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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