people as may be the case with quantitative data (Mays and Pope, 1995). Rather, qualitative interviews are an opportunity to explore individual people's perspectives in detail to engage with the reasons and mechanisms underpinning the organisation of the social world (Coffey and Atkinson, 1996). Results from qualitative research make theoretical inferences based on assumptions about the consistency of practices, structures and forms of reasoning in the social world, rather than empirical generalisations about commonalities between categories of people (Williams, 2000). Purposive sampling was used in order to access key stakeholders accessing a range of different expertise and backgrounds within the schemes (Miles et al., 2014). Potential interviewees were identified through personal contacts, information about the schemes available on websites and snowball sampling where interviewees identify other relevant

participants. All interviews were confidential, and interviewees' details are anonymised in outputs. Interviews took place in person and over the phone. Interviews were audio recorded and transcribed. Interviews lasted around an hour with the shortest being 30 minutes and the longest 120 minutes. A total of 25 people were interviewed: 5 from Ireland, 5 from Northern Ireland, 4 from Wales, 5 from England and 6 from Scotland. Interviewees included government employees, private vets, academics and representatives of agricultural organisations involved in the organisation and implementation of the eradication schemes. The country of the interviewee is reported in results. Thematic analysis of the interview responses provides insights into how BVD governance is perceived and implemented.

## BVD Eradication Schemes by Country

### Wales

A three year voluntary scheme to eradicate BVD in Wales, 'Gwaredu BVD' (Eradicating BVD) was launched in September 2017 led by industry and funded by the Welsh Government Rural Development Programme (Farming Connect, 2017). The scheme is being managed by Animal Health and Welfare Wales – a partnership between Coleg Sir Gâr's Agriculture Research Centre and the Royal Veterinary College (RVC). A blood test of 5 unvaccinated animals between the ages of 9-18 months is carried out by the vet, usually at the same time as the annual bovine tuberculosis test (TB) (Animal Health and Welfare Wales, 2018). The initial test is free and further support is available to find a PI animal if there are positive results. Seventy percent of farmers offered screening have availed of free testing as of March 2018, and the remaining 30% do not have eligible stock (James, 2018). A total of 3100 herds have been screened, with 27% showing some evidence of infection (James, 2018). It is anticipated that after the end of the three-year subsidised scheme testing will be made compulsory and sale of animals will be dependent on BVD negative status.

### Scotland

The Scottish government's policy document 'Animal Health and Welfare in the Livestock Industry: Strategy 2016-2021' states one of its priorities is to work with industry to help tackle endemic livestock disease (The Scottish Government, 2016). The BVD eradication scheme was introduced in 2010 and has involved four phases: subsidised screening for the disease in the first phase; mandatory screening in the second phase under the Bovine Viral Diarrhoea (Scotland) Order 2013; movement restrictions based on BVD status in the third phase; and enhanced testing and further movement restrictions in the fourth phase (The Scottish Government, 2015). In the fourth phase herds can tissue tag test every animal born onto the farm or blood test a sample of calves in each management group (The Scottish Government, 2015). A herd can have one of three statuses in the scheme: a BVD negative status; a non-negative status; or a positive status which indicates the presence of a PI animal on the farm. Animals can only be sold if they are from a herd with a 'negative' status, or if they are individual tested and found to be negative. As a result of the eradication scheme the number of non-negative or positive breeding herds has decreased from 40% in 2013 to 14% in 2019 (The Scottish Government, 2017a; Scottish Government personal communication).

### England

The BVDFree scheme in England is an industry led voluntary scheme launched in 2016 to eradicate BVD from the English cattle population by 2022 (BVDFree England, 2018). The Cattle Health and Welfare Group (CHAWG) identified a need for BVD eradication and the scheme is managed by a national BVD steering group and supported by 113 industry bodies. Farmers can tag and test all calves born on the holding or blood test a sample of calves in each management group for two consecutive years to achieve a BVD status (BVDFree England, 2018). The BVD status of participating farmers can be found on the BVDFree website

through their County Parish Holding number and the status of individual animals through their tag number. The Agriculture and Horticulture Development Board (AHDB) have supplied resources to coordinate the development of the scheme. In the first two years of the scheme 1231 holding registered to take part, making up 9.2% of England's cattle breeding population (BVDFree England, 2018). A parallel Stamp It Out BVD eradication scheme was introduced in 2018 funded by the Rural Development Programme for England through the Department of Environment and Rural Affairs (SRUC, 2019). Stamp it Out BVD funds testing and herd investigations for farmers and results can be joined up with the BVDFree database.

## Northern Ireland

A voluntary phase of the BVD eradication programme for Northern Ireland was launched by Animal Health and Welfare Northern Ireland (AHWNI) in 2013. AHWNI is a not for profit organisation set up by farming organisations and the wider agricultural industry in 2012 to promote the control of livestock disease (AHWNI, 2019a). The voluntary phase was replaced by a compulsory phase in 2016 with legislation under the Bovine Viral Diarrhoea Eradication Scheme Order (Northern Ireland) 2016. Like the scheme in the Republic of Ireland, the compulsory phase involves tag testing of calves within 20 days of birth using official identification tags and optional follow up testing that may be carried out after a positive test result. PI animals must not be moved off farm unless to slaughter (although a voluntary abattoir ban on slaughter of PIs is in place) and should be isolated. Animals born after the introduction of the compulsory stage of the scheme cannot be sold unless they have a negative status. As of the end of April 2019 6.57% of herds had a positive or inconclusive result within the previous 12 months (AHWNI, 2019b).

## Ireland

A voluntary scheme to tissue tag calves was introduced in 2012. The scheme is administered by Animal Health Ireland (AHI), a not for profit company made up of a partnership between the private sector and the Department of Agriculture, Food and the Marine (Animal Health Ireland, 2016a). The scheme was made compulsory in 2013 under the BVD Order (2012) which introduced compulsory tag testing of all calves before the age of 20 days and a ban on the sale of non-negative calves (Animal Health Ireland, 2016b). From 2017 herds with a positive test are required to undergo a follow up investigation funded by the Rural Development Programme 2014-2020, which must be completed within 3 months of the positive test (Animal Health Ireland, 2018). If a PI is identified neighbouring farms are informed. Movements of animals onto and off herds with PIs are restricted until the PI is removed. There is a payment scheme for beef and dairy farmers for removal of PI animals within 10 days of the first test (14 days for male dairy calves) and a lower payment for removal within 3 weeks. Between 2013 and 2018 the number of positive herds has fallen from 11.27% to 0.9% (Animal Health Ireland, 2019). As of the 26th week of 2019 there were 29 herds with retaining live PIs for more than 3 weeks (Animal Health Ireland, 2019). A summary of the BVD eradication schemes in the UK and Ireland is shown in table 1.

# Results

## Key elements for BVD eradication

### BVD as a 'straightforward' disease

BVD was largely framed as a relatively 'straightforward' disease. Interviewees viewed the epidemiology of the virus as knowable to science and communicable to farmers. In the recent past, government involvement in disease eradication concerned only exotic diseases and diseases that impact on human health (Woods, 2011). In contrast, industry led schemes are concerned with BVD because of its economic impacts and the perception the disease lends itself to eradication. In addition, BVD does not have a known

wild reservoir.

Wales: [I]t became very evident early on that BVD was the low hanging fruit, or the lowest hanging fruit, I don't say it's low, and therefore, given that it's relatively achievable, it's already happening in other regions as a bit of a precedent been set, it quickly became our disease of choice.

The primary aim of all the schemes was the removal of PI animals. While stakeholders recognized that their national contexts would require unique disease management strategies, they nonetheless invoked the successful eradication campaigns in other countries as a motivation for BVD eradication in the UK and Ireland.

## Trade motivation for BVD eradication

BVD eradication was also framed in terms of keeping up with other European countries. In this view, being BVD free was necessary to defend the reputation of the industry in terms of high health and quality.

Scotland: And the other thing I would have been saying was that given that we sell our product on the basis of high standards, high health, we have to match that with reality. And that if we drag our heels and don't actually maintain our status and other parts of the country or other countries do, to give an example, to take Scandinavia or Austria or Germany, I don't know where they are now, but I certainly was led to believe that they were well ahead of us in terms of controlling BVD.

Wales: [...] if people are spreading PI animals, knowingly or otherwise we're really ruining the Welsh herd and its reputation, and actually, because of Brexit, they're really worried about how we look in terms of trade.

Current and potential future trade arrangements thus motivated BVD eradication. If animals or animal products were being traded across borders, stakeholders saw BVD disease status as having an impact on the reputation of the industry, and the presence of BVD potentially creating trade barriers in future.

## Stakeholder collaboration

All the schemes were primarily industry led. The Irish, Northern Irish and Scottish schemes involve hybrid government-industry governance, with government legislation. The Welsh and English schemes are, at the time of the research, in an industry led voluntary phase. Industry leadership was a new type of animal health governance:

Ireland: [...] this is the first industry led, or perceived to be, or industry driven eradication programme, managed by industry.

Northern Ireland: It'll be really positive, and there is a culture change here for Northern Ireland farmers because they're so used to [...] statutory disease control – if a government steps in, government pays for compensation, you know, the lorry driver takes away their [bovine tuberculosis] reactors, and, [...] this is just a completely different approach [...], obviously the industry, we're taking responsibility ourselves.

The industry-government design was framed as an asset for the schemes' potential success in eradicating BVD.

Scotland: [...] it has the huge advantages that people, if you can engage them, they'll come and talk to you, they will point out the pitfalls so that you don't have to make the mistakes, which is massively valuable, and also, they'll feel ownership and involvement and perhaps that, the whole thing is more likely to be successful because the industry genuinely do feel like it's, they're part of it, and they are.

Animal health governance has been increasingly devolved from Westminster to the administrations in Northern Ireland, Wales and Scotland since the 1990s. Several interviewees endorsed the devolved approach to eradication.

Scotland: I think large parts of Scotland can rightly claim to have a very different agricultural system and economy to the rest of the UK and it would make sense that they do have differentiated agricultural policies. And it would be peculiar if

we've got a devolved government and they have responsibility for agriculture, it would be peculiar then not to ever do anything unless it was at a national, as in a GB wide, or a UK wide scheme.

Devolved responsibility for BVD eradication allowed the individual countries in the UK to tailor the specifics of the scheme to their industry.

Collaboration between the stakeholders in the different national eradication schemes was also important to successful eradication.

England: We meet up once a year [...] and we share experiences with the various programmes and try and get ideas from each other [...].

Northern Ireland: We're using the same labs and people from the southern scheme at our implementation group and vice versa. You know, so keeping that flow of information going.

Amongst the BVD stakeholders, there was broad agreement that government involvement was necessary to achieve eradication. This support was conceptualized as 1) explicit approval of the efforts of industry led schemes, 2) appropriate government funding, 3) legislation to enforce measures including compulsory testing and movement restrictions.

Ireland: If the legislation wasn't there, whether it's industry led or otherwise, it'd be just kind of hovering and, you know, it'd be going nowhere.

Northern Ireland: It's good to try to be co-operating and collaborating in this way, but, at the end of the day, there will be a dependence on having legislation in place. And government support for what industry is trying to do, that is necessary, there will always have to be an element of enforcement there, to encourage everyone to comply.

Research with farmers in Orkney and Suffolk also found that these farmers supported regulation to enforce compliance (Heffernan et al., 2016).

Many interviewees saw vets as key stakeholders for communicating information about BVD. Blood testing required veterinary involvement, providing a pathway for additional communication about BVD. Vets can also be involved in the other schemes that use tag testing through for instance subsidised herd investigations in Ireland for herds with a PI.

Wales: Without a doubt [...] if you bypass the vet, you wouldn't get buy-in at all.

England: So, we are largely reliant on vets to make the case for joining BVDFree to farmers.

Vets were framed as important for communicating with farmers about disease test results and encouraging farmers to remove PI animals.

## Farmer involvement

During the voluntary phase farmers needed to be recruited to take part (Devitt et al., 2014). Within the compulsory stages of the scheme there was still a need for farmers to comply with the advice of the scheme under their own accord because none of the schemes enforced removal of PI animals.

Farmers were recruited to take part in the voluntary phase through communication about the disease and the benefits of the scheme.

Ireland: So there was a lot of education around that, there were clinical society talks, farmer meetings, the whole communication piece was fundamental to that. And, you know, we did a lot of town hall meetings for vets, farmers, right across the country.

It was stated that the easier it was for farmers to understand and comply with the requirements of the scheme the more likely they were to sign up in the voluntary phase.

Wales: [...] we wanted something that farmers could do without really thinking about it. So, we didn't want farmers to have to do anything special, because, when they have to do that, they generally don't.

There was also a need to recruit enough farmers through the

voluntary phase of the scheme to convince government that the scheme had support.

Wales: And I guess, the other challenge is to get a significant enough participation by the industry during this voluntary phase, in order for the government to be convinced that we need it enough for legislation to be approved.

Legislation restricting the movement of herds and animals that did not have a negative status was seen to provide an economic incentive for farmers to achieve a negative status in order to be able to sell animals. The Republic of Ireland is on the only country which gives farmers financial support for the removal of PI animals within a given time frame (an incentive for prompt removal rather than compensation for the value of the animal). Clegg et al. (2016) found that PI retention rates decreased as more measures were introduced in the compulsory phase of the scheme in Ireland.

In Ireland if a farmer retains a PI animal for more than 21 days the neighbouring farmers are informed. Stakeholder interviewees stated that the inclusion of social pressure helped ensure compliance.

Ireland: The other thing, their neighbours were told that there was a herd neighbouring them, retaining a PI, and that, the, peer pressure of that persuaded them to move those animals off a bit quicker.

Elements that complicated scheme compliance will be dealt with below.

## Data integration

The integration of farmers' BVD results with official cattle registration information and movement data was key for the successful organisation of the schemes. This meant that farmer involvement could be accurately assessed, and the data was easily accessible to farmers. In Scotland, Northern Ireland and Ireland BVD data is integrated with official cattle data, but not yet in the voluntary English and Welsh schemes.

Ireland: Critically, it [the scheme] had members of Irish Cattle Breeding Federation, because, key to the whole story of BVD, and fundamental to its, in my opinion, success has been a centralised database that's called ICBF.

Integration of data between the schemes in different countries was also framed as important to help prevent spread of disease across borders. The schemes have been discussing how they could work together and how they might arrive at mutual recognition of individual animal status and then herd status. Irish and Northern Irish results can be shared on the database if they use the same certified laboratories, though farmers may still need to test animals crossing borders.

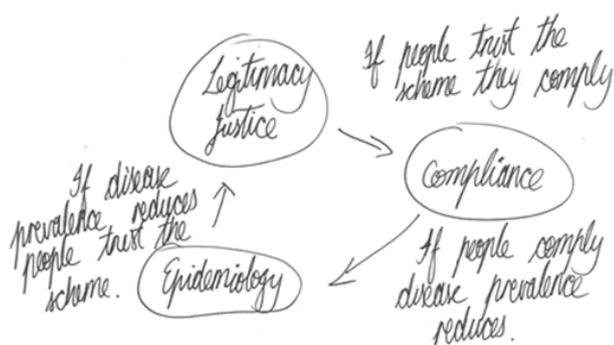
Ireland: But there is exchange of results between the databases if a laboratory is designated in both jurisdictions, this is one of the requirements for any result to go to a database, but in that situation, then, there is exchange, so they [farmers] might end up being tested on top of that.

## A perceived virtuous circle of legitimacy, compliance and epidemiology

Interviewees described the interaction of legitimacy, compliance and epidemiological risks within the schemes. Legitimacy is defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions." (Suchman, 1995 p.574). Legitimacy refers to how schemes establish authority for their institutional structures, rules and knowledge claims among stakeholders. Justice is related to legitimacy and means that the scheme is perceived as being fair in terms of the distribution of costs and benefits for different actors. Compliance means relevant actors make decisions in accordance with the guidelines set out by the scheme. Stakeholders complying was seen to lead to a reduction in epidemiological risk. A reduction in epidemiological risk was also seen to build legitimacy for the scheme as stakeholders could see it was "working". Figure 1 below shows the virtuous circle of legitimacy,

justice, compliance and epidemiological risk as described by key stakeholders.

Figure 1 Perceived interaction of legitimacy, justice, compliance and epidemiological risk in BVD eradication schemes.



Eradication of BVD is made possible through the unhindered momentum of the virtuous circle described in figure 1. The next section explores what stakeholders saw as challenges to this virtuous circle.

## Key challenges to BVD eradication

### Maintaining scheme legitimacy

The recruitment of enough farmers in the voluntary phase of the scheme was a tool to convince government that the scheme had appropriate legitimacy. If enough farmers were not recruited there was a risk the government may not legislate.

England: [...] there was a lot of discussion with government about introducing compulsory scheme but the feedback we were getting was that government felt that often, we introduced these schemes when they were asked to by the industry organisation but then, took a lot of flak from farmers blaming government for introducing the scheme that they didn't want, so what they said was, that the industry needed to demonstrate that it was sufficient engagement with a BVD, a voluntary engagement with a BVD scheme to demonstrate that there was that demand, it wasn't just the case of people asking for it, the farmers were actively engaging in BVD control, and demonstrating that it was a real demand for a compulsory scheme.

As can be seen in the above quote there were legitimacy risks not just for the legitimacy of the scheme as a whole but for individual actors. The role of government in dealing with non-notifiable, non-zoonotic disease was painted as somewhat problematic. Stakeholders stated that some amount of government distance was important because BVD was not a public health risk.

Ireland: The department fund it. The department supports confirmatory testing, in the sense that it, the testing is done in the department's lab, but, it's one step removed, it's been delegated to AHI and, for a number of reasons, and I think it probably works, because the department doesn't want to be dirtying its hands, so to speak with these non-regulatory diseases.

The idea that the government would "dirty its hands" by lending its powers to eradicate BVD shows the legitimacy risks of pursuing an aggressive eradication scheme.

Stakeholders identified how the organisation ultimately tasked with carrying out enforcement of undesired measures faced legitimacy risks.

Northern Ireland: We're currently starting that process so the industry's got itself in the position now where it's frustrated waiting on legislation. And, they would prefer the legislative approach, like, nobody wants to be bad cop.

It was stated that the division of responsibility and ownership within a joint industry-government scheme could be unclear.

Scotland: I think there's something about 'our scheme' 'your scheme'. I tell people this is the industry led scheme, this is

your scheme. And most people [farmers] who phone me up to complain will be saying, "Your scheme is rubbish!" And sometimes it hard to see who's the actual owner. And there isn't a single responsible person. Because, one of the things, I think, maybe Animal Health Ireland does better, because they are, it's kind of clear that they're in charge. [...] So there's a bit of ambiguity there which is not completely comfortable.

This quote identifies an embedded legitimacy challenge of joint "consensual" policy making where the distribution of responsibilities and roles are unclear.

The schemes were generally organised through a technical expert group which informed an implementation group which made decisions about the scheme. Where there were disagreements over expertise there was also a desire expressed for the scaling up of expertise to overcome legitimacy risks. An Irish stakeholder stated that if the EU set criteria for freedom from BVD this would mean less contestation of the expertise by stakeholders within the Irish scheme.

Ireland: [...] it's [the proposed EU animal health law] actually going to set out the rules for Ireland to be recognised within the EU for BVD freedom. And it's actually going to take the responsibility away from the technical working group to come up with the rules of the scheme.

Interviewees framed involvement of farmers in the voluntary phase as necessary to demonstrate its legitimacy to government who would then step in to legislate and enforce compliance. Taking responsibility for enforcing compliance presented legitimacy risks for whatever body took it on. The scaling up of technical decisions, via an EU framework, was presented as a legitimate way to coordinate compliance to a given standard across countries.

### Fair distribution of costs and benefits

There was a risk of 'unfair' distribution of benefits and burdens in the schemes. For instance, there were concerns that dairy farmers stood to benefit more economically from the eradication of BVD and suffered less than beef farmers from the removal of PIs.

Ireland: I think a lot of that had come down to the fact that, for these beef farmers, all their income was contained in these calves. For a dairy farmer it mightn't have been so palatable to destroy a calf, but at least his main income was left intact through the sale of milk, whereas with a beef farmer, all the income for that cow was gone.

There were seen to be justice risks around the distribution of costs and benefits between the industry and government. There was disagreement about the extent to which BVD eradication was a public good. Some stated that the case within government for support may be difficult, given competing government priorities.

Northern Ireland: I think, economic case for state intervention is difficult, because it's a production disease, because at this stage, there haven't been any barriers to trade and so on, and because effectively, the economic benefits are for the herd owners. So, the economic case for state intervention on a financial level, if not legislative level, isn't desperately strong.

A stakeholder stated what they see as the public good benefits of eradicating BVD:

Northern Ireland: And to me, there's a piece on antimicrobial reduction, industry efficiency, environmental concerns, all these things, eradicating disease, to me, would argue, that's a positive. So therefore, you should be able to say well, there's a wider public interest in making the industry more efficient from a greenhouse gas perspective.

There were also issues of justice raised around measures to encourage farmers to remove PIs. There were concerns that paying farmers financial support or compensation may not be perceived as 'fair' because it would 'reward' farmers who were not doing the right thing by getting rid of PIs of their own accord and was unfair to farmers who were.

Northern Ireland: Which isn't going to be popular with the, you know, the vast majority now that have done the tag and test, have put down the animals, out of their own cost, to then

suddenly say, well, now, we're going to pay the people that have been slow adopters and we're going to pay for it.

## Ensuring stakeholder compliance

With regards to BVD, compliance is required at a number of crucial steps. In some schemes, vets must carry out their own outreach to enrol farmers in their practice into voluntary schemes. In the compulsory phase, marts must ensure that the BVD status of traded animals is visible to their participants, and animals without a BVD negative status are not sold. Within voluntary and compulsory schemes farmers who identify PIs within their herd must isolate and cull them. There were concerns over a failure of compliance at each of these stages. In some cases, the failure of compliance is seen as a threat to BVD eradication.

In the voluntary phase of the scheme compliance means farmers signing up to take part in the scheme. There were a number of reasons why they may not do this. If farmers carried out the test and did not get a negative status and their results were searchable on the database – such as on the English database – then they risked other farmers knowing that they had disease problems, which was voiced by farmers as a concern in previous research (Heffernan et al., 2016). In the voluntary phase of the scheme when there was not a clear mechanism for communicating the farmer's status – such as the Welsh scheme – the farmer also did not stand to gain anything from receiving a negative status.

In the voluntary phase it was stated that marts may be reluctant to become involved in case any they were held account for any discrepancies in disease status.

England: I think the auctioneers seem to have a big reluctance to get involved with this, or some of them do, I think they are worried a liability is placed on them if they tell buyers if this animal is being tested.

Across all the schemes interviewees stated that one of the main challenges for disease eradication was farmers retaining PI animals. These are animals infected with BVD in utero that cannot be cured and will act as disease reservoirs. Several interviewees stated it was expected at the outset that farmers would remove PI animals because it was in their financial interests.

Northern Ireland: [...] the main stumbling block to our programme, at the moment, as far as we're concerned, the fact that PIs are being retained.

Ireland: But, you know, at the start of the programme, it was an industry led, the ambition at least was that farmers would do the right thing. And some did and some didn't.

Ireland: We expected people to get rid of PIs, because it's a good thing to do.

Here the right thing is framed as following epidemiological advice and removing PI animals. But farmers valued the production potential and economic value of the animals and may use their own judgment to assess their health and value (Shortall and Brown, in press), revealing a mismatch between perceptions "good" animal management.

As described above, in terms of division of roles and power between industry and government within the schemes it was framed as the responsibility of government to enforce compliance. Interviewees expressed concern about lack of government involvement in some countries. The suspension of the Stormont assembly in Northern Ireland since 2017 stopped further legislation being passed on the scheme. In England, there was concern that a commitment to industry rather than government responsibility for animal health would mean the English government was reluctant to implement any legislation.

England: I've known [person involved in high level animal health governance in England] for quite a period of time. [...] And, they told me then, the issue with BVD in England, you will not get any legislation because the government is against extra legislation. For every new piece of legislation, the government puts in, they want to take two pieces out, so that's government policy, so you're struggling there.

Stakeholders also stated that agriculture was less important to the English government compared to other UK countries and Ireland:

England: I don't think anybody is really taking control and I think I believe that government ought to be at the heart of that but I think agriculture, agriculture in England is less and less of a priority for government and it's different in Scotland and it's different in Wales and Ireland but I think it sits at a different level, that the politicians don't hear.

Scotland: I think within Scotland the Scottish Government, and maybe the BVD scheme is part of this, they do take an active interest in agriculture and rural life, and rural economy. Possibly there is a feeling that they do that better than the Westminster government.

Where it was not possible for government to enforce compliance, industry led compliance initiatives were undertaken or suggested. In Northern Ireland abattoirs no longer accept PI carcasses to deter farmers from keeping PI animals to slaughter. In England it was suggested that existing industry quality assurance schemes could be used to enforce compliance. However, there was a perception of an unwillingness for voluntary schemes to take on the responsibility of enforcing compliance in the same way the government did, because of legitimacy risks outlined above.

In addition, enforcement of compliance by government was not always straightforward.

Northern Ireland: Is isolation of PIs enforced? In theory, they're meant to be isolated in the legislation. In reality, nobody's going to check that. So, phase one was to be light touch. But the department has had its budget constrained substantially for the last eight years. And this is not a, something that it considers to be in the wider public interests, so they aren't really particularly willing to throw money at this when they have other priorities, TB, for example. So there's, who should be going out and checking? AHWNI don't have an enforcement team, they have no powers to be an enforcement team, so that's not particularly happening.

When BVD eradication is not as clearly a public good as other diseases priorities such as TB it is difficult for governments to allocate scarce resources to enforcement. A new body (AHWNI in NI, for example) created to manage the scheme and other animal health initiatives does not have the same remit or power to enforce compulsory actions. Though it was stated that government involvement was needed, 'government involvement' was not homogeneous or unproblematic.

Scotland: [...] up to now the enforcement has been in the hands of the local authority and trading standards who, I would say that their inspectors almost certainly don't understand the basics of how BVD works. And they probably don't have the resources and I think with what resources they do have they are more likely to use them on simple, easy things to do, which is probably going around and taking feed samples out of feed wagons. So I don't think that's an adequate....we've lobbied for APHA to be the enforcers but then they'll talk about resources and money and time.

We can see that 'government' is not one homogeneous entity but different areas of government carry out different functions – passing legislation, communicating with farmers, enforcing legislation etc. In Scotland, central government are involved in the scheme administration but local government are responsible for enforcing compliance and do not necessarily have the resources or knowledge to carry out this function.

In addition, crucially, none of the schemes compel farmers to cull PIs. Thus, farmers are not technically in violation of the rules of any of the scheme if they retain PIs. Compliance to the letter of the law in all schemes did not lead in a straightforward way to reduced epidemiological risk of BVD spread. Stakeholders stated that legislation enforcing compulsory slaughter of PIs was too onerous and costly for governments to implement.

Ireland: We just had a law that meant that they [PIs] couldn't be sold at an open market. We couldn't force you to kill it. And the reasons are complex, I guess, and that's where you get into major conversations in the Department of Agriculture.

England: I think the reason the, both Ireland and the UK have kept away from compulsory slaughter there's a feeling that if you require a compulsory slaughter, that you've got to provide compensation, which makes a scheme much more expensive.

Interviewees described farmers retaining PIs and not 'complying'

with the scheme as leading to epidemiological risks of disease spread. It was stated that if epidemiological risks of disease spread do not reduce, this calls into question the legitimacy of the scheme.

Scotland: [...] failing to achieve substantial progress towards eradication over the next 3-4 years I think would be dangerous. I think the reason for that is that people will become disillusioned. They've put in the effort, they've put in the cost of testing, they've made those efforts so...in the absence of seeing substantial national progress in the next 3-4 years I think fatigue builds in, I think people get fed up with it. I think doubt "does this really work?"

Thus, in the dominant BVD eradication logic, broad scheme compliance is assumed to reduce disease prevalence and the epidemiological risks of disease spread. Government involvement through funding, administration and crucially legislation was seen as necessary to enforce compliance. This was an issue in England and Northern Ireland where passing legislation was problematic. However, government was not one homogenous entity and negotiating compliance between different parts of the government and in an environment of scarce resources was difficult. The main area of 'non-compliance' was described by interviewees as farmers retaining persistently infected animals. However, none of the schemes legally compelled farmers to remove PIs instead relying on market-based measures to drive farmer decision making. Thus, what exactly 'compliance' means within a hybrid industry-government scheme is open to question – this will be explored further in the last section.

## Testing – reasons why testing methods were chosen and challenges

Thulke et al. (2018) state that evidence from previous European eradication schemes has shown that both blood test and tag testing methods can be effective in national eradication schemes. Test methods were selected not only based on infrastructure and practices, but also different assessment of the epidemiological merits of the tests. Different relationships also shaped scheme design. In Ireland for instance it was stated that a tag testing method was chosen because the farmer would be in control of the testing methods and there was a desire for a farmer led rather than a veterinary led scheme.

Ireland: And you know, the farm organisations collectively, at least, would not have supported a scheme that required vets to come and bleed animals. Just because you'd be paying vets to come and bleed animals. And the farmer, they were potentially looking at the compare and contrast between the farmers in charge of the tag testing, he can do that himself, as opposed to paying the vet.

In Wales a key element of the design of the scheme was the idea that vets could carry out a BVD test at the same time as the TB test. Herds are required to carry out yearly TB testing so a BVD blood test of calves could be done at the same time as the TB test, minimising work for farmers.

Wales: So it needs to be that the vet is out there and saying, you know, "Whilst I'm here [for the TB test], I've got, you know, I've got the vials in the van, I'll just go get them, it'll take me two seconds, I'm only testing this many, it's free." And it's almost like, [laughs] it's a little bit like the organ donation thing where you assume consent.

The testing regime and rules were chosen around the specifics of the industry. For instance, in Ireland the average beef herd size is relatively small so the absolute cost of tissue tagging every individual calf was not seen as too large, and many Irish farms may not have the required number of animals in the right age group to carry out the blood test (Tratalos et al., 2017). Yearly TB testing is also required in Ireland, but the majority of cows calve in spring, whereas the TB test takes place all year round so it would be difficult to test the required age profile of calves between the ages of 9 and 18 months during the TB test.

It was stated that the blood test was quicker, cheaper and very effective for finding PIs on farm. The tag test of all calves at birth was described as more expensive and it took longer to be able to attribute a farm with a status.

Wales: I mean, for tag and test, to be honest, tag and test, it's so specific, but I think it's too expensive.

But stakeholders also stated that the tag and test was easy for farmers to do because they had to tag animals with an official identification tag anyway.

England: [...] whereas with the scheme whereby you have to tag, you have to test the animal at the time of tagging, it's almost seamless, it becomes a normal part of operation on the farm. [...] and it's probably easier to ensure compliance by using the tag and test approach.

Because the blood test could be done once or twice a year, depending on the specifics of the herd, this created the potential for infection to enter the herd when the herd still had a negative status.

Scotland: The status is given for a year, that's not based on any biological principles its purely on...it's a logistical thing to say once a year testing and obviously any herd can have a breakdown. To actually generate a new PI and have the PI born if you're in a clear status there's obviously a cycle of at least sort of 6 months.

The epidemiological merits of the blood test which involved testing a small number of animals in each management group were also questioned because of the ambiguity over the interpretation of management group and the possibility that not all management groups would be represented in the test. A management group was defined as a group of animals with nose to nose contact (The Scottish Government, 2015).

Scotland: Well, depending on how long the groups have been together, if you are doing five or ten animals. There is a degree of weakness there in the vet just having to trust the farmer to tell him the truth. And that's another factor in all of this, which I'll mention, which is especially with young vets – that for a vet to challenge the honesty of a farmer is very difficult, not least if they are a young vet and the farmer is an important client of the practice that they work for.

It was stated that this problem does not exist in Wales because the vet does the BVD test at the same time as the TB test (in most cases), meaning the vet will see all animal and they can use their judgement to test the animals they perceive to be the most at risk.

Wales: Because the vets are supposed to be identifying the ones that they think are the most risky, I think that's the pro of the issue.

Thus, while there is evidence that both types of tests can lead to BVD eradication there were both logistical and epidemiological challenges to tests raised by key stakeholders.

## Cross border disease transmission

The lack of integration of the schemes across borders was framed as creating epidemiological risks of disease spread. Animals moved across the UK and Ireland, but schemes were administered by individual countries with differing degrees of integration.

Northern Ireland: If you suddenly get to the point where our industry had eradicated BVD, spent lots of money to eradicate BVD, and then somebody brings in an animal, unknown with the disease and circulates and spreads and isn't caught, then, you undo all that effort.

Ireland: So, look, it'd be better if it was eliminated in the north as well. It's not going to make it any easier to eradicate it from Ireland, having a load of it up in the north.

England: In Scotland, the problem would be that England and Wales are significantly behind Scotland and don't have systems in place for all herds at this stage, and there is significant trade [...].

While stakeholders have annual meetings to discuss integration between the schemes, and progress is underway to further align different schemes individually, stakeholders stated it was potentially difficult to align the schemes so that infected animals could not move across borders.

Wales: [...] what I wouldn't want to see happen is that farmers in England could move cattle into Wales without any of those checks. Because that could cause us problems. That's the one thing that, you know, if we were going to do legislation, the legislation would have to somehow enable farmers here to get some certificate from English farmers. And that's really hard, we've tried it with TB in the past, and it doesn't, it hasn't happened, so that would worry me slightly, [...].

The difference in testing methods created issues for future integration of schemes.

Northern Ireland: However, for our programme, the bottom line is that we have a virus test, so, [...] it's got to be integrated into our results recording at present or used to give a negative status to an animal. At present, that can only be done on the basis of virus testing. So, because we are such, such a range of approaches in the different schemes, it's actually incredible, you know, for all the different jurisdictions you could hardly come up with a more diverse range, it will actually be quite difficult to align. But at the same time, that is going to have to be our standard for us accepting BVD results for another animal from another herd, and we can only accept results from laboratories that have been approved by the Department of Agriculture. So, laboratories that are used in Scotland and England, if they're not already approved by us, they would have to be approved as well.

Interviewees stated that integration may only be optimal when disease eradication has been achieved across different countries. Amendments to the EU animal health law would allow countries which are free from BVD to restrict imports from countries which are not free from BVD.

Northern Ireland: It's highly desirable if, let's say, the EU animal health law comes in under, whatever happens with Brexit, let's say that we're going to work to the EU animal health laws for trade reasons, et cetera.

Ireland: I think certainly, the ambition would be to get that, to get that freedom formally recognised at [European] commission level, and, ideally then, on the back of that, whether there'll, still be referred to as additional guarantees but you know, certainly protected trade to prevent reintroduction through uncontrolled trade, certainly.

If the EU stipulates the criteria for freedom from BVD this will become a trade barrier within the EU. But the potential rules around "BVD freedom" as stipulated by EU law were questioned by interviewees.

Scotland: [...] the EU's going to be setting rules for how to eradicate BVD. And, at the moment, it doesn't kind of match up for what we would be doing in Scotland.

Scotland: So it's all quite onerous, we couldn't manage in Scotland without a vaccination, because of all this cattle movement, we'd be insane.

Thus, integration of the different schemes was framed as difficult by stakeholders and a way to stop reintroduction of BVD from other countries was through adherence to rules around BVD freedom as stipulated by the EU animal health law, rather than through trying to align the five UK and Irish schemes individually. Similarly, to the scaling up of responsibility from industry to government we see a desire to scale up responsibility from national government to adherence to an EU framework. The inclusion of BVD in the law currently under negotiation and the designation of what BVD freedom means and how this is demonstrated will not be without political difficulties however.

## Policy Considerations

### Rethinking compliance

The hybrid industry-government structure raises questions as to what 'compliance' means in this context. The default assumption within the schemes was to understand compliance in terms of following the epidemiological advice behind the scheme to remove PIs. This is in keeping with the understanding of the goal of biosecurity as persuading farmers to adhere to advice

from epidemiological experts (Enticott and Wilkinson, 2013). But research has shown farmers have their own values and goals in relation to animal husbandry which may differ from epidemiological advice (Shortall et al., 2018). And compulsory slaughter of PI animals was too onerous and problematic for government to legislate for, given that BVD is not a zoonotic or notifiable disease. Enforced removal of animals in other schemes such as TB has been shown to be highly controversial (Enticott, 2008). This created a gap between what compliance was conceived of more broadly and how it was enforced more narrowly (if it was indeed enforced). It may be useful for stakeholders to consider in more detail what compliance means in this new domain of industry-government governance partnerships for eradication of a non-zoonotic endemic disease. The government does not have the same powers, responsibility or desire for involvement as in relation to exotic and zoonotic diseases. And assumptions that farmers will adhere to epidemiological advice in the absence of a compulsion or incentive to do so have been problematised in this example and previous ones (Shortall et al., 2018).

### Continued industry-government partnership working

Several interviewees stated that novel industry-government partnerships to govern the schemes were working well. However, reliance on government to enact legitimacy and compliance also created tensions in the schemes. There were tensions between a perceived need for government to legislate to enforce compliance but also a desire for industry to retain autonomy. In addition, as the interviews showed 'government' was far from being a homogeneous entity which could ensure compliance in a straightforward way. In Scotland for instance, central government were involved in the design and administration of the scheme, but local government were responsible for prosecution of breaches of legislation. In addition, there were problems of lack of resources in terms of funding and time at different scales of government in different countries. Given disagreement over whether or not BVD eradication was a public good (Barratt et al., 2018) the case for using scarce government resources was sometimes difficult to make. Thus, government involvement through funding and legislative support was seen as crucial for the success of the schemes but it was not a panacea.

Previous research has shown how hybrid industry-state governance mechanisms can derive their legitimacy not from government authority but through market mechanisms (Cashore, 2002). The compulsory schemes did involve private actors through for instance requiring auction markets to make sure only BVD animals were being sold. But as can be seen in quotes in the above section the government were widely viewed as the ultimate source of legitimacy and enforcement of compliance. The exception was Northern Ireland which was enlisting industry actors to change markets conditions by not accepting PI to abattoirs because there was no sitting government to pass legislation. The professed reasons for the need for government legislation were its ability to enforce actions and the perceived unpopularity of enforcement which industry stakeholders felt could erode their legitimacy – if they developed industry led non-legally binding enforcement strategies. Stakeholders may be working within this new governance domain characterised by shared decision making with an understanding of command and control mechanisms by government as the ultimate source of legitimacy and compliance for the schemes. Given that industry-government partnership governance of disease eradication is a new departure in the UK and Ireland there is a need to keep negotiating roles and responsibilities as schemes evolve.

### Negotiating integration of the schemes

There was work underway to link up databases and animal statuses between schemes individually. The challenges in terms of technical difficulties, different testing methods and rules were also highlighted. There were also discussions of the benefits of the EU setting out a framework for what BVD freedom means within the animal health law which individual schemes would need comply with. An EU wide approach to BVD eradication was an

aspiration of the report published in 2005 by the thematic network (EU thematic network on the control of BVDV, 2001). This creates a parallel tension between autonomy and responsibility created by the need for government enforcement of compliance with an industry led scheme. When the criteria for what it means to be 'BVD free' within the EU are drawn up there is a danger of the 'depoliticisation' of risk, where risk is treated as an a-political scientific issue, based on precedents of transnational biosecurity government from other studies (Higgins and Dibden, 2011). The EU designation of what BVD freedom means will involve

political choices which will benefit and disadvantage different countries and different types of farmers within those countries. The political work of negotiating the meaning of BVD freedom within the EU is underway, but the translation of this definition to different contexts will again open up questions of legitimacy and compliance within each individual country. Integration of schemes whether individually or at the EU level will also involve trading of responsibility and autonomy between different organisations.

Country	Scotland	England	Wales	Northern Ireland	Republic of Ireland
Voluntary	2010	2016	2017	2013	2012
Compulsory	2013 (compulsory testing) 2014 (movement restrictions)	No	No	2016 (compulsory testing within 20 days of birth, movement restrictions at animal level)	2013 (compulsory testing within 20 days of birth, movement restrictions at animal level) 2017 (compulsory PI investigation)
Testing method	Blood test or tag test	Blood test or tag test	Blood test	Tag test	Tag test
Administering organisation	BVD advisory group – Industry-government partnership group.	BVDFree England Scheme: BVD Steering Group. Administered by AHDB: agricultural levy body funded by farmers. BVD Stamp It Out England – Administered by Scotland's Rural College.	Animal Health & Welfare Wales (AHWW) – a collaboration between Coleg Sir Gâr and Royal Veterinary College.	Animal Health and Welfare Northern Ireland – Industry led not for profit partnership.	Animal Health Ireland – Industry led not for profit partnership.
Terminology	Negative, non-negative, positive.	Test negative, registered.	BVD free, BVD present.	Negative, inconclusive, unknown, positive.	Negative, negative herd status (NHS), inconclusive, unknown, positive.
Scheme funding	Temporarily, not currently.	Yes – under RDP 2018-2021 "Stamp It Out" project to carry out BVD tests and PIs investigations.	Yes – RDP 2017-2020 to carry out BVD blood tests and PI investigations.	Temporarily, not currently.	Yes – payment for prompt removal of PI within a given timeframe. Payment for veterinary investigation into the source of PI. Additional RDP funding in past.

# Funding

This work was funded by the Scottish Government Rural and Environment Science and Analytical Services Division, as part of the Centre of Expertise on Animal Disease Outbreaks (EPIC).

## References

- AHWNI (2019a) About Animal Health and Welfare NI. Available at: <http://www.animalhealthni.com/about.aspx> (accessed 15 May 2019).
- AHWNI (2019b) Statistics update for the BVD Programme. Available at: [http://www.animalhealthni.com/page.aspx?page\\_id=39](http://www.animalhealthni.com/page.aspx?page_id=39) (accessed 24 May 2019).
- Animal Health and Welfare Wales (2018) *Gwaredu BVD programme*.
- Animal Health Ireland (2016a) About AHI. Available at: [http://animalhealthireland.ie/?page\\_id=499](http://animalhealthireland.ie/?page_id=499) (accessed 15 May 2019).
- Animal Health Ireland (2016b) National Eradication Programme. Available at: [http://animalhealthireland.ie/?page\\_id=220](http://animalhealthireland.ie/?page_id=220) (accessed 17 January 2018).
- Animal Health Ireland (2018) *BVD eradication - Key messages for 2018*. Carrick-on-Shannon.
- Animal Health Ireland (2019) Programme results. Available at: [http://animalhealthireland.ie/?page\\_id=229](http://animalhealthireland.ie/?page_id=229) (accessed 24 May 2019).
- Barratt AS, Arnoult MH, Ahmadi BV, et al. (2018) A framework for estimating society's economic welfare following the introduction of an animal disease: The case of Johne's disease. *PLoS one* 13(6): e0198436. DOI: 10.1371/journal.pone.0198436.
- BVDFree England (2018) BVDFree England. Available at: <https://bvdfree.org.uk/> (accessed 8 August 2018).
- Cashore B (2002) Legitimacy and the Privatization of Environmental Governance: How Non-State Market-Driven (NSMD) Governance Systems Gain Rule-Making Authority. *Governance* 15(4): 503–529.
- Clegg TA, Graham DA, O'Sullivan P, et al. (2016) Temporal trends in the retention of BVD+ calves and associated animal and herd-level risk factors during the compulsory eradication programme in Ireland. *Preventive Veterinary Medicine* 134. Elsevier B.V.: 128–138. DOI: 10.1016/j.prevetmed.2016.10.010.
- Coffey A and Atkinson P (1996) *Making sense of qualitative data: Complementary Research Strategies*. London: Sage Publications.
- Devitt C, Graham DA, Coughlan S, et al. (2014) Herd owner experiences of the voluntary phase of a BVD eradication programme. *Veterinary Record* 174(19): 479. DOI: 10.1136/vr.101990.
- Enticott G (2008) The spaces of biosecurity: Prescribing and negotiating solutions to bovine tuberculosis. *Environment and Planning A* 40: 1568–1582. DOI: 10.1068/a40304.
- Enticott G and Wilkinson K (2013) Biosecurity: Whose knowledge counts? In: Dobson A, Barker K, and Taylor SL (eds) *Biosecurity: The Socio-Politics of Invasive Species and Infectious Diseases*. London and New York: Routledge, pp. 91–104.
- EU thematic network on the control of BVDV (2001) *BVDV Control Position Paper*. Brussels.
- Evermann J and Ridpath J (2002) Clinical and epidemiologic observations of bovine viral diarrhoea virus in the northwestern United States. *Veterinary Microbiology* 89(2–3): 129–139.
- Farming Connect (2017) Welsh BVD Eradication Programme FAQ. Available at: <https://businesswales.gov.wales/farmingconnect/welsh-bvd-eradication-programme-faq>.
- Gunn GJ, Saatkamp HW, Humphry RW, et al. (2005) Assessing economic and social pressure for the control of bovine viral diarrhoea virus. *Preventive Veterinary Medicine* 72(1–2): 149–162. DOI: 10.1016/j.prevetmed.2005.08.012.
- Heffernan C, Azbel-jackson L, Brownlie J, et al. (2016) Farmer Attitudes and Livestock Disease: Exploring Citizenship Behaviour and Peer Monitoring across Two BVD Control Schemes in the UK. *PLoS ONE* 11(3): 1–14. DOI: 10.1371/journal.pone.0152295.
- Higgins V and Dibden J (2011) Biosecurity, trade liberalisation, and the (anti)politics of risk analysis: the Australia - New Zealand apples dispute. *Environment and Planning A* 43: 393–410. DOI: 10.1068/a43289.
- Houe H (1993) Survivorship of animals persistently infected with bovine virus diarrhoea virus (BVDV). *Preventive Veterinary Medicine* 15(4): 275–283.
- James D (2018) Welsh farmers respond positively to BVD eradication scheme. *Farmers Weekly*, 12 March. Available at: <https://www.fwi.co.uk/livestock/welsh-farmers-responding-positively-bvd-eradication-scheme>.
- Lindberg A, Brownlie J, Gunn GJ, et al. (2006) The control of bovine viral diarrhoea virus in Europe: today and in the future. *Preventive Veterinary Medicine* 72(3): 961–979.
- Mays N and Pope C (1995) Qualitative Research: Rigour and qualitative research. *British Medical Journal* 311: 109. DOI: <http://dx.doi.org/10.1136/bmj.311.6997.109>.
- Miles MB, Huberman AM and Saldaña (2014) *Qualitative data analysis: A methods sourcebook*. Thousand Oaks, CA.: Sage Publications.
- Moennig V, Houe H and Lindberg A (2005) BVD control in Europe: current status and perspectives. *Animal Health Research Reviews* 6(01): 63–74. DOI: 10.1079/AHR2005102.
- Presi P, Struchen R, Knight-jones T, et al. (2011) Bovine viral diarrhoea (BVD) eradication in Switzerland — Experiences of the first two years. *Preventive Veterinary Medicine* 99(2–4). Elsevier B.V.: 112–121. DOI: 10.1016/j.prevetmed.2011.01.012.
- Shortall O, Sutherland L-A, Ruston A, et al. (2018) True cowmen and commercial farmers: Exploring vets' and dairy farmers' contrasting views of 'good farming' in relation to biosecurity'. *Sociologia Ruralis* 58(3): 583–603. DOI: 10.1111/soru.12205.
- SRUC (2019) Stamp it out England. Available at: [https://www.sruc.ac.uk/info/120112/premium\\_cattle\\_health\\_scheme/2001/bvd\\_stamp\\_it\\_out\\_england](https://www.sruc.ac.uk/info/120112/premium_cattle_health_scheme/2001/bvd_stamp_it_out_england) (accessed 24 May 2019).
- Suchman M (1995) Managing Legitimacy: Strategic and Institutional Approaches. *Academy of Management Review* 20: 571–610.
- The Scottish Government (2015) Farmers' guidance: BVD eradication scheme phase 4. Edinburgh.
- The Scottish Government (2016) *Animal Health and Welfare in the Livestock Industry: Strategy 2016 to 2021*. Edinburgh.
- Thulke HH, Lange M, Tratalos JA, et al. (2018) Eradicating BVD, reviewing Irish programme data and model predictions to support prospective decision making. *Preventive Veterinary Medicine* 150. Elsevier: 151–161. DOI: 10.1016/j.prevetmed.2017.11.017.
- Tratalos JA, Graham DA and More SJ (2017) Patterns of calving and young stock movement in Ireland and their implications for BVD serosurveillance. *Preventive Veterinary Medicine* 142. Elsevier B.V.: 30–38. DOI: 10.1016/j.prevetmed.2017.04.005.
- van Roon AM, Santman-berends IMGA, Graham D, et al. (2019) STOC Free: An Innovative Framework to Compare Probability of Freedom From Infection in Heterogeneous Control Programmes. *Frontiers in Veterinary Science* 6(April): 1–5. DOI: 10.3389/fvets.2019.00133.
- Weldegebriel HT, Gunn GJ and Stott AW (2009) Evaluation of producer and consumer benefits resulting from eradication of bovine viral diarrhoea (BVD) in Scotland, United Kingdom. *Preventive Veterinary Medicine* 88(1): 49–56. DOI: 10.1016/j.prevetmed.2008.07.001.
- Wernike K, Gethmann J, Schirmmeier H, et al. (2017) Six Years (2011–2016) of Mandatory Nationwide Bovine Viral Diarrhoea Control in Germany — A Success Story. *Pathogens* 6: 1–8. DOI: 10.3390/pathogens6040050.
- Williams M (2000) Interpretivism and Generalisation. *Sociology* 34: 209–224. DOI: 10.1177/S0038038500000146.
- Woods A (2011) A historical synopsis of farm animal disease and public policy in twentieth century Britain. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 366(1573): 1943–1954. DOI: 10.1098/rstb.2010.0388.