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The relative effectiveness of testers during field surveillance for bovine tuberculosis in unrestricted low-risk herds in Ireland

T.A. Clegg[a,*], A. Duignan[b], S.J. More[a]

[a] Centre for Veterinary Epidemiology and Risk Analysis, UCD School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland
[b] Department of Agriculture, Food and the Marine, Backweston, Celbridge, Co., Kildare, Ireland

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ABSTRACT

In Ireland, new bovine tuberculosis (bTB) cases are detected using both field and abattoir surveillance. Field surveillance is conducted on all cattle annually using the single intradermal comparative tuberculin test (SICTT). Testing is reliant on the skills and experience of the tester and a broad range of factors may adversely affect test accuracy. There is considerable emphasis on quality control (QC) within the national programme and field inspection of testers has been conducted in Ireland for many years. Since 2008, inspection has been supplemented with quantitative performance reports, enabling testers to be evaluated and ranked using a range of performance indicators. The objectives of this study were first, to quantify the relative effectiveness of testers during field surveillance and, second, to assess whether there has been any change in the performance of testers between 2008 and 2011. Mixed logistic regression was used to assess the relative effectiveness of testers. The study population included all testers who carried out at least ten eligible tests in Ireland during 2008 or 2011. The outcome measure was a herd restriction at the eligible test. Results from the mixed model indicated that the variation by tester had significantly ($p = 0.039$) decreased from 0.589 in 2008 to 0.426 in 2011, indicating an increase in consistency of testing, after accounting for other known risk factors. This study provides objective data on the variation in tester performance over time and the relative performance of testers during field surveillance in Ireland.

1. Introduction

In Ireland, new bovine tuberculosis (bTB) cases are detected using both field and abattoir surveillance. Field surveillance is conducted through annual testing of all cattle in unrestricted, low-risk herds using the single intradermal comparative tuberculin test (SICTT). In this test, bovine and avian PPD tuberculins are used in combination to measure the skin response at 72 [±4] hours following intradermal injection (Monaghan et al., 1994). Field surveillance is conducted by private veterinary practitioners (PVPs). Each PVP is nominated and paid directly by their farmer clients. Surveillance is also conducted in the abattoir; between 30 and 35% of herd bTB breakdowns were detected using this method (Abernethy et al., 2013). Details of the management of Irish herds infected with *Mycobacterium bovis* are described by Good et al. (2010).

Variations in the quality of both field and abattoir surveillance have been areas of concern for some time, noting that aspects of each procedure require subjective

* Corresponding author. Tel.: +353 1 716 6142; fax: +353 1 716 6147.
E-mail address: tracy.clegg@ucd.ie (T.A. Clegg).

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interpretation. In previous work, concerns have been highlighted regarding abattoir surveillance and the relative effectiveness of abattoirs in detecting lesions among attested cattle (Frankena et al., 2007), although discrepancies between abattoirs have lessened over time (Olea-Popelka et al., 2012). Concerns have also been raised about the effectiveness of field surveillance, which is highly reliant on the skill and experience of the individual tester (Monaghan et al., 1994; De la Rua-Domenech et al., 2006). A broad range of factors may adversely affect test accuracy, including the quality of handling facilities, site preparation and tuberculin injection technique etc. Field inspection of testers has been conducted in Ireland for many years. Since 2008, this has been supplemented with quantitative performance reports, enabling the performance of each tester to be evaluated and ranked using a range of performance indicators (Duignan et al., 2012). The objectives of this study were to quantify the relative effectiveness of testers during field surveillance and, to assess whether there has been any change in the performance of testers in Ireland between 2008 and 2011.

2. Materials and methods

2.1. Study population

The study included all annual herd-level screening tests conducted in unrestricted herds (subsequently termed an 'eligible test') in Ireland during 2008 and 2011. All testers who carried out at least ten eligible tests during 2008 or 2011 were included. At this test, the 'standard' interpretation of the SICTT was applied. An animal with an increase in skin thickness at the bovine site more than 4 mm greater than the increase at the avian site was classed as a 'standard' reactor. Herds with one or more reactor animals at this test had movement restrictions imposed ('a herd restriction') until two clear consecutive tests were achieved.

2.2. Statistical analysis

A mixed logistic regression model, incorporating tester as a random effect, was used to model the probability of a herd being restricted with 1 or more reactor(s) using the GLIMMIX procedure in SAS v 9.3 (SAS Institute Inc., 2008). The risk factors considered in the model included *Year*; herd size (*Hsize*) at the time of the test; herd incidence within the county in the previous year (*Location*); number of days free from bTB prior to the test (*History*); proportion of cows in the herd (*Pcows*); season of the test (*Season*) and the number of animals purchased in the previous year aged over 12 months (*Boughtover1*). Each risk factor was tested within a univariable model. Significant risk factors (p-value $\leq$0.20) were then used to build the multivariable model. Two-way interactions between *Year* and the other risk factors were included in the initial multivariable model. A backward selection procedure was used based on a likelihood ratio test ($p > 0.05$). An assessment of the goodness-of-fit was obtained by examining plots of studentised residuals. The appropriate format or transformation of continuous variables was based on a plot of the log odds of the outcome and the variable. The choice of estimation method used to fit the model was based on the AIC.

A likelihood ratio test was used to compare a model with separate variance parameters for the testers each year to a model with the same variance parameter for both years (SAS Institute Inc., 2008). The odds of a tester recording a restriction each year, compared to an average tester, were estimated using the random effects from the model along with the confidence limits (Cohen et al., 2013). Testers were ranked according to the odds ratio (OR) from the final model and then grouped (in 10 evenly sized groups) according to this ranking. OR group 0 included the 10% of testers with the lowest odds of finding a restricted herd, and group 9 the 10% of testers with the highest odds.

The average number of herds and animals tested per tester and reactors per restriction by the OR groups were compared using an analysis of variance (ANOVA). The proportion of herds that had an animal with a lesion at slaughter in the following year by OR group were compared using a chi-square test. For testers that tested in both years, the rankings in the different years were compared using Spearman's correlation coefficient.

The mixed logistic regression models were repeated for two sub-sets of data. The first included all counties that increased in herd-level incidence, and the second all counties that decreased in incidence between 2008 and 2011.

3. Results

In 2008, 901 testers conducted 10 or more eligible tests, on 89,257 herds, including 2,031 (2.28%) that were restricted. In 2011, 877 testers conducted 10 or more eligible tests on 94,470 herds of which 1,661 (1.76%) were restricted.

All risk factors were significant in the univariable analysis. In the multivariable model, log of *Hsize* was used and all other variables were treated as categorical. The final multivariable model included the risk factors: *Year*, log of *Hsize*, *Pcows, Location, History, Season, Boughtover1* and the 2-way interactions: *Year* × log of *Hsize* and *Year* × *Boughtover1* (Supplementary material: Table 1). A model estimated using the Laplace method was preferable based on the AIC.

The variance of testers in 2008 was significantly ($p = 0.039$) higher (0.589) compared to 2011 (0.426). Based on the confidence interval of the odds ratio for each tester, one tester in 2008 and none in 2011 had significantly lower odds compared to the average tester in the respective year. The proportion of testers identifying significantly more restrictions than the average was higher in 2008 (8.9%) compared to 2011 (4.6%). The odds of detecting a restriction ranged from 0.33 to 7.25 in 2008 and from 0.45 to 5.46 in 2011.

There was a significant difference by OR group in the average number of herds and animals tested and the restriction rate in both years ($p < 0.001$) (Table 1). In 2008, there was also a significant difference ($p < 0.001$) in the average number of reactors per OR group and in the proportion of herds with an animal with a lesion at slaughter in the following year ($p = 0.015$). There were no significant differences in either of these measures in 2011 ($p > 0.158$)