Evaluating the performance of risk-based trading scores to control bovine tuberculosis

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Introduction

The Risk Based Trading (RBT) Score was developed using bovine tuberculosis (TB) testing data from 2009 to 2010 (Adkin et al 2016). In the final methodology, herds are given a score from 1 to 5 based on their perceived TB risk. The TB history component of the risk score is published on the ibTB tool for herds in England. It can be used by farmers to inform their purchasing choices when introducing new animals to their herds.

In this study, we used TB surveillance data collected between 1 January 2014 and 31 March 2020 to evaluate the performance of the whole RBT score.

The **null hypothesis** was that there would be no increase in the odds of a positive TB test as the RBT score increased.

Methods

All herds tested for TB using the single intradermal comparative cervical tuberculin (SICCT) test in Great Britain, between 1 January 2014 and 31 March 2020, were selected for the analysis.

The **exposure variable** was the RBT score assigned to each herd on the day before a TB test took place. The **outcome variable** was the result of the herd TB test (positive or negative).

All data handling and statistical analysis was carried out using STATA 14. Univariate and multivariable logistic regression was carried out using the *logistic* command.

Assessment of confounding and effect modification for additional variables was carried out using the test of homogeneity of ORs in the Mantel-Haenszel (M-H) estimate of the trend of odds using *mhodds outcome exposure, by(variable)*.

Figure 1. GB TB Risk Areas

The Risk Based Trading score

The RBT score is assigned to all herds in Great Britain based on their history of TB and whether they have had a risky cattle movement in the past 5 years. All herds start with 1 point, and additional points are added as follows:

TB history (years since a TB breakdown)

0–2 years	+3
3–5 years	+2
6–10 years	+1
>10 years	No additional points

Cattle movements from a RBT Score 5 herd

>0 in the last 5 years	+1

For example, a herd that had a TB breakdown 4 years ago and purchased cattle from a Score 5 farm 2 years ago would have:

Starting point	1
TB history points	+2
Cattle movement points	+1
Final RBT score	**= 4**

Univariate analysis of the Risk Based Trading Scores

As the risk score increased, the percentage of herds that tested positive for TB increased (Table 1). Twenty two per cent of herds classified with a risk score of 5 went on to test positive for TB, compared to only 2.8% of herds with a risk score of 1. Herds with a risk score of 5 were 9.66 times more likely to test positive for TB, compared to herds with a risk score of 1, with 95 per cent confidence that the true odds of disease is between 9.25 and 10.10 (95% CI).

Multiple factors are known to be associated with the risk of a herd contracting TB. Within the dataset several variables were assessed to explore the stratum specific performance of the Risk Based Trading score. This process helps to identify which variables should be controlled for within a multivariable analysis, and those variables that are effect modifiers, and so where the results should be presented within individual stratum.

Table 1 Percentage of TB positive herds and crude odds ratios with 95% confidence intervals, by risk score category

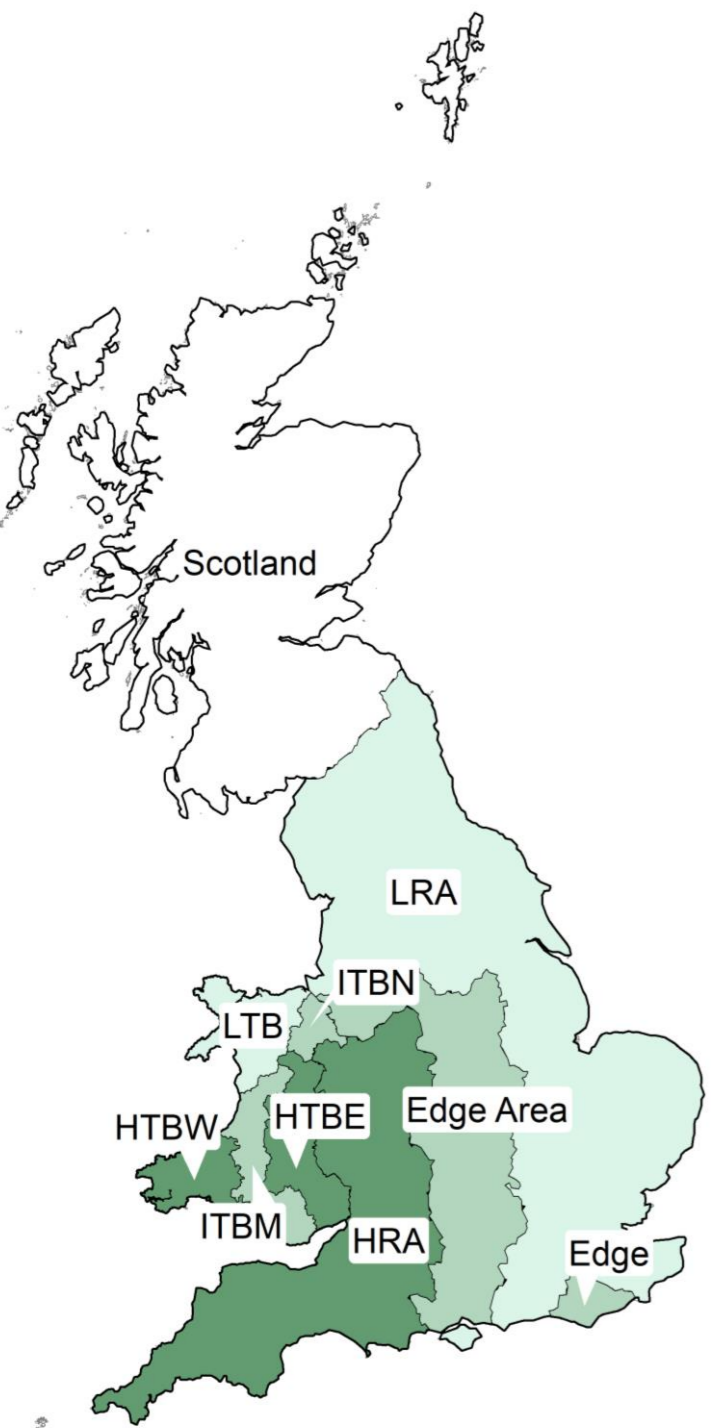| Risk Score	Positive herds	Negative herds	Percentage	Crude odds ratio	(95% confidence interval)
1	3,121	107,209	2.8%	Ref.	Ref
2	4,596	69,463	6.2%	2.27	(2.17 - 2.38)
3	3,893	27,515	12.4%	4.86	(4.63 - 5.10)
4	7,996	36,566	17.9%	7.51	(7.20 - 7.84)
5	7,374	26,220	22.0%	9.66	(9.25 - 10.10)
Not known	378	5,459	6.5%	2.45	(2.20 - 2.73)

Assessment of confounding and effect modification

Year of test

There was a decreasing trend in TB period prevalence within cattle herds in GB between 2014 (9.1%) and 2019 (8.5%). Overall, the distribution of risk score categories was very similar between years in this period (Fig 2).

The M-H test of homogeneity of ORs did not provide strong evidence for interaction between the year of test and the risk score (p=0.4980).

Year was not controlled for in the final model.

Figure 2. Risk scores by year of test
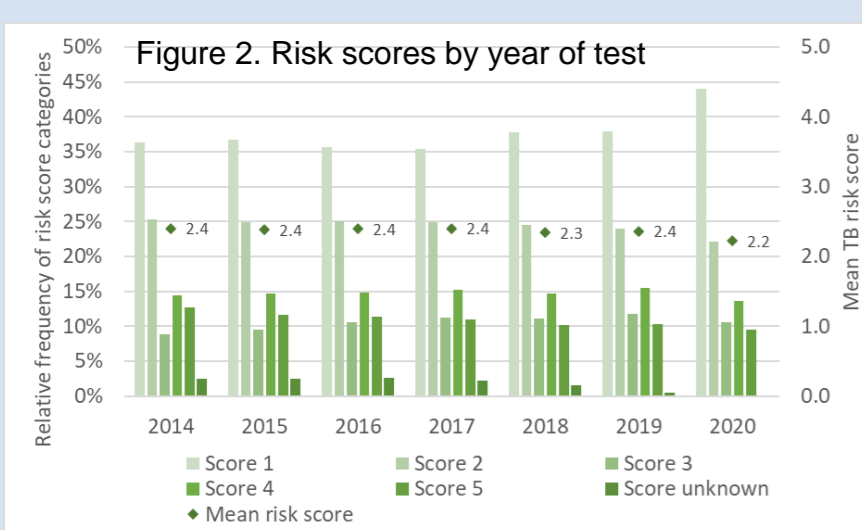
Location of Herd

Great Britain is divided into nine risk areas, each with different levels of TB and TB control policies (Fig 1). A greater proportion of risk score 1 herds were found in areas with a lower level of TB, while areas with a higher TB prevalence had higher mean risk scores (Fig 3).

The M-H test of homogeneity of ORs provided strong evidence of differences between the odds in each risk area stratum (p=0.0037).

The results of the multivariable analysis was presented for each risk area separately.

Figure 3. Risk scores by TB risk area
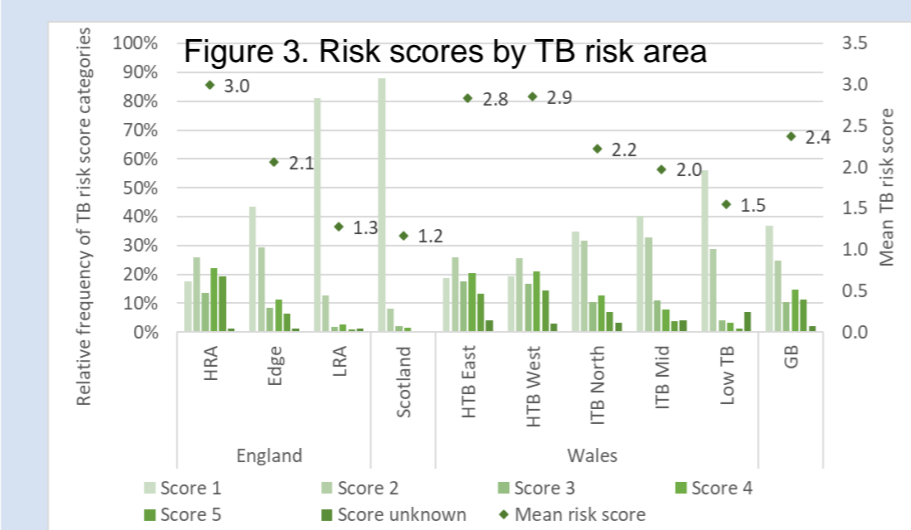
Herd Type

Herds are recorded as beef (76%), dairy (23%), or 'other' (2%). It has been shown previously that dairy herds are more likely to test positive for TB than beef herds. Within this dataset, 16.2% of dairy herds vs. 7.2% of beef herds had a positive TB test (OR 2.51, 95% CI 2.44-2.57). Dairy herds also had a higher mean risk score (Fig 4).

There was very little difference between the risk score odds ratios for each herd type, however the M-H test of homogeneity of ORs suggested that there was a small degree of effect modification by herd type (p=0.016). **Herd type was controlled for as a confounding variable.**

Figure 4. Risk scores by TB herd type
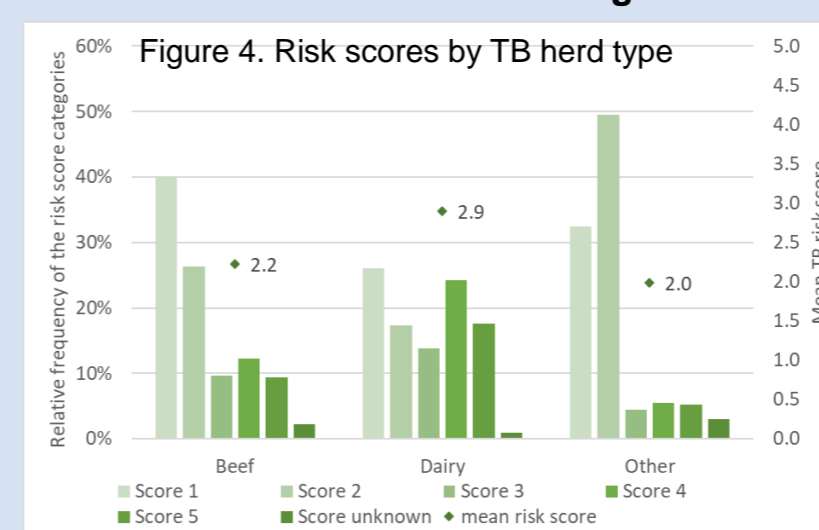
Herd Size

Herd size is related to herd type. Seventy per cent of large herds (301+ cattle) are dairy enterprises, while over 90% of small herds (50 or fewer cattle) are beef enterprises. Herd size is also known to be associated with the odds of TB infection, with larger herds at greater risk.

The mean TB risk score increased with herd size (Fig 5).

The M-H test of homogeneity of ORs suggested that there was very little effect modification by herd size (p=0.8310). **Herd size was controlled for as a confounding variable.**
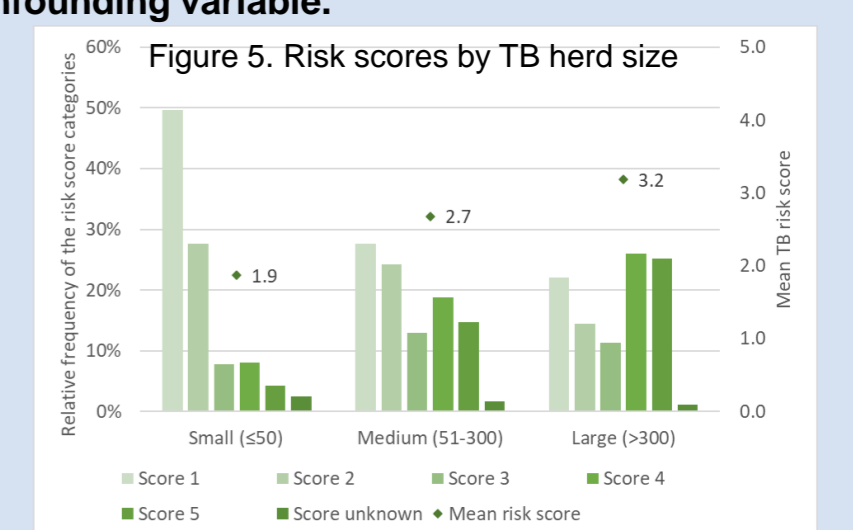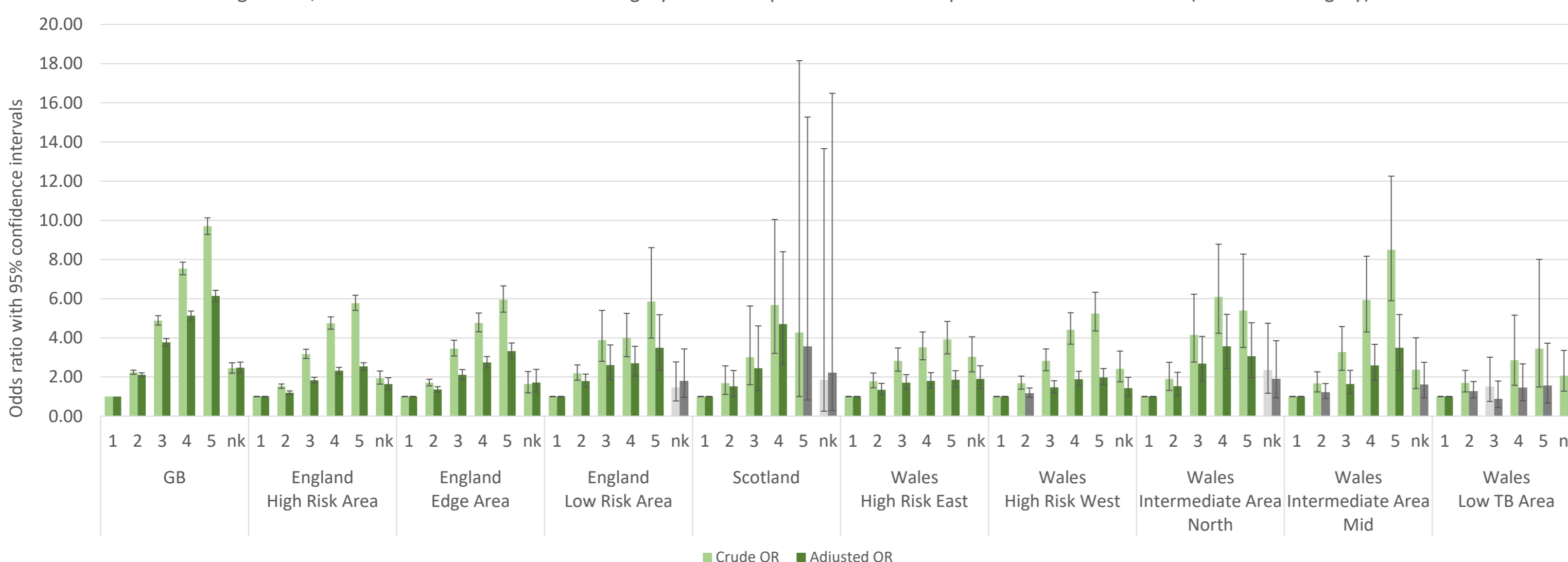

Figure 5. Risk scores by TB herd size

Figure 6. Crude and adjusted (controlling for herd type and herd size) odds ratios with 95% confidence intervals, calculated by logistic regression, for herds in each TB risk score category that had a positive TB test compared to risk score 1 herds (reference category)

Conclusions

After controlling for herd type and herd size, risk score 5 herds in Great Britain were over 6 times more likely to test positive for TB than score 1 herds (OR 6.14, 95% CI 5.87-6.42), Fig 6.

When stratified by risk area, the risk scores performed well in most areas. They had the greatest predictive power in the England LRA, and Wales IA Mid (adjusted odds ratio for score 5 herds compared to score 1 herds was 3.49 in both areas (95% CI 2.35-5.18)), Fig 6.

The weakest evidence for the performance of the risk scores was observed in the Wales Low Risk Area where the p values for the adjusted odds ratios was >0.05 for all risk scores, Fig 6.

Further work is required to explore how these scores could be used by farmers to mitigate risks when purchasing cattle, and whether they have impacted the spread and proliferation of TB within GB.

Adkin A, Brouwer A, Simons RR, Smith RP, Arnold ME, Broughan J, Kosmider R, Downs SH. Development of risk-based trading farm scoring system to assist with the control of bovine tuberculosis in cattle in England and Wales. Preventive veterinary medicine. 2016 Jan 1;123:32-8.