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Decision support beyond total savings—Eligibility and potential savings for individual participants from changes in the national surveillance strategy for bovine viral diarrhoea (BVD) in Ireland

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ABSTRACT

Surveillance and management of livestock diseases is often evaluated with reference to expected sector-wide costs. In contrast, we calculate losses or savings for individual herd owners of a change in monitoring strategy during a national cattle disease eradication programme: bovine viral diarrhoea (BVD) in Ireland. The alternative strategy differs in how the disease is identified; by its sample- rather than census-based approach; and by its greater cost per test. We examined the costs faced by each breeding herd if testing were conducted using serology on a sample of young stock, in contrast to the current method of tissue-tag testing of all newborn calves. Following best knowledge of the likely costs, the following input values were used: i) €2.50 per test for tissue-tag testing and €7.66 for serology, ii) serology conducted on a sample of 10 young stock per management group from either the 6–12 month or 9–18 month cohorts; iii) 3 scenarios for the number of management groups: one per herd (M∞), one per 100 cows (M100) and one per 50 cows (M50). We found that many herds would often not be able to supply a suitable sample of young stock for serology or would face higher testing costs than when using tissue tag testing. The largest number (25%) of herds would benefit from participating in the change if sampling were done in October. These could annually save between €2.1 million under M∞ and €0.8 million under M50 (€108 - €49 per herd). However, analysing herd-level data we found that 90% of all Irish breeding herds would save less than €1.42 per cow or €99 in total per annum under M∞, and €0.59 per cow or €36 in total under M50. In a sensitivity analysis, we allowed serology costs to vary between €2 and €10 per animal. Herds at the 10 t h percentile of most savings made from switching would save at most €155 (M∞ at €2 per serology test) but would not save anything under M50 at costs ≥ €10. We conclude that, under these assumptions, the expected reduction in testing costs for the majority of beneficiaries would barely outweigh the practical implications of the strategy switch or the risks to the eradication programme associated with sample based surveillance. This study does not assess the cost-effectiveness of alternatives post-eradication.

1. Introduction

Considerable costs have been associated with bovine viral diarrhoea (BVD) (Lindberg and Houe, 2005; Stott et al., 2010; Barrett et al., 2011; Richter et al., 2017), which is endemic in many countries. Control is achieved through identification and slaughter of animals persistently infected (PI) with BVD virus (BVDv), which are the main drivers of transmission (Lindberg and Houe, 2005; Lindberg et al., 2006; Lanyon et al., 2013). This method has been the cornerstone of eradication programmes in a number of countries (Rossmanith et al., 2010; Presi et al., 2011; Ståhl and Alenius, 2012; Graham et al., 2014; Laureyns, 2014; Nagy et al., 2014; Norström et al., 2014).

Surveillance to identify PIs is based on one of two general methods – tissue tag testing to detect the presence of the virus or serology to detect viral antibodies. In the Republic of Ireland ('Ireland'), a national eradication programme was initiated in 2012, and testing was made compulsory from 2013 onwards (Anon, 2012, 2014; Graham et al., 2014). It has been based on tissue-tag testing of all newborn calves,

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with samples collected and submitted by herd-owners, and is similar to that previously implemented in Switzerland and Germany (Ståhl and Alenius, 2012). It has resulted in a marked reduction in the number of calves considered to be PI, from 0.77%, in 2013, to only 0.12%, for the year to 20th December 2017. The programme assigns a negative herd status (NHS) to a herd if the following three conditions are met: i) tissue-tag testing for a minimum of three years; ii) a negative BVDv status for all animals in the herd (assigned directly on the basis of the animal itself having been tested, or indirectly on the basis of it having been the dam of one or more test-negative calves); and iii) no PI animals found within the herd during the previous 12 months. By July 2017 approximately 69,000 of 80,000 breeding herds had achieved NHS status (Anon, 2017). The aim of the programme is to achieve eradication of BVDv in the shortest possible time.

Decisions on the management of the programme are taken by a BVD Implementation Group (BVDIG). As more and more herds obtain NHS status, the BVDIG has been considering alternative pre-eradication options for these herds. In particular, the introduction of serological surveillance was suggested for NHS herds through the sample-based screening of homebred young stock, known as young stock check testing. This approach, in addition to testing of milk samples in dairy herds, has been the basis of the successful eradication programmes in the Scandinavian countries (Lindberg and Alenius, 1999; Houe et al., 2006; Løken and Nyberg, 2013). The conceptual basis of such serological testing is that any PI animal present in a given management group will transmit infection to the majority of other cattle in the group within a relatively short period of time. This has been shown experimentally by Sarrazin et al. (2014). Therefore, screening of a limited number of homebred animals for antibodies to BVDv may provide an effective means of surveillance. Detection of antibodies would point to the presence of BVDv in the herd within the lifetime of the animals sampled. Each separately managed group within the target age range must be sampled to achieve high herd-level sensitivity (HSe) (Houe et al., 2006). The required number of samples per group has varied between different national programmes.

In Ireland, the BVD technical working group (BVDTWG), which provides scientific information to inform BVDIG decision-making, has considered the use of serological surveillance (without bulk-milk testing) during the pre-eradication phase, to consist of sampling 10 young stock (of either sex) from each management group with a cut-point of two positive test results. This sample size is consequent to requesting herd-level sensitivity (HSe) and specificity (HSp) of 99.5% and 100%, respectively (*HerdAcc;* Jordan and McEwen, 1998). Calculations assumed a cohort size of 50 animals, a design prevalence of 50% and individual test sensitivity and specificity of 96.9% and 97.8%, respectively (Guelbenzu Gonzalo, 2015). Animals would be tested when at least 6 and preferably 9 months of age, in order to prevent false positive results caused by maternally derived antibodies (MDA, Muñoz-Zanzi et al., 2000; Sagar, 2003). Additionally, the management group needs to have been established for a long enough period to allow sufficient contact between a PI and its fellow cohort animals to achieve the design seroprevalence on which the sample size is based. On the other hand, testing of animals older than 18 months of age is usually not recommended, as positive test results do not necessarily indicate recent exposure of the animal to the virus. On the basis of these considerations, testing from amongst the 6–12 month or 9–18 month age range has been recommended (Pillars and Groom, 2002; Houe 1994; Anon, 2015).

Applying serology in NHS herds would thus require sampling only a proportion of the young stock in each herd, as opposed to tissue-tag testing every calf born. Using serology may therefore be a cheaper option for some herds. However, this would clearly depend on the cost of each surveillance method. Furthermore, many herds might not be able to provide a sufficient number of homebred young stock to allow serology to be used as a surveillance method, particularly if many are sold in advance of serological testing being carried out.

The usefulness of veterinary interventions in the control of livestock diseases is often evaluated on the basis of financial costs. This has usually been done with reference to total costs or average gain or burden per producer across an entire sector. However, in reality there are usually important differences in size and production practices which determine the distribution of costs and benefits amongst producers and these may result in a highly skewed distribution of benefits. This means that total or average values may not be particularly useful to decision-makers. However, with the growing availability of data at an individual animal-level this kind of simplification is no longer necessary.

2. Objectives

With the above considerations in mind, we conducted an analysis to examine eligibility and potential savings for individual participants from changes in Ireland's BVD surveillance strategy. We did this to inform decision-making on whether reductions in testing costs would mean that serology should be used as an alternative for surveillance in NHS herds prior to eradication.

3. Methods

3.1. Data sources, estimates of testing costs and herd type classification

Data for the analysis was drawn from the Irish Government's Department of Agriculture, Food and the Marine (DAFM) Animal Identification and Movement system (AIM) database. We used data for 2015 comprising animal-level information on cattle movements and birth registrations. Data processing was conducted in Microsoft SQL Server 2012, SAS 9.3 and Microsoft Excel 2010, and graphical outputs produced using Microsoft Excel 2010.

To estimate the costs of tissue-tag testing, we calculated the number of calves born in each herd in 2015 and multiplied this figure by €2.50, which an investigation by Animal Health Ireland (AHI) had found to be the most likely testing cost to be faced by NHS herds. Tissue-tag testing is carried out in designated laboratories (Graham et al., 2014), with samples from NHS herds typically pooled for screening by real time RT-PCR.

To compare these costs with serological testing of blood samples collected by the herd's veterinary practitioner, we calculated, for each calendar month in 2015, the number of young stock still in their birth herd for each of the two recommended age classes: i) those between 6 and 12 months; and ii) those between 9 and 18 months. Using these data, for each month of 2015 we identified those herds with $\geq$10 animals available for serological testing in at least one of the age classes.

As we did not have any information on the management structure of each herd, costs for serology were calculated under 3 different assumptions about the relationship between the number of cows (female animals which had produced a calf) in the herd on 30 th June 2015 and the number of distinct management groups, with a sample of 10 animals tested from each management group. In our opinion, the three assumptions covered the plausible extremes for management group size in both dairy and beef herds in Ireland: i) all members of the herd managed as one group and ii) one management group per 50 cows, as well as iii) an intermediate value of one management group per 100 cows. We will refer to these as M∞, M50 and M100, respectively. For most of our analysis, we assumed a combined sampling and test cost for serology of €7.66 per animal, in accordance with information provided by investigations conducted by AHI. Herd owners are required to meet the test cost themselves. We did not include the costs of submitting either tissue tag samples or blood samples to a laboratory. We assumed that the effectiveness of the two methods for eradication of BVD in Ireland was similar, as shown in modelling work described in Thulke et al. (2018).

We also wanted to examine how the results of these analyses would

vary according to the enterprise type (beef, dairy or mixed) of the herd. Following Good et al. (2009) and Tratalos et al. (2017), we classifed Irish cattle herds as being of beef or dairy enterprise type if ≥66% of their stock were from beef or dairy breeds, respectively, calculated using their combined end of year herd profiles for 2014 and 2015. All other herds were classified as 'mixed', except a few herds which had no stock at the end of the year in both 2014 and 2015: these were classified as 'unknown'. Breed type in the AIM system is based on breed of the sire.

3.2. Comparison between herds

Using these data we compared: i) how the number of herds with sufficient young stock to supply a sample for serological investigation varied by test-month (in 2015) and enterprise type, ii) how potential savings in testing costs, and the number of herds that would achieve reduced testing costs following a switch to serology, would vary by month, enterprise type and management group size (M∞, M50 and M100), iii) the distribution of these reduced costs across herds, and v) how potential testing costs varied with the number of cows in each herd.

As we have already described, we made a number of assumptions in this study on matters such as the cost per animal, sample size and the age of sampled animals for serology. Amongst these, we were least certain of the cost per animal for serology, recognising that these might reduce as test volumes grow, or (less likely) increase due to unknown factors. We therefore examined how costs for serology might affect i) the number of herds which would potentially benefit from a switch to serology, ii) total reduced testing costs if these herds were to switch and iii) savings per herd in those herds which would achieve the largest reduction in costs. This was done by means of a Visual Basic for Applications (VBA) macro which calculated each of these 3 values at increments of 0.1 Euro cent at testing costs between €2 and 10 per animal, for the same 3 management group sizes used previously.

4. Results

4.1. Herds with sufficient young stock for serology

There were 78,380 herds which produced calves in 2015, consisting of 59,196 beef, 14,247 dairy, 4880 mixed and 57 of unknown breed type. These herds had 2,322,989 cows as of 30th June 2015, of which 998,151 were in beef, 1,117,120 were in dairy, 207,303 were in mixed and 415 were in unknown herd types. 41,606 herds had ten or more young stock in at least one of the two age classes examined (6–12 or 9–18 months of age) in at least one month of the year. Of these, almost all (40,759) had sufficient young stock in the younger, 6–12 month, category and most (34,663) also in the older category. The months between September and April furnished the most herds with sufficient young stock. Dairy herds were much more likely to have sufficient young stock than beef (Fig. 1).

4.2. Herds with both sufficient young stock and a financial incentive to choose serology under 3 different management scenarios

The number of herds which both i) contained sufficient young stock for serological testing, and ii) would achieve a reduction in testing costs from a switch to serology also varied by enterprise type and month of the year when testing would be conducted, under each of the three management group size variants (Fig. 2). Total potential savings were for all months much greater for the dairy than beef sector and fewer beef than dairy herds could reduce costs by switching to serology. This was true even though beef herds greatly outnumbered dairy, a reflection of larger herd sizes amongst the latter. The largest number of herds would achieve reduced costs in October, with 19,712 (25%) doing so under M∞, 19,686 (25%) under M100 and 16,470 (21%) under M50. Each month from September to March showed only slightly lower percentages than October but there was a pronounced dip during May to August, reflecting the larger number of herds lacking a large enough sample of homebred young stock during these months. October was also the sampling month for which the greatest total savings could be realised: testing costs could be reduced by over €2.1 million under M∞ and €1.8 million under M100, and by approximately €0.8 million under M50.

4.3. Reduced costs for individual herds

All further investigations were conducted under the assumption that testing would take place in October, as more herds could potentially benefit from a switch to serology if testing took place then. Fig. 3 shows how savings would be distributed across the national herd, at an individual herd-level, if herds with a suitable number of young stock were able to switch to serology (and assuming that only herds able to benefit financially would do so), both in terms of € saved per cow and summed for the herd. Fewer than 10% of all Irish herds would save more than €1.42 per cow under M∞, €1.27 under M100 and €0.59 under M50. Similarly, fewer than 10% of all Irish herds would save more than €99 each year in total under M∞, €96 under M100 or €36 under M50. Amongst those herds that would save, the median amount saved would be €73.4 per year under M∞ and M100, and €34.3 under M50.

4.4. Reduced costs by number of cows in the herd

The variability in potential savings for individual herds is shown in Fig. 4, which plots the relationship between the number of cows in the herd and reduction in testing costs if all herds which had a suitable sample of young stock for serology were to use it (irrespective of whether they would achieve reduced costs). Many of the smaller herds would face larger costs using serology than tissue-tag testing. As might be expected, given that testing costs for tissue-tag testing are a function of the number of calves produced, the relationship between the number of cows in the herd and the potential reduction in costs was found to be positive.

4.5. Impact of changes in serology: cost-sensitivity analysis

Analysis of the effect of varying costs for serology (Fig. 5) showed that overall costs varied between €3.6 million at the lowest serological testing cost (€2) under M∞ to €0.24 million at the highest cost (€10) under M50 (Fig. 5a). The effect of the number of management groups tested (M∞, M50 or M100) on potential savings from switching to serology was much more evident at higher testing costs (Fig. 5). This was particularly true when the number of herds benefitting from switching was measured (Fig. 5b), where it was found that the number of groups made little difference at serology costs of less than €6 per sample. At the lowest cost, €2, almost all herds which were able to supply enough (10) appropriately aged young stock for serology would achieve lower testing costs if they switched, as the cost per animal tested would be lower than for tissue-tag testing (Fig. 5b). At serology costs of less than €5, most herds with more than 50 cows (and thus > 1 management group under M50) would face lower testing costs using serology, and therefore the number of herds which would benefit from a switch was found to be only slightly lower under M50 than M∞ (Fig. 5b). Restricting this analysis to the 10th percentile of herds which could potentially save the most from switching showed very little difference between the M50 and M100 scenarios, but that potential savings were much higher for these groups than for the M50 group, particularly as the assumed cost of serology testing increased (Fig. 5c). However, Fig. 5c reveals that for 90% of all Irish herds the savings from a strategy switch would be < = €155 per herd even under the most extreme assumption that costs per test for serology would be lower than for tag testing.

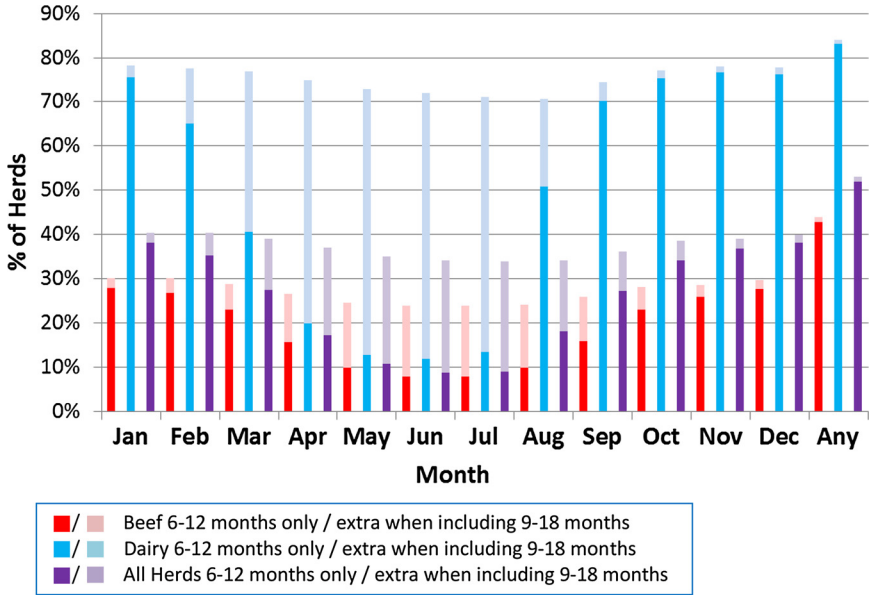

Fig. 1. Percentage of herds with sufficient (10) young stock for serological testing in each month of 2015, by herd type (beef, dairy, mixed). Data for 'Any' month shows the percentage of herds which would have a large enough sample if the month of testing could be tailored to each herd. The section of each bar shown in bold represents those with sufficient animals in the 6–12 month cohort. The pale section shows the number of additional herds which would be eligible if the sample could also be taken from a 9-18 month cohort. Separate information is shown for beef and dairy herds and for all herds (including mixed) considered together.

5. Discussion

Using BVD as an example, the objective of our study was to estimate the expected financial impact of changing an animal health intervention strategy on the individual beneficiary. Only with this information can we make informed decisions on the suitability of differing control options in a programme driven by individually acting agents. We used a three-stage method which might also be used for other diseases and interventions, including: i) evaluating herd-level eligibility to participate in each strategy using annual stocking and production data, ii) estimating costs, both industry wide and per individual production unit i.e. cattle herd, summed for the unit and per individual animal (calving cow in our example), and iii) examining variability in the distribution of individual net benefits including grouping of beneficiaries into percentiles according to the net benefit accrued.

This method has allowed us to compare the herd-level costs of tissue-tag testing of all newborn calves in a herd versus cohort-based sampling of young stock for serological testing. Assuming our best estimates of the testing costs of both techniques, we have found that total savings across the Irish cattle industry would be approximately €2.1 million, which is substantial compared to the current annual testing budget of about €9 million; although it is small relative to the estimated annual costs of BVD of €102 million before the eradication programme was commenced (Stott et al., 2012). BVD control in Ireland is an industry-funded initiative designed to benefit its individual members. Therefore, we believe that the benefits per individual participant in a strategy change is more useful information than the total expected gains. Only 25% of herds would face reduced testing costs if they switched to serology, irrespective of what assumptions we made about the number of management groups; and, depending on the number of such groups per herd, as few as 2.3% of all Irish herds would save more than €1 per cow, or €100 in total (Fig. 3). In general, dairy herds would benefit more from a change to serology than beef herds, which reflects the fact that dairy herds are typically larger than beef herds in Ireland.

We have found that sampling during the period September to March would maximise the number of herds with a sufficiently large sample of young stock for serological testing. We chose October for detailed analysis as this was the month in which most savings could be made if all serological testing were conducted then, and on the assumption that it would not be practicable to have sampling dates tailored to each herd. However, we did find that an additional 14.6% of herds would have a sufficiently large sample for serological testing if the sampling month could be tailored to each herd, rather than required to be October (compare Fig. 1. October – All herds with Fig. 1. Any month – All herds). This seasonality may be a reflection of the seasonal nature of cattle breeding in Ireland, where predominantly grass-based production systems biases the calving profile to the spring (DAFM, 2016), combined with common practices such as selling male calves from dairy herds in their first month of life and selling weaned beef calves in the autumn.

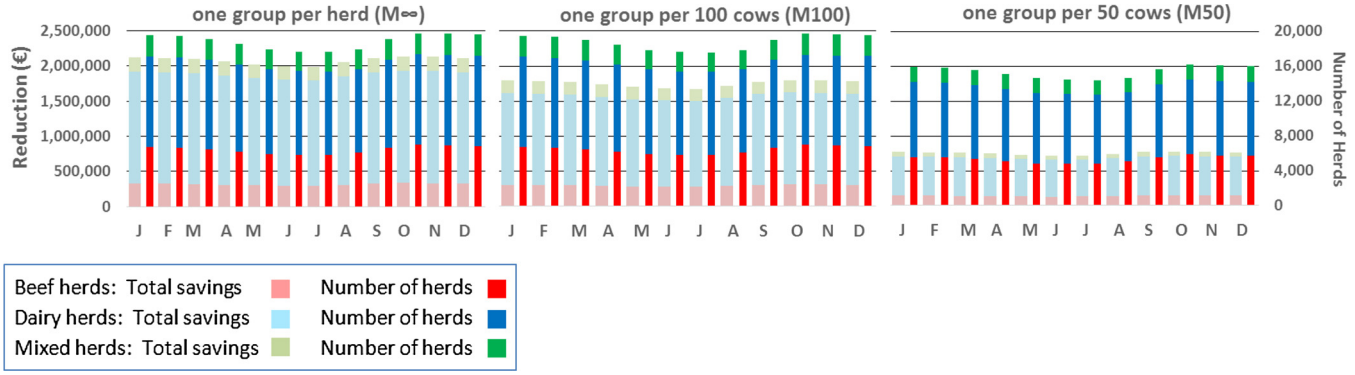

Fig. 2. The number of herds (right-hand axis) with a suitable sample of young stock in 2015 which would reduce testing costs by switching to serology (darker bars) and the total annual reduction (left hand axis) in these costs which would be made if these herds were to switch (pale bars), for beef, dairy and mixed herds, by month in 2015.

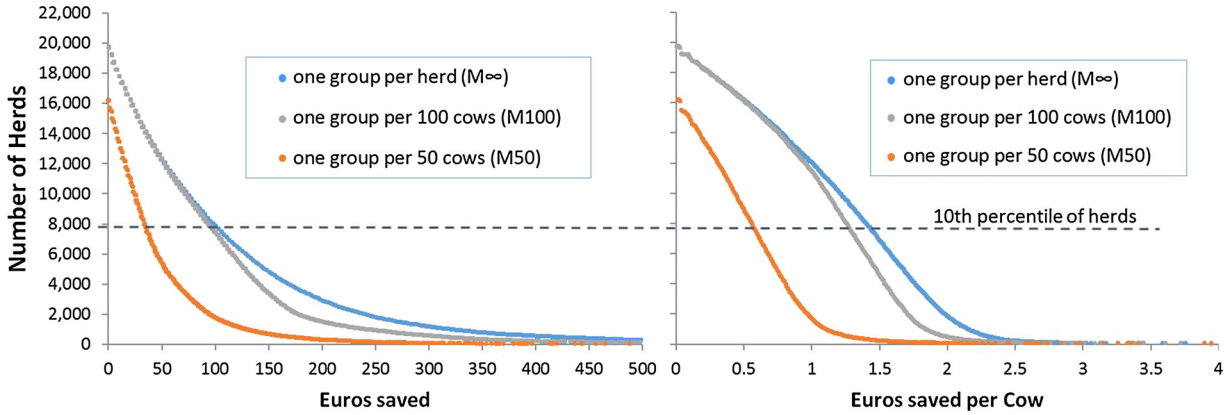

Fig. 3. The distribution of € saved per herd (left hand figure) among the 78,380 breeding herds in Ireland, and per cow in these herds, if all those herds with a suitable sample of young stock and able to benefit financially were to switch to serology, under 3 assumptions on the number of young stock management groups (see legend). For a given value on the X-axis, the corresponding Y-axis value shows the number of herds which would save that amount or more.

We have utilized a number of assumptions in our analysis which should be borne in mind when interpreting the results. One is that herds need to be able to supply a sample of 10 animals of appropriate ages if serology is to be an option for them. In the scientific literature, the number of animals per management group required for serological testing varies between 5 and 19 (e.g. Pillars and Grooms, 2002; Hanon et al., 2016; see also Humphry et al., 2016). The BVDTWG recommendation regarding sampling is based on the strategic requirement to provide sufficient sensitivity and specificity at the herd-level, which, used with a cut-point of two positive test results, requires 10 blood tests per management unit (Jordan and McEwen, 1998). While smaller sample sizes and a cut point of 1 would reduce immediate costs, the associated reduction in HSp would increase costs from follow up testing and would also undermine confidence in the surveillance strategy. In theory, herds could be allowed to test fewer young stock if 10 were not available. While this strategy could be used in herds where fewer than 10 calves are born each year, it will not be less costly than tissue tagging, based on the higher unit cost of serology (approximately three-fold) and the small number of animals being tested. It would not be appropriate in those herds where most of the young stock have been sold before reaching the testing age for serology (see Tratalos et al., 2017).

We also assume that herds should be able to supply these sampled animals either from a 6–12 month or 9–18 month cohort. Again, the age ranges stipulated vary between published studies, and we have chosen these two ranges as the most typical, and able to fit the production systems of most Irish herds. Making the age criteria wider (for example, allowing the sampled animals to come from the entire age range of 6–18 months) or narrower (for example, allowing only the 9–18 month age group, avoiding the possibility of interference from MDA) might have some impact on our results. In some cases the testing of older animals which had remained in the herd since the last herd test and had previously tested negative might also be possible. However, it should be borne in mind that herds with fewer than 10 young stock in both of the two age cohorts considered in this study would also usually produce fewer than 30 calves, and would therefore face lower costs for tissue-tag testing at €2.50 per calf than serology at €7.66 per calf even if serology were an option for them. We have also assumed that all young stock tested should be homebred stock, to avoid positive tests due to infection in previous herds.

We have assumed a cost of €2.50 per animal for tissue-tag testing, which the current cost offered to NHS herds. In contrast, our estimate of €7.66 for serology, used for most of the analyses, is a predicted cost based on a survey of designated laboratories and expert opinion within the TWG. It assumes that sera will be tested individually, as no Irish laboratories are currently designated for testing of pooled sera, although pooling has been used elsewhere (Løken and Nyberg, 2013; Norström et al., 2014; Muñoz-Zanzi et al., 2000). This lack of certainty is the reason we conducted the cost of serology to a sensitivity analysis (Fig. 5).

We assume that sampling would be conducted in a single month of the year. Although this is probably a simplification, we believe that it represents a good approximation to the reality in Ireland where, given the predominantly spring-based calving patterns, serology would be conducted during a single time period in the autumn.

It should be emphasised that our analysis only considers the direct costs of the two surveillance strategies, i.e. laboratory costs and professional fees for sample taking. However, other costs might need to be considered to capture the full economic costs of the two systems. For example, postage costs are not included in the tissue-tag testing or

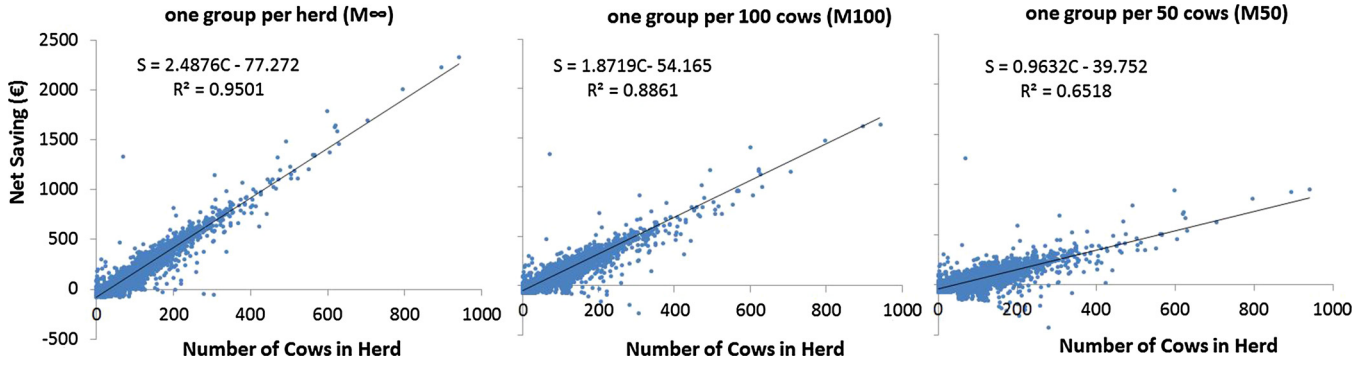

Fig. 4. Net savings/loss versus the number of cows for each herd if all herds with a suitable sample of young stock were to switch to serology. A linear trend line is shown for each plot as well as the Pearson regression equation used to generate it.

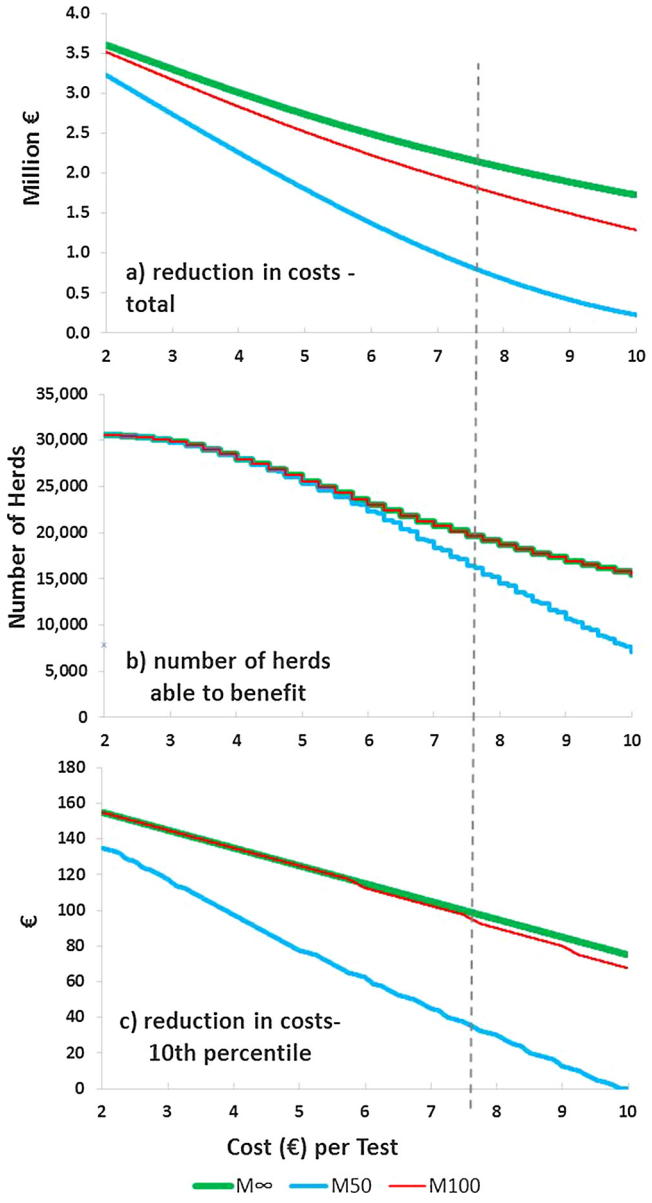

Fig. 5. The effect of testing costs for serological surveillance for BVD on a) the total annual reduction in costs from a switch to serology in all herds which both i) had a suitable sample of young stock in 2015 and ii) would reduce costs by switching; b) how many herds would meet these criteria; and c) the reduction in costs per herd which would be experienced by a herd at the 10th percentile of savings. The grey vertical line is at €7.66, the assumed most likely testing cost.

serological analyses, and costs of a veterinary visit (as opposed to a sampling fee) are not considered for serology on the assumption that the sampling can be carried out in conjunction with another visit. Furthermore, we did not consider additional costs of PI identification and removal for herds identified as positive under serological testing (although there would be relatively few of these). In both cases, inclusion of these costs would further reduce the cost-effectiveness of the serological alternative and the number of herds for which it would be cheaper than tag testing.

We conducted our analyses on the assumption that young stock management groups sizes would vary between one group per 50 cows and one group for the whole herd (irrespective of herd size), and assumed that the number of management groups would be determined purely by the number of calving cows. In reality, group sizes would differ between herds and may be determined with respect to factors other than the number of animals - for example, males are commonly separated from female calves in dairy herds. However, we believe the three management group sizes we consider (M∞, M100 and M50) cover a plausible range for most Irish herds.

We have made 2 further assumptions which are less important than those discussed above but should nevertheless be borne in mind. Firstly, we have calculated costs per cow by dividing total testing costs per herd by the number of cows in that herd on 30th June. In the vast majority of Irish herds, the mid-year number of cows in the herd should be a good proxy for the size of the herd's breeding stock for a given year. However, the possibility of in- and out-movements mean that this might not always be the case, and this should be borne in mind when examining the information shown in Fig. 3 (especially outliers for Euros saved per cow) and Fig. 4 (all outliers). Secondly, in all herds where we estimate i) that there were sufficient (10) young stock for serology and ii) that, based on the number of cows in the herd on 30th June, there was more than one management group, we have assumed that in these herds there would also be sufficient (10) young stock in each group – this may not always be the case, for example where there has been a lot of selling of young stock or where the number of cows in the herd has been recently increased.

Our analysis suggests that, before eradication is achieved, serological testing may only be practicable and cost effective for a minority of herds in Ireland, particularly in the beef sector, where herds often contain relatively few animals. In addition to costs, there are other considerations which argue for the continuation of tissue-tag testing. Firstly, if serology were to replace tissue-tag testing, tracing of PIs would be harder to achieve, as many may have moved from their birth herd before serological testing is conducted (see Tratalos et al., 2017, for an analysis of Irish calf movements), a problem which has been identified in the Swiss programme after making a switch from tissue-tag testing to serology and bulk milk sampling (Schwermer and Di Labio et al., 2016). Secondly, tissue-tag testing has been shown to be effective in reducing the number of PIs born each year in Ireland and is expected to result in eradication of BVD there; it would therefore introduce unnecessary risk to switch to a different approach in the later stages of the programme. Thirdly, a mixed tissue-tagging / serology programme would be likely to bring about further inefficiencies caused by trying to integrate the two approaches. Finally, the analysis did not consider secondary market effects due to changes in the number of tag tests conducted or the impact of other infections that could undermine our confidence in the results of serological testing e.g. border disease virus (BDV) circulation (Kaiser et al., 2017).

It is recognised that serological surveillance will have an important role to play after eradication has been achieved, when the primary purpose will be to provide early warning of reintroduced infections rather than prompt detection of PI births. In this context, many of the limitations identified here will be less important. There will be greater flexibility in the ages of animals sampled, with the confounding effect in younger calves of maternally derived antibodies being greatly reduced, while older animals can be sampled, increasing the numbers available per herd, reducing the impact of sale of young stock and facilitating greater flexibility in the timing of sampling. In addition, other serological surveillance strategies, particularly the use of bulk tank milk testing, will become more useful as seroprevalence falls.

As other countries seek to eradicate BVD from their national herd, they should take these results into account when evaluating alternative surveillance strategies. In particular, the uneven distribution of benefits amongst herds, with many smaller herds facing higher testing costs if they were compelled to use serology, highlights the fact that there may be losers as well as winners from any switch. In general, the larger the herd and the fewer its management groups the more cost-effective serology becomes as a surveillance method. Furthermore, we believe that the general approach here is more widely applicable to other diseases.

6. Conclusions

An examination of benefits at the herd level has shown the majority of Irish cattle herd owners would not benefit financially from a switch to serological testing for BVD before the disease is eradicated in Ireland, with few, generally very large, herds benefitting substantially. In the light of this, and given the risks involved in modifying an existing successful eradication programme, we believe the use of serology in BVD monitoring in Ireland should not be taken up until eradication has been achieved. This analysis has shown the importance of looking at the herd level in examining costs and benefits of any proposed changes to disease surveillance.

Conflicts of interest

None.

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