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Agency

Analysis of bovine tuberculosis surveillance at routine slaughter of cattle in Great Britain

2016-2019

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Contents

Abstract

This report evaluates the results of tuberculosis (TB) surveillance in cattle at routine (commercial) slaughter between 2016 and 2019. It is an update to an earlier analysis conducted by the Animal and Plant Health Agency (APHA) in 2018 for the period 2013/16. Slaughterhouse surveillance is an important part of the bovine TB surveillance system; in 2019, 12% of all new TB incidents and 17% of TB incidents with OTF status withdrawn (OTF-W) in Great Britain (GB) were initiated by slaughterhouse surveillance.

Between 2016 and 2019, 3,784 samples from commercially slaughtered non-TB reactor cattle with suspected tuberculous lesions detected in 261 slaughterhouses were submitted to APHA for culture, equivalent to an overall rate of 0.41 submissions per 1,000 animals. Mycobacterium bovis (*M. bovis*) was identified in 2,581 (68%) slaughterhouse case samples from officially tuberculosis free (OTF) and TB breakdown.

Of the 261 slaughterhouses where animals were processed, 186 (70%) had an annual throughput greater than 40 animals between 2016 and 2019. Cattle originating from the High Risk Area (HRA) of England accounted for the highest number of samples (68% of all slaughterhouse case submissions in GB), while the same area was responsible for only 29% of all cattle slaughtered.

The submission rate and positive submission rate per 1,000 animals processed was relatively stable between 2016 and 2019. Since 2011, the positive submission rate per 1,000 animals processed has decreased from 0.55 to 0.25 in 2019. In contrast, the number of reactors per 1,000 animals tested varied more widely between 2011 and 2019, which may reflect changes in TB testing policies. For this reason, the rate of detection in slaughtered animals may provide a more constant measure of the underlying TB risk.

The submission rate per 1,000 animals processed was higher in the HRA of England than other regions. However, a sharp decrease in the HRA submission rate was observed in 2016 relative to the previous five years and this lower level of submissions was maintained through to 2019.

Between 2016 and 2019, *M. bovis* was cultured from 62% (1,986/3,189) of the slaughterhouse case samples submitted from OTF herds and there was a decline in the samples tested for histology from 561 in 2016 to 433 in 2019. The odds of *M. bovis* isolation in laboratory culture was highest in slaughterhouse case samples from the HRA, from dairy herds, when there was more than one submission from the same herd and when the last skin test in the herd of origin took place more than 90 days before slaughter.

Of the 17,513 TB incidents (‘breakdowns’) in cattle herds between 2016/19, 11% (1,986) were initiated by routine slaughterhouse surveillance, as opposed to tuberculin skin testing on farms and this percentage was the same as for the previous reporting period (2013/16). Of these, 1,933 (97.3%) subsequently had OTF herd status withdrawn (OTF-W). Between

2016 and 2019, the overall proportion of OTF-W TB incidents in GB initiated by slaughterhouse surveillance increased slightly from 18.1% in 2016 to 18.5% in 2019, mainly observed in the HRA and Edge Area in England and in Scotland. The odds of disclosure of a TB incident in the slaughterhouse were more likely in the Intermediate TB Area Mid region of Wales, where incidents were over two times more likely to be detected. Other factors influencing the odds of disclosure of an incident in the slaughterhouse were when the last TB test was performed in the herd of origin during the previous 90 days, the last test type performed prior to slaughter, when the herd size exceeded 50 animals and when more than 7 animals were moved on to the farm.

Between 2016 and 2019, 61.1% (1,182/1,933) of OTF-W TB incidents disclosed through slaughterhouse surveillance had one or more skin test reactors or IFN-gamma test-positive animals at subsequent herd check tests. The proportion of new TB incidents detected by post mortem meat inspection (PMMI) with no reactors detected subsequently in the herd during control tests in GB remained stable at 39% in both 2016 and 2019. The odds of detecting reactors at check tests following a slaughterhouse case were highest from dairy herds, when there was more than one reactor in the last TB incident, in the Edge Area, HRA and Scotland, in 2005 and when there were less animals moved on to the farm.

The statistical model originally built by Cambridge University has explored residual variation in detection rates of TB lesions between slaughterhouses. This model identified slaughterhouses that detected a lower than expected number of suspect cases in the period of interest, based on the comparative risk of infection of the animals that are processed. Out of 218 slaughterhouses analysed, 14 were identified as significantly ‘underperforming’, in the sense that those premises detected fewer TB-infected animals at routine slaughter than expected. However, caution needs to be applied in interpreting these data and the model will be used as a guide for further investigation, not as a definitive ranking of performance.

Glossary

- **BCMS:** British Cattle Movement Service.
- **CTS:** Cattle Tracing System.
- **Exempt herds:** Herds that had not had a tuberculin skin test in 51 months prior to the TB incident (allowing three months for a herd in a 4-yearly tested area to be tested) and those that had no recorded test on Sam.
- **HRA:** High Risk Area, one of the three risk regions in England.
- **HTBE:** High TB Area East, one of the five risk regions in Wales.
- **HTBW:** High TB Area East, one of the five risk regions in Wales.
- **ITBM:** Intermediate TB Area Mid, one of the five risk regions in Wales.
- **ITBN:** Intermediate TB Area North, one of the five risk regions in Wales.
- **LIMS:** Laboratory Information Management Systems.
- **LRA:** Low Risk Area, one of the three risk regions in England.
- **LTB:** Low TB Area, one of the five risk regions in Wales.
- **Non-exempt herds:** Herds which do not fall under the category of Exempt herds.
- **Non-visible lesions (NVL):** No lesions typical of bovine TB detected in the carcass at post mortem examination. Equivalent to the “no detectable lesions (NDL)” terminology used in Wales.
- **OTF:** a herd that has officially bovine tuberculosis free status according to Council Directive 64/432/EEC and hence is not subject to TB movement restrictions.
- **OTF-S:** Officially bovine tuberculosis free status suspended.
- **OTF-W**: Officially bovine tuberculosis free status withdrawn.
- **RADAR:** Rapid Analysis and Detection of Animal-related Risks.
- **Region:** It refers to the herd origin unless stated otherwise.
- **Sam database:** APHA’s herd registration and notifiable animal disease control and surveillance system, which records, for example, details of herds, TB tests, TB incidents and the details of any slaughtered (reactors, slaughterhouse cases and direct contacts) and inconclusive reactor cattle.
- **Sensitivity (of a test):** The proportion of truly infected individuals in the screened population who are identified as infected (positive) by the test.
- **Slaughterhouse:** (**i**) premises registered as official slaughterhouses identified internally by a 4 digit code, or (**ii**) CPH that are slaughterhouse type premises where either keeping animals before sending them to slaughterhouse or killing them on site (these have very low submissions and are included in the report only for completeness, and the animals involved will all have died at this premises type).
- **Slaughterhouse case:** This refers to a privately slaughtered, non-test reactor animal that had lesions consistent with TB during routine post-mortem meat inspection (PMMI) in an abattoir. A slaughterhouse case is considered ‘confirmed’

or ‘positive’ if the bovine TB bacterium (Mycobacterium bovis – *M. bovis*) has been isolated from the suspect lesions in laboratory cultures at APHA.

- **Specificity (of a test):** The proportion of truly uninfected individuals in the screened population who are identified as uninfected (negative) by the test.
- **Spoligotype:** The result of one molecular technique used for genomic typing of organisms of the Mycobacterium tuberculosis complex, known as Spacer Oligonucleotide typing.
- **TB incident or TB breakdown**: the identification in a herd of one or more animals with a positive reaction to the tuberculin skin test, or one or more slaughterhouse cases with a positive culture result for *M. bovis*. The affected herd is placed under movement restrictions and loses its OTF status (OTF-S or OTF-W).
- **Visible lesions (VL):** Lesions typical of bovine TB detected in the carcass of a skin test reactor or interferon-gamma (IFN-γ) blood test positive animal at post-mortem examination. Equivalent to the “detectable lesions (DL)” terminology.

Executive Summary

Introduction

- The proportion of bovine tuberculosis (TB) incidents disclosed by routine post-mortem meat inspection (PMMI) in the slaughterhouse and the rates of submission of suspect TB lesions from slaughterhouses in GB is low compared to other countries with high levels of endemic TB incidence such as Ireland. Additionally, the rates of disclosure vary widely across GB slaughterhouses.

- In GB in 2019, 15% of all new TB incidents (598/3983) and 17% (456/2,644) of all TB incidents where official TB-free status was withdrawn (OTF-W incidents) were detected in the slaughterhouse.

- In 2019, 20% of all TB incidents in the High Risk Area (HRA), 14% in the Edge Area, 22% in the Low Risk Area (LRA) of England, 47% in Scotland and 11% in Wales were disclosed through slaughterhouse surveillance.

- In GB, the proportion of suspected slaughterhouse samples where *M. bovis* was isolated was 66% in 2019.

Section 1: Slaughterhouse case submission numbers and rates between 2016 and 2019

- Between 2016 and 2019, over 9 million cattle were recorded as slaughtered in 261 slaughterhouses in GB (about 2.3 million each year).

- In the same period, samples were collected from 3,784 animals with suspected tuberculous lesions, equivalent to an overall rate of 0.41 submissions per 1,000 animals slaughtered. This is a lower number of samples and submission rate than the previous reporting period, 5,639 and 0.63 respectively in 2013-2016.

- During 2016-2019, *M. bovis* was identified by laboratory culture in 2,581 of the 3,784 suspect cattle samples (68%).

- Of the 261 slaughterhouses in GB where animals were processed, 186 (70%) had an annual throughput of greater than 40 animals between 2016 and 2019.

- Cattle herds from the HRA of England submitted the highest number of samples in the study period, while the number of submissions from beef cattle was higher than

for dairy cattle. The greater number of beef submissions may reflect the higher throughput of beef animals (three times that of dairy animals).

- The number of submissions and those positive for *M. bovis* decreased between 2016 and 2019. The submission rate per 1,000 animals processed was stable over that time, but varied by region.

- The rate in the HRA of England was higher than other regions, however a sharp decrease in the HRA submission rate in 2016 relative to 2011-2015 was maintained through to 2019.

- In 2019 the HRA submission rate was only marginally greater than that for the Intermediate TB Area Mid area of Wales. Elsewhere in GB, submission rates were comparatively stable over the time period. However, submission rates in both of the high and the Intermediate TB Area North areas of Wales have fallen since 2009.

- Of the 261 slaughterhouses in GB, only 56 (21%) had a submission rate greater than 0.5 per 1,000 animals slaughtered, slightly lower than the previous reporting period, 27%. Only slaughterhouses in the HRA of England and Wales with a throughput greater than 40 animals per year, had a median submission rate over 0.5 per 1000 animals slaughtered (HRA - 1.4 (IQR 0.6, 2.2), Wales 0.5 (IQR 0.4, 1.3)).

Section 2: Proportion of slaughterhouse cases positive on culture

- Between 2009 and 2019, 14,174 samples from cattle with lesions indicative of TB (slaughterhouse cases) were submitted to APHA for confirmation by laboratory culture. Of these, 10,789 (76%) were submitted to APHA from OTF cattle herds (i.e. that were not under movement restriction).

- Of the 3,784 samples with lesions submitted for culture during 2016-2019, 3,189 were from OTF herds.

- Between 2016 and 2019 *M. bovis* was cultured from 62% of the slaughterhouse case samples submitted from OTF herds. The equivalent percentage for samples submitted from all TB breakdown herds in the slaughterhouse was 68%.

- Multivariable logistic regression identified herd region, herd type, time since the last TB test and TB incident, the number of movements onto the farm, and the annual throughput of the slaughterhouse to be significant risk factors for an increased odds of a slaughterhouse case leading to a new OTF-W TB incident. The proportion of dairy cattle handled by the slaughterhouse, herd size and death year was not

significantly associated with the odds of a slaughterhouse case proceeding to an OTF-W incident.

Section 3: Proportion of new TB herd incidents disclosed in the slaughterhouse between 2016 and 2019

- Between 2016 and 2019, there were 17,513 new TB incidents in cattle herds in GB, of which 11,277 were classified as OTF-W. Of the 17,513 incidents, 1,986 (11.3%) were initiated by routine PMMI in the slaughterhouse, of which 1,933 (97.3%) were subsequently classed as OTF-W.

- Between 2016 and 2019, the overall proportion of OTF-W TB incidents in GB initiated by slaughterhouse surveillance have increased slightly from 18.1% in 2016 to 18.5% in 2019. The proportion of OTF-W incidents that originated in the slaughterhouse increased in the England HRA and Edge Area and Scotland, but decreased in the England LRA. Proportions for all Welsh regions remained stable, bar for an increase in the Low TB Area in Wales since 2016.

- Counties demonstrating unusually high proportions of OTF-W TB incidents disclosed in the slaughterhouse include Carmarthen (7% in 2009, 21% in 2016, and 26% in 2019), Ceredigion (8% in 2009, 3% in 2016 and 24% in 2019), and Devon (22% in 2009, 19% in 2016 and 24% in 2019) among others.

- Multivariable logistic regression analysis determined that TB incidents in herds located in the Intermediate TB Area Mid region of Wales were over two times more likely to be detected in the slaughterhouse compared with TB incidents in herds in the HRA of England; while herds located in the Wales High TB Area East region and England Edge Area were less likely to be detected in the slaughterhouse. Other factors significantly affecting the odds of disclosure of a TB incident in the slaughterhouse include the time since the last test, larger herd sizes, the last test type, having more than one reactor, previous history of an OTF-W incident in the previous four years and the number of cattle movements on to the holding in the 12 months prior to the TB incident.

- A total of 38 spoligotypes of *M. bovis* were isolated in the period between 2016 and 2019, but due to the low frequency of spoligotypes detected, no further analysis was able to be conducted.

Section 4: Identification of test reactors in the source herd following a positive slaughterhouse case between 2016 and 2019

- Between 2016 and 2019, 61.1% (1,182/1,933) of OTF-W TB incidents disclosed in the slaughterhouse had reactors at subsequent tuberculin skin herd tests, an increase compared to 56.1% in the last reporting period (1,411/2,517).
- Reactors at follow-up skin testing appeared more likely when the slaughterhouse case originated from: larger herds; Intermediate TB Area North or Low TB regions in Wales; dairy herds; or 'non-exempt' herds.
- The proportion of new TB incidents detected by PMMI with no reactors detected subsequently in the herd during control tests in GB was around 39% in 2019. As in previous reports, the proportion of OTF-W TB incidents disclosed in the slaughterhouse with no reactors in herds with 100 animals or less rises to 61% and is even higher (69%) when restricted to herds with 50 animals or less.
- OTF-W incidents detected by skin testing had a median of 4 (IQR 2-7) reactors at the first whole herd test, compared to 0 (IQR 0-4) for OTF-W incidents detected at the slaughterhouse. The mean number of reactors was higher by skin testing than slaughterhouse surveillance for nearly all TB herd regions, except for the Intermediate TB Area Mid area of Wales where the mean was higher in slaughterhouse surveillance incidents, and in the England LRA and Scotland, where means were similar for both skin testing and slaughterhouse surveillance.
- Multivariable logistic regression analysis showed that TB incidents in dairy herds and those where more than two reactors were detected in the previous incident within four years were more likely to have reactors at the check test triggered by a slaughterhouse case.
- The number of movements onto the farm in the 12 months prior to the start of the incident was significantly associated with a lower probability of detecting reactors at the check test.
- TB incidents where spoligotype 21 of *M. bovis* was isolated had a higher probability of detecting reactors at the check test, compared to the more widespread spoligotype 9. These results should be interpreted with caution, given the low amount of variation explained by the model and the correlation of some variables.

Section 5: Model to explore residual variation in detection rates of TB lesions between slaughterhouses

- This section presents the output of the statistical model created at Cambridge University and subsequently adopted at APHA Weybridge under project SE3133. This model explores patterns in residual variation in slaughterhouse case detection rates between British slaughterhouses after accounting for individual animal-level risk factors, such as sex, age, breed, days in high risk or low herds, contact with high or low risk herds, skin testing status, year, quarter, and risk area.

- These patterns can be summarised by the posterior mean odds ratio (OR) and credible intervals (Appendix 3). Slaughterhouses with positive posterior ORs are finding more TB than the average expected for the types of animals that they processed, and slaughterhouses with negative posterior ORs are finding less than the average expected. The size of the interval is mainly down to the throughput of the slaughterhouse; the higher the throughput the smaller the interval and hence more certainty around the estimated mean.

- Using data from 2016 to 2019, there were 14 slaughterhouses with an upper credible interval below zero, meaning that post-mortem surveillance for TB on these premises may have been sub-optimal.

Introduction

Bovine tuberculosis (TB) is a respiratory disease predominantly (in the UK) caused by the bacterium *Mycobacterium bovis*, (*M. bovis*); a member of the *M. tuberculosis* complex (MTBC). *M. bovis* is a zoonotic pathogen and can infect humans and all known mammals, and is therefore a notifiable disease. It is currently endemic in parts of the UK, with wildlife providing a reservoir of infection in some areas. Cattle can become infected when directly exposed to infectious animals including wildlife. The movement of cattle with undetected infection is considered the most likely way that disease spreads to new areas.

There are substantial epidemiological differences in the bovine TB epidemic between and within the countries of GB. Differences in surveillance and control policies make it inappropriate to directly compare TB in cattle between countries and therefore these are best considered separately. Great Britain is therefore divided into nine different risk areas for TB. Within England, there are three risk areas: the High Risk Area (HRA), Edge Area and Low Risk Area (LRA). Wales has five risk areas: the High TB Area East (HTBE), High TB Area West (HTBW), Intermediate TB Area Mid (ITBM), Intermediate TB Area North (ITBN) and Low TB Area (LTB). Scotland remains Officially TB free as a single risk area.

Surveillance for TB can be classified into four ‘streams’. ‘Routine’ testing and ‘Slaughterhouse’ surveillance look for TB in herds (or animals) that are not expected to be at increased likelihood of infection. ‘Area and herd risk’ (e.g. short interval, tracing, inconclusive reactor and contiguous herd tests) together with ‘Trade and other’ testing (e.g. post import, pre- and post-movement and private tests) target cattle thought to be at higher risk of infection, and/or those where owners consider infection could have a greater impact. This report will concentrate on slaughterhouse surveillance of TB in cattle. A more detailed analysis on the other surveillance streams, including the epidemiology and incidence of TB is available in the annual GB bovine TB reports.

Slaughterhouse surveillance is the post-mortem meat inspection of cattle routinely (commercially) slaughtered for human consumption, looking for suspect visible granulomatous lesions in the carcases and viscera of these cattle. A slaughterhouse case is declared when suspect lesions are found in a carcass and *M. bovis* infection is consequently confirmed by laboratory testing. However, the OTF status of the herd of origin is automatically suspended (OTF-S) as soon as lesions are found in the carcass, pending test results. If positive test results are confirmed, OTF herd status is withdrawn (OTF-W). If the culture results are negative, the movement restrictions are lifted and no TB herd incident is generated, unless TB reactor cattle are found at a skin check test initiated by APHA before the completion of bacteriological cultures. Slaughterhouse surveillance is particularly important in Scotland following its attainment of OTF status in 2009. Slaughterhouse surveillance has replaced live animal testing in Scottish herds where a sufficient proportion of cattle go for slaughter and the risk of TB introduction through cattle movements is low.

Between 2012 and 2018, TB incidence mostly plateaued in GB, with an average of8.5 TB incidents per 100 Herd-Years at Risk (HYR) annually. There was a peak in TB incidence in 2017 of approximately 9.4 TB incidents per 100 HYR, falling to 7.9 TB incidents per 100 HYR in 2019 [2].

Post-mortem meat inspection of cattle in the slaughterhouse is an important element of the surveillance system for bovine TB in GB. Such passive surveillance supplements active TB testing of cattle on farms. In GB in 2019, 15% of all new TB incidents (598/3,983) and 17% (456/2,644) of all TB incidents where official TB-free status was withdrawn (OTF-W incidents) were detected in the slaughterhouse [2]. More specifically, 20% of all TB incidents in the HRA, 14% in the Edge Area, and 22% in the LRA in England; 47% in Scotland; 8.8% in the high TB regions (HTBE and HTBW), 10.7% in the intermediate TB regions (ITBM and ITBN), and 16.7% in the low TB region of Wales were disclosed through slaughterhouse surveillance during 2019 [2]. The latest available estimates available from Northern Ireland suggest that 18–28% of new TB herd incidents every year are disclosed by the detection of TB lesions in animals at routine (commercial) slaughter [3].

In GB, confirmation of infection in slaughterhouse cases is performed by identification of the bacterium in laboratory cultures at present. The proportion of suspected GB slaughterhouse samples where *M. bovis* was isolated was 68% in 2019 [2]. Sensitivity of meat inspection is generally regarded as low, particularly in the early stages of *M. bovis* infection where the proportion of small incipient lesions can be high [4].

This report updates an earlier analysis published by APHA in 2018 to evaluate the results of TB surveillance in cattle at routine slaughter during 2013-2016 [5]. The data obtained in the previous report from 2016 was not complete at the time of writing as it was obtained early in the year and some tests were still pending. In this report, we have thus included again the 2016 data to update the results presented in the previous report.

Methods

Data extraction and management

Data used in this report were extracted from three sources; the Cattle Tracing System (CTS, source BCMS), the Animal and Plant Health Agency (APHA) core information management system (Sam) and the APHA laboratory information and sample management system database (LIMS). The relevant data were downloaded from Sam on 15th October 2020.

1. Animal and herd level data

The ear tag numbers and laboratory information for animals with lesions suspicious of TB identified at routine slaughter (suspect slaughterhouse cases) that were submitted to APHA between 1st January 2016 and 31st December 2019 were extracted from LIMS. These data were appended to the database used for the previous report (1st January 2009 and 31st December 2015), updating the 2016 data. Herd data, TB testing and TB incident history for the herd of origin of each slaughterhouse case were extracted from Sam. Where a TB incident did not occur, herd type is the current herd type as recorded in Sam or the type at time of sample archive, whilst where a TB incident did occur, herd type is the type at the time of the TB incident.

Farm CPH, birth date, death date, movements onto the CPH (holding) in the 12 months prior to the death date, slaughterhouse identifier and location were all extracted from CTS using animal ear tags as the identifier. Bovine animals (cattle, farmed water buffalo and farmed bison) with suspect lesions submitted to APHA from which *M. bovis* was confirmed, were considered to be disclosing cases if their lesions were identified at the slaughterhouse outside of an existing TB incident or within seven days of another disclosing slaughterhouse case from the same herd.

For the period of the current report (2016-2019), individual animal test data were used (rather than estimating numbers from test records conducted during the year), which is more accurate and has led to an increase in the number of animals tested. Note this revised approach is only possible since the advent of Sam recording every animal test performed. It is thus likely that rates shown prior to 2013 and in previous reports are slightly inflated compared to the new method.

2. TB incident data

Data on all TB incidents that began between 1st January 2016 and 31st December 2019 were extracted from Sam. As before, these data were appended to the dataset downloaded for the previous report, and the 2016 data was updated. All TB incidents with a confirmed positive slaughterhouse case at the very start of the TB incident were assumed to have been disclosed by detection of lesions in the slaughterhouse. All other

slaughterhouse cases were assumed to have been detected in animals slaughtered during TB incidents (herd already under movement restrictions) or on-going surveillance and control activities.

3. Slaughterhouse throughput data

Denominator data describing all individual animal movements to slaughterhouses between 1st January 2009 and 31st December 2016 had previously been extracted from CTS and supplemented with new data from 1st January 2016 to 31st December 2019 for the update. These movements to slaughter were aggregated by year, month, slaughterhouse, county and region of source holding, test interval of source holding and type of source holding (based on the current type registered for herds active under the holding). The slaughterhouse region was obtained using the map reference provided in RADAR for the slaughterhouse.

Data quality

The data including slaughterhouse case submissions for this report come from the APHA TB management system (Sam). Information describing suspect slaughterhouse cases were extracted from the APHA's TBCS/LIMS database. Sam is used to validate that negative slaughterhouse cases are indeed such; otherwise only submissions that appear in the APHA database LIMS contribute to the analysis.

The CPH of the animal immediately prior to slaughter was established using the animal's ear tag record on CTS (with rare exceptions). The previous CPH was also recorded if the animal was resident within 30 days of slaughter, unless the animal's slaughter data in Sam referred to the more recent CPH. Checks were made to ensure that the CTS information matched that on the APHA database to ensure the animals were the same.

There may be some historical inaccuracies associated with herd type data. The herd type recorded at a TB incident is static and will not change, even if the production type of that herd subsequently changes. However, the number of herds in existence for a particular time period by production type is either the current herd type or that at archive, and so is subject to change as the population demographics of the national herd changes. This has implications for the calculation of incidence by herd type. The number of TB incidents per 100 live dairy herds in, for example 2016, may seem higher using data downloaded in 2019 than it did at the time, i.e. it is possible that the reduction in the number of current herds classed as dairy may artificially inflate past incidence in dairy herd type.

Although at least one movement was recorded to 261 slaughterhouses between 2016 and 2019, 45 of these slaughterhouses were represented by a CPH number and not a four-digit slaughterhouse ID. These may be lairages associated with the slaughterhouses, but they are the final movement destination recorded for a number of animals. They may also be collection centres prior to movement to slaughter where cattle die there rather than in the slaughterhouse. However, the number of animals passing through these apparent

lairages was 723, which represents less than 0.01% of the whole throughput between 2016 and 2019. Obvious lairages were removed from the data by attempting to find the true slaughterhouse ID of the lairage by identifying the slaughterhouse from the movements on to that from the lairage; the movement thus counting for the true slaughterhouse (Note, this was not done for reports before 2009). Those that remain have no onward movement onto a true slaughterhouse.

Consistency and sense checks were conducted using STATA 15.0®. Data were cleaned and checked for duplicate records from the same animal; new variables were created and datasets were merged to prepare the necessary datasets for analysis.

Statistical analyses

All statistical analysis was conducted using STATA 15.0®. Relationships between outcome and predictor variables were first examined in univariable analyses using chi squared tests or t-tests, as appropriate. Multivariable logistic regression analysis was then used to identify risk factors for binary outcome variables.

The following outcomes and predictors were investigated:

Outcomes

- Slaughterhouse cases that resulted in an OTF-W TB incident vs. those that did not (binary variable)
- OTF-W TB incidents detected by slaughterhouse surveillance vs. those detected during on-farm surveillance (binary variable)
- OTF-W TB incidents detected in the slaughterhouse that had reactors in subsequent testing vs. those that did not (binary variable)

Predictors

- Characteristics of source herd (herd type, testing history, herd size)
- English risk region or country of source herd
- Total number of movements into source herd/holding
- Time since last skin test of source herd/holding
- Last herd test type conducted in source herd/holding
- Time since, and nature of, last TB incident in source herd/holding
- Number of reactors in last TB incident of source herd/holding
- Slaughterhouse throughput and characteristics of that throughput
- Slaughterhouse region
- Date (month, year, season)
- Spoligotype of *M. bovis* isolated

Where appropriate, standard errors were adjusted for clustering at the herd or slaughterhouse level. Where the relationship between outcome and continuous predictor was not linear, fractional polynomial transformation of the predictor was investigated and implemented if it reduced the Akaike information criterion (AIC) or improved the model fit. Logarithmic transformations (ln(n+1)) were also used for continuous predictor variables

with positively skewed distributions. If the transformations of the continuous predictor did not improve the model, then the predictor was used in its initial format. All plausible two-way interaction terms were tested between predictors in the final models. Models were evaluated and compared using the AIC.

The fit of each multivariable logistic regression model was tested using the Hosmer-Lemeshow goodness of fit test, whereby a statistically significant p-value ($p \leq 0.05$) was considered strong evidence of an unsatisfactorily fitting model.

Herd size, slaughterhouse throughput, time since last test and number of reactors were converted to categorical variables that approximated rounded quintiles of the numerical data.

To account for TB incidents in which more than one spoligotype was detected, it was necessary to adjust the data where spoligotype was included as a factor. Where multiple spoligotypes were identified in the same herd, each TB incident was duplicated and the robust standard errors in the model were adjusted for clustering within the breakdown ID.

Results

Section 1: Slaughterhouse case numbers and rates between 2016 and 2019

AIM: To examine the number and rate of bovine carcases with tuberculous lesions detected during routine post-mortem meat inspection of cattle in British slaughterhouses, by slaughterhouse, slaughterhouse throughput, region, year and herd type.

Slaughterhouse case numbers in GB and by region

Between 2016 and 2019, 9,288,609 cattle were slaughtered in 261 slaughterhouses or premises acting as slaughterhouses in GB. This includes 45 premises with a farm CPH where animals were killed without a forwarding slaughterhouse. Between 2016 and 2019, 3,784 carcases with lesions suspicious of TB (slaughterhouse cases) were detected and submitted for culture at APHA, leading to an overall submission rate of 0.41 submissions per 1,000 animals slaughtered. *M. bovis* was identified in 2,581 of the 3,784 submitted samples (68%). Both the submission rate and the proportion of samples where *M. bovis* was identified was lower in 2016/19 than in 2013/16 (0.63 and 73%, respectively).

The annual number of slaughterhouse cases from which samples were submitted to the APHA – by slaughterhouse region, herd of origin region, slaughterhouse throughput levels per year and herd type – is shown in Table 1.1a-d. By far the most submissions came from the herds (and abattoirs) located in the HRA in England (Table 1.1a and 1.1b). Submission numbers (and cattle slaughters) were relatively stable over the reporting period, fluctuating between approximately 850 and 1,000 cases per year. This is a considerable decrease compared to the period 2011 to 2015, when submission numbers ranged from 1,500 to 1,800 (Figure 1.1a). This decrease was mainly driven by reductions in the HRA, while submission numbers have been comparatively stable in other areas (Figure 1.1b).

Unsurprisingly, submissions for all slaughterhouses with low throughput (≤40 a year) are low, with only one of these submitting one sample (Table 1.1c). The number of submissions from beef herds was higher than for dairy herds, reflecting the higher throughput of beef animals, which is consistently four times that of dairy animals (Table 1.1d). However, caution should be taken with interpreting herd type, as current herd type is used and the loss of dairy herds and transfer to beef in recent years could skew the proportion of beef to dairy.

Table 1.1a: Annual total numbers of slaughterhouse cases submitted to the APHA (subs) and total number of animals slaughtered (N), between 2016 and 2019, by slaughterhouse region. Figures include slaughterhouse cases detected in herds under movement restrictions due to a TB breakdown.

Slaughterhouse region		**2016**	**2017**	**2018**	**2019**
England High Risk Area	subs	768	583	741	652
	N	727,502	734,269	765,262	753,848
England Edge Area	subs	48	55	32	43
	N	114,737	118,558	126,819	141,459
England Low Risk Area	subs	109	148	120	132
	N	843,483	841,350	844,451	861,919
England - Total	subs	925	786	893	827
	N	1,685,722	1,694,177	1,736,532	1,757,226
Scotland	subs	9	6	9	20
	N	470,493	463,016	459,368	451,781
Wales High TB Area East	subs	10	2	4	3
	N	11,815	9,218	11,449	7519
Wales High TB Area West	subs	1	0	1	2
	N	176	182	217	3,395
Wales Intermediate TB Area Mid	subs	70	69	70	68
	N	122,448	117,643	120,086	136414
Wales Intermediate TB Area North	subs	0	3	2	2
	N	6,316	3,941	3,427	3413
Wales Low TB Area	subs	2	0	0	2
	N	4,454	3,137	2,746	2298
Wales - Total	subs	83	74	77	77
	N	145,209	134,121	137,925	153,039
Total submissions	subs	1,017	866	979	922
Total throughput	N	2,301,424	2,291,314	2,333,825	2,362,046

Table 1.1b: Annual total numbers of slaughterhouse cases submitted to the APHA (subs) and total number of animals slaughtered (N), between 2016 and 2019, by herd region of origin. Figures include slaughterhouse cases detected in herds under movement restrictions due to a TB breakdown.

Herd region of origin		**2016**	**2017**	**2018**	**2019**
England High Risk Area	subs	742	567	658	589
	N	662,965	671,286	691,324	701,564
England Edge Area	subs	107	116	99	144
	N	317,330	320,681	332,671	336,000
England Low Risk Area	subs	68	69	67	44
	N	601,684	596,601	602,262	608,608
England - Total	subs	917	752	824	777
	N	1,581,979	1,588,568	1,626,257	1,646,172
Scotland	subs	11	17	20	31
	N	477,943	466,504	460,662	463,816
Wales High TB Area East	subs	23	26	30	29
	N	50,210	49,884	50,968	54,106
Wales High TB Area West	subs	38	44	64	52
	N	94,876	91,867	98,543	100,979
Wales Intermediate TB Area Mid	subs	17	14	22	19
	N	25,529	24,958	26,290	26,197
Wales Intermediate TB Area North	subs	6	5	7	6
	N	20,337	19,920	21,185	22,179
Wales Low TB Area	subs	3	8	11	8
	N	50,550	49,613	49,920	48,597
Wales - Total	subs	87	97	134	114
	N	241,502	236,242	246,906	252,058
Total submissions	subs	1,017	866	979	922
Total throughput	N	2,301,424	2,291,314	2,333,825	2,362,046

Table 1.1c: Annual total numbers of slaughterhouse cases submitted to the APHA (subs) and total number of animals slaughtered (N), between 2016 and 2019, by slaughterhouse throughput level. Figures include slaughterhouse cases detected in herds under movement restrictions due to a TB breakdown.

Throughput level		**2016**	**2017**	**2018**	**2019**
<1 animal/year	subs	0	0	0	0
	N	7	12	8	9
1-40 animals/year	subs	0	0	1	0
	N	649	422	474	494
41-250 animals/year	subs	6	3	5	3
	N	6,193	4,735	4,366	4,542
251-1500 animals/year	subs	30	25	19	24
	N	45,412	35,731	33,570	34,845
1501-7500 animals/year	subs	45	69	36	41
	N	145,133	133,077	129,454	120,908
>7500 animals/year	subs	936	769	918	854

Throughput level		2016	2017	2018	2019
	N	2,104,030	2,117,337	2,165,953	2,201,248
Total submissions	subs	1,017	866	979	922
Total throughput	N	2,301,424	2,291,314	2,333,825	2,362,046

Table 1.1d: Annual total numbers of slaughterhouse cases submitted to the APHA (subs) and total number of animals slaughtered (N), between 2016 and 2019, by herd type. Figures include slaughterhouse cases detected in herds under movement restrictions due to a TB breakdown.

Herd type		2016	2017	2018	2019
Beef	subs	600	515	547	525
	N	1,674,616	1,687,851	1,697,746	1,704,094
Dairy	subs	347	255	344	318
	N	562,648	542,685	576,826	593,279
Other	subs	4	4	2	5
	N	26,997	25,305	23,236	28,284
Total submissions	subs	1,017	866	979	922
Total throughput	N	2,301,424	2,291,314	2,333,825	2,362,046

Figure 1.1a: Annual number of bovine carcases with suspected TB lesions detected at routine slaughter in GB submitted to the APHA for culture between 2009 and 2019. Culture positive submissions are those from which *M. bovis* was isolated in the laboratory.

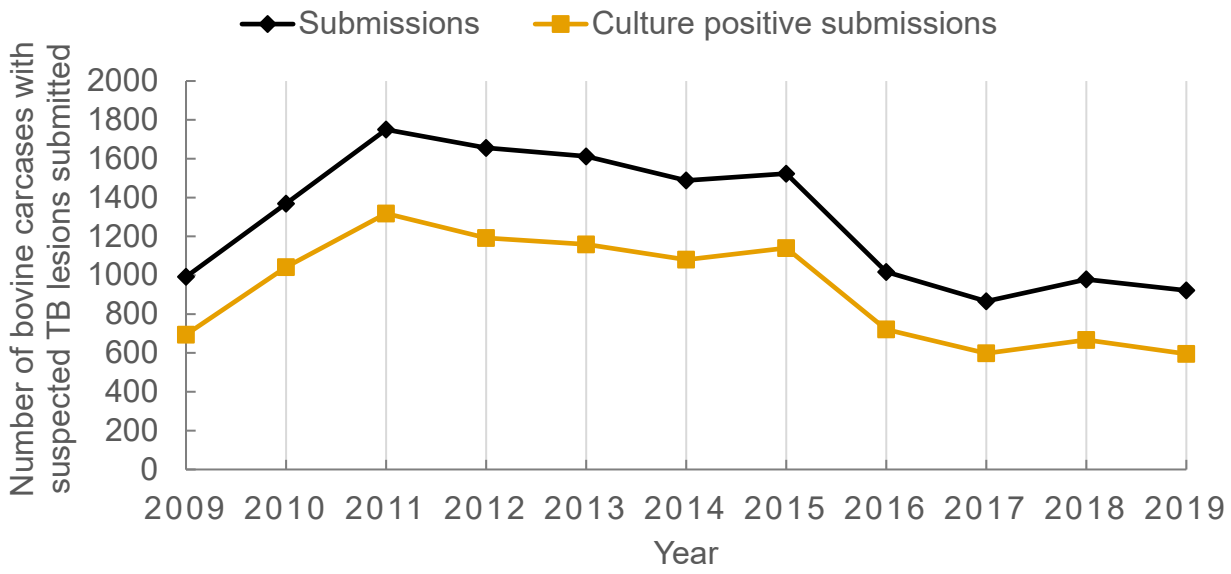
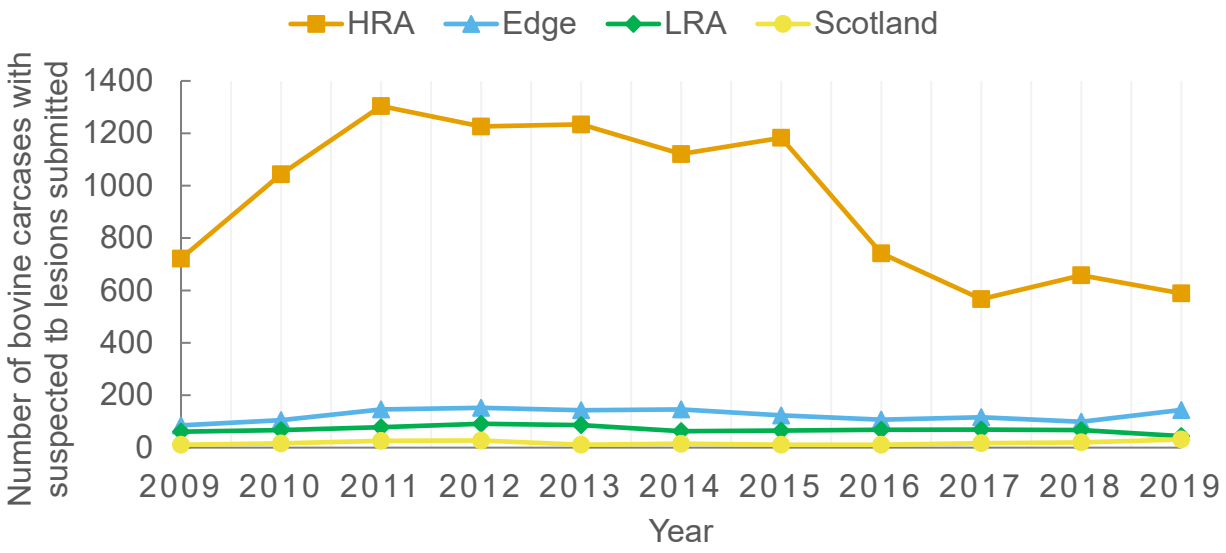
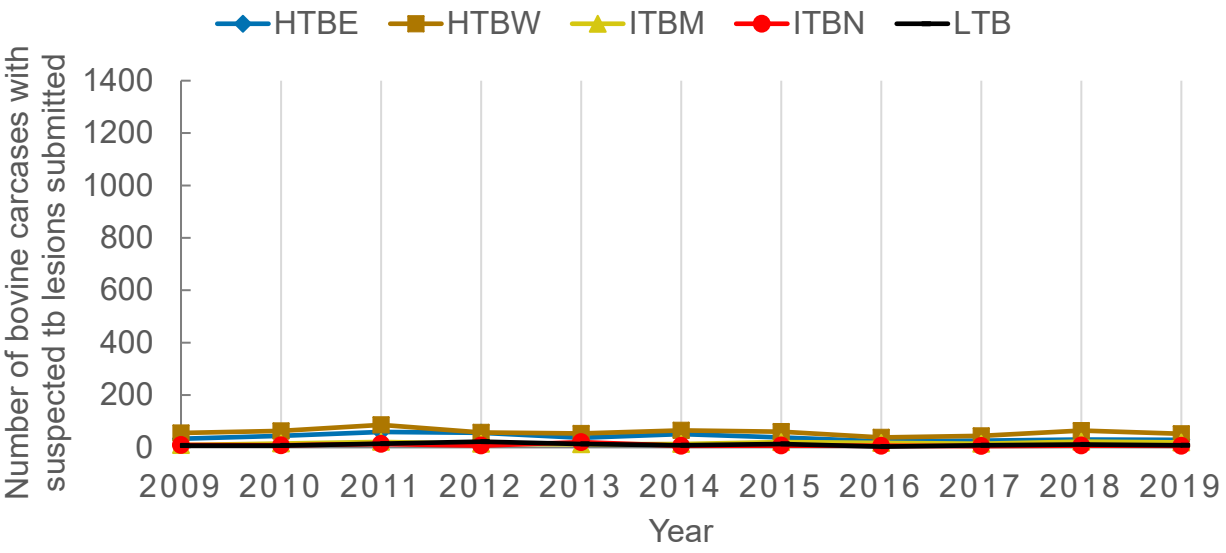


Figure 1.1b: Number of bovine carcases with suspected TB lesions detected at routine slaughter in GB submitted to the APHA for culture between 2009 and 2019, by risk region of origin of the slaughtered animals in England and Scotland (above) and in Wales (below).

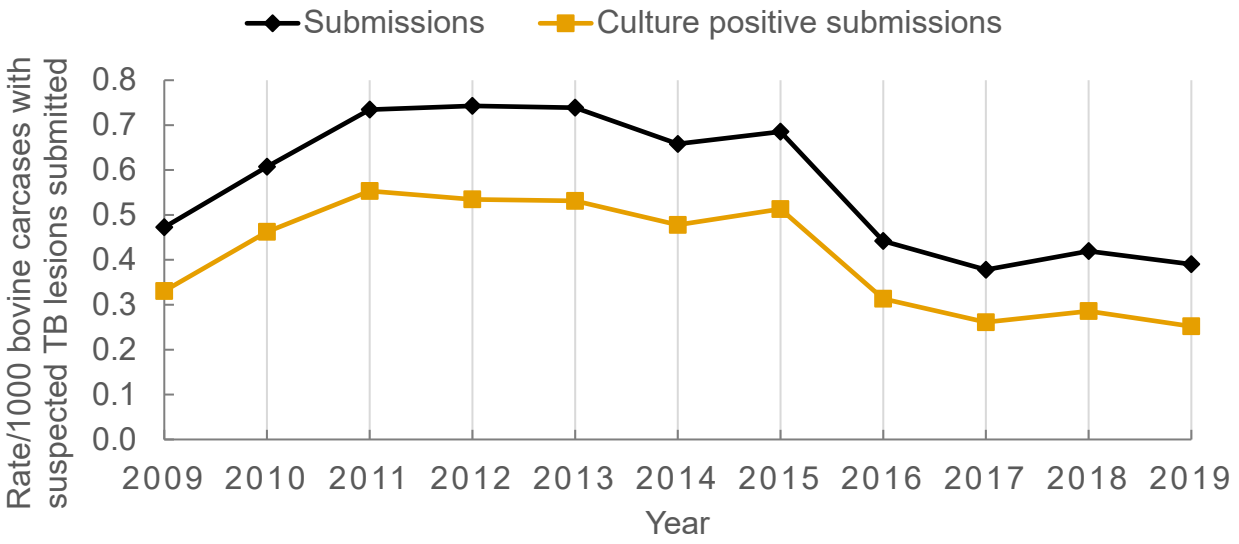




Slaughterhouse case submission rates

The annual submission rate per 1,000 animals slaughtered in GB is shown in Figure 1.1c. There was a sharp decrease in both the total and the culture-positive slaughterhouse case submission rates in 2016 and this reduced rate was maintained over the following three-year period. There was an overall decrease in both the total and the culture-positive slaughterhouse case submission rates between 2013 and 2019, with a particularly sharp decrease observed between 2015 and 2016. The rate in 2019 was around half the rate in 2015.

Figure 1.1c: Rate of bovine carcases with suspected TB lesions detected at routine slaughter in GB submitted to the APHA for culture per 1,000 animals slaughtered between 2009 and 2019. Culture positive submissions are those from which *M. bovis* was isolated in the laboratory.



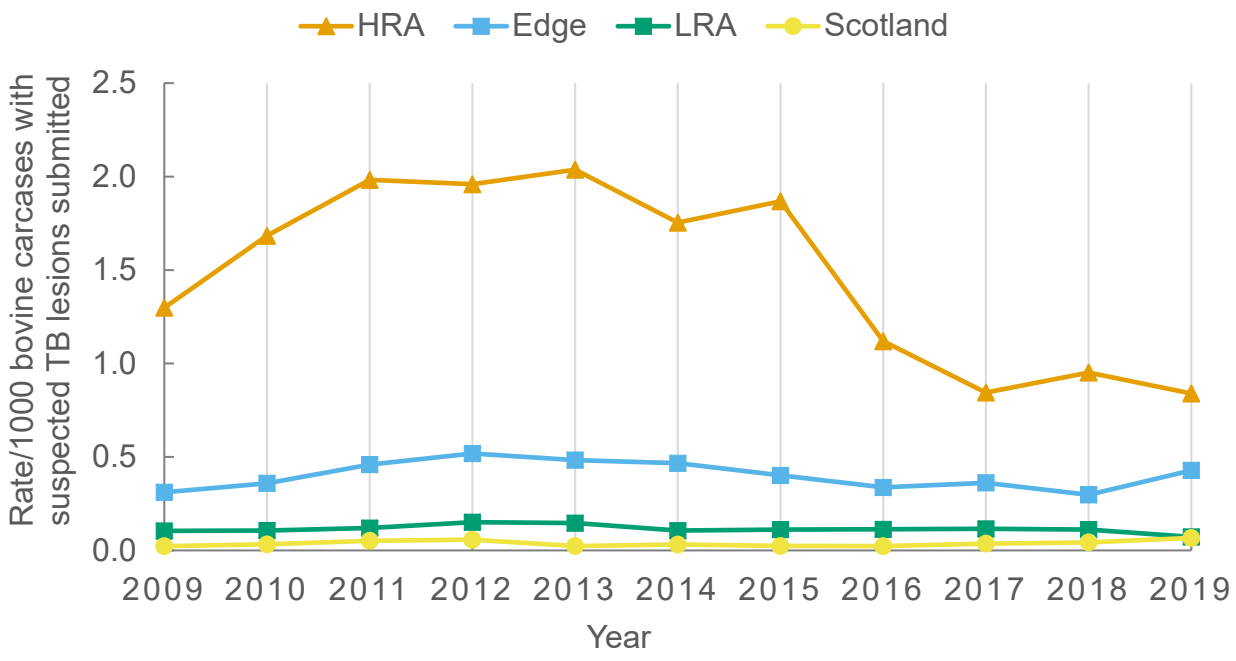
There was strong regional variation in submission rates, as would be expected given the heterogeneous geographic distribution of bovine TB risk (Figure 1.1d, Tables 1.1e and 1.1f). The highest submission rates were in cattle from herds in the HRA, however the rate in the HRA decreased substantially since 2015, and in 2019 was only marginally greater than the rate in the Intermediate TB Mid area (ITBM) of Wales. The rate in the HRA increased from 2009 to 2011, plateaued between 2012 and 2015, decreased in 2016 and remained stable thereafter. Elsewhere in GB, submission rates were comparatively stable over the time period; however decreasing submission rates were observed in both of the high and the intermediate TB Area North (ITBN) areas of Wales between 2009 and 2019.

In the HRA, the reduced submission rate since 2016 may be due to fewer bovine carcases presenting with visible lesions of TB at routine slaughter. It is not possible to definitively identify the factors that have led to the reduced submission rate. However, it is likely that falling TB herd incidence in parts of the HRA and/or a reduced level of disease progression in cattle has occurred. If infection is detected earlier on the farm, lesions

would not have the time to develop, as this takes approximately eight to twelve weeks following infection. Enhanced quality assurance and training for OVs carrying out tuberculin skin testing in the field and several policy changes aimed at improving detection and removal of infected cattle from herds with TB incidents may have influenced the positive trend. Relevant TB testing policy changes implemented in the HRA during 2016 and 2017 include:

1. A more stringent skin testing regime for herds with lesion and culture-negative (OTF-S) TB incidents (i.e. two consecutive short interval tests with negative results at the severe interpretation before movement restrictions can be restored.
2. A marked expansion of supplementary IFN-gamma parallel blood testing in cattle herds with OTF-W TB incidents.

Figure 1.1d: Rate of bovine carcases with suspected TB lesions detected at routine slaughter in GB submitted to the APHA for culture per 1,000 animals slaughtered between 2009 and 2019, by risk region of origin of the slaughtered animals in England and Scotland (above) and in Wales (below). For the equivalent rates of culture-positive submissions only, see Figure 1.7.



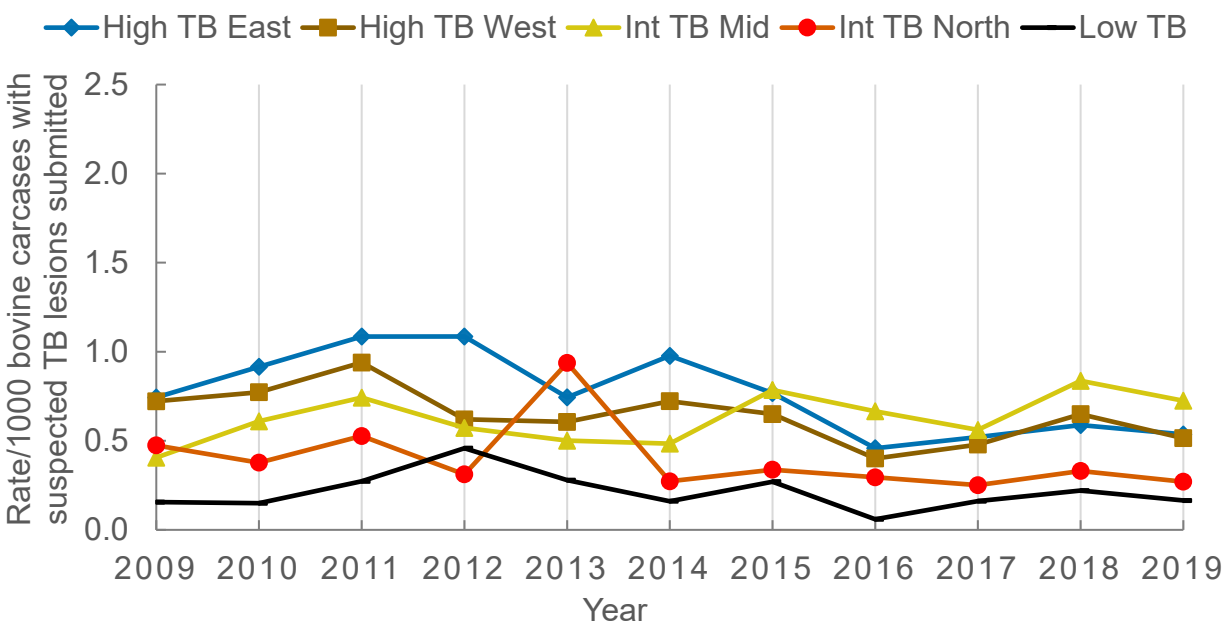

High TB East
High TB West
Int TB Mid
Int TB North
Low TB
Rate/1000 bovine carcases with suspected TB lesions submitted
2.5
2.0
1.5
1.0
0.5
0.0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year

Table 1.1e: Annual rate of slaughterhouse cases detected at routine slaughter and submitted to APHA between 2015 and 2019, per 1000 animals slaughtered. The data include submissions from OTF and herds irrespective of culture result, stratified by region of the herd of origin.

	2015	2016	2017	2018	2019
England – High Risk Area	1.87	1.12	0.84	0.95	0.84
England- Edge Area	0.40	0.34	0.36	0.30	0.43
England – Low Risk Area	0.11	0.11	0.12	0.11	0.07
England - Total	0.90	0.58	0.47	0.51	0.47
Scotland	0.02	0.02	0.04	0.04	0.07
Wales - High TB Area East	0.77	0.46	0.52	0.59	0.54
Wales - High TB Area West	0.65	0.40	0.48	0.65	0.51
Wales - Intermediate TB Area Mid	0.79	0.67	0.56	0.84	0.73
Wales - Intermediate TB Area North	0.34	0.30	0.25	0.33	0.27
Wales - Low TB Area	0.27	0.06	0.16	0.22	0.16
Wales - Total	0.58	0.36	0.41	0.54	0.45
Total	0.68	0.44	0.38	0.42	0.39

Table 1.1f: Annual rate of slaughterhouse cases detected at routine slaughter and submitted to APHA between 2015 and 2019, per 1000 animals slaughtered. The data include submissions from OTF and herds with positive culture results, stratified by region of the herd of origin.

	2015	2016	2017	2018	2019
England – High Risk Area	1.49	0.88	0.66	0.74	0.61
England – Edge Area	0.25	0.20	0.20	0.18	0.24
England – Low Risk Area	0.04	0.03	0.03	0.02	0.01
England - Total	0.68	0.42	0.33	0.36	0.31
Scotland	0.01	0.01	0.02	0.01	0.02
Wales - High TB Area East	0.67	0.32	0.32	0.37	0.41
Wales - High TB Area West	0.42	0.18	0.35	0.44	0.32
Wales - Intermediate TB Area Mid	0.47	0.39	0.20	0.46	0.46
Wales - Intermediate TB Area North	0.29	0.20	0.15	0.09	0.05
Wales - Low TB Area	0.06	0.00	0.04	0.06	0.06
Wales - Total	0.39	0.00	0.04	0.06	0.06
Total	**0.51**	**0.31**	**0.26**	**0.29**	**0.25**

Overall, of the 261 GB registered slaughterhouses, only 56 (21%) had a submission rate greater than 0.5 per 1,000 animals slaughtered. Eighteen per cent of slaughterhouses in the Edge Area of England (with a >40 throughput) had a submission rate greater than 0.5 per 1000 animals, compared with 67% of slaughterhouses in the HRA and 43% in the High and Intermediate TB areas of Wales.

For slaughterhouses with a throughput greater than 40 animals per year, the highest median submission rate was in the HRA of England, 1.4 per 1000 (IQR 0.6, 2.2), followed by Wales 0.5 (IQR 0.4, 1.3), the Edge Area 0.4 (IQR 0.2, 0.7) and the LRA of England 0.1 (IQR 0.1, 0.3). The median submission rate for Scotland was around zero.

Geographic variation in submission numbers and rates

Figures 1.2 to 1.4 display the geographical distribution of slaughterhouses in GB according to their bovine animal throughput and case (sample) submission rate.

Figure 1.2a shows the locations of the 185 slaughterhouses that processed animals between 2016 and 2018 and that had an average throughput of greater than 40 animals per year. Figure 1.2b shows the locations for the 169 slaughterhouses that processed animals in 2019 with a throughput greater than 40 animals. These two maps show that there has been a reduction in the throughput for some slaughterhouses between 2016 and 2019.

The geographic distribution of submissions per 1,000 animals slaughtered between 2016 and 2018 is shown in Figure 1.3a. The majority of the 16 slaughterhouses with a submission rate of greater than 2.0 (and a throughput > 40 animals/year) were located in the HRA of England, while two were located in Wales. In 2019, 10 slaughterhouses had a submission rate of > 2.0 animals per 1000, all located in the English HRA or Wales (Figure 1.3b).

Figures 1.4a and 1.4b show the distribution of the culture-positive submission rate per 1,000 animals slaughtered in 2016-2018 and in 2019 respectively. As expected, slaughterhouses with high positive submission rates are mainly located in regions with a high incidence of TB.

Figure 1.2: The locations of the 185 slaughterhouses where > 40 animals per year were processed between 2016 and 2018 (left) and in 2019 (right), categorised by slaughterhouse throughput (animals/ year)).

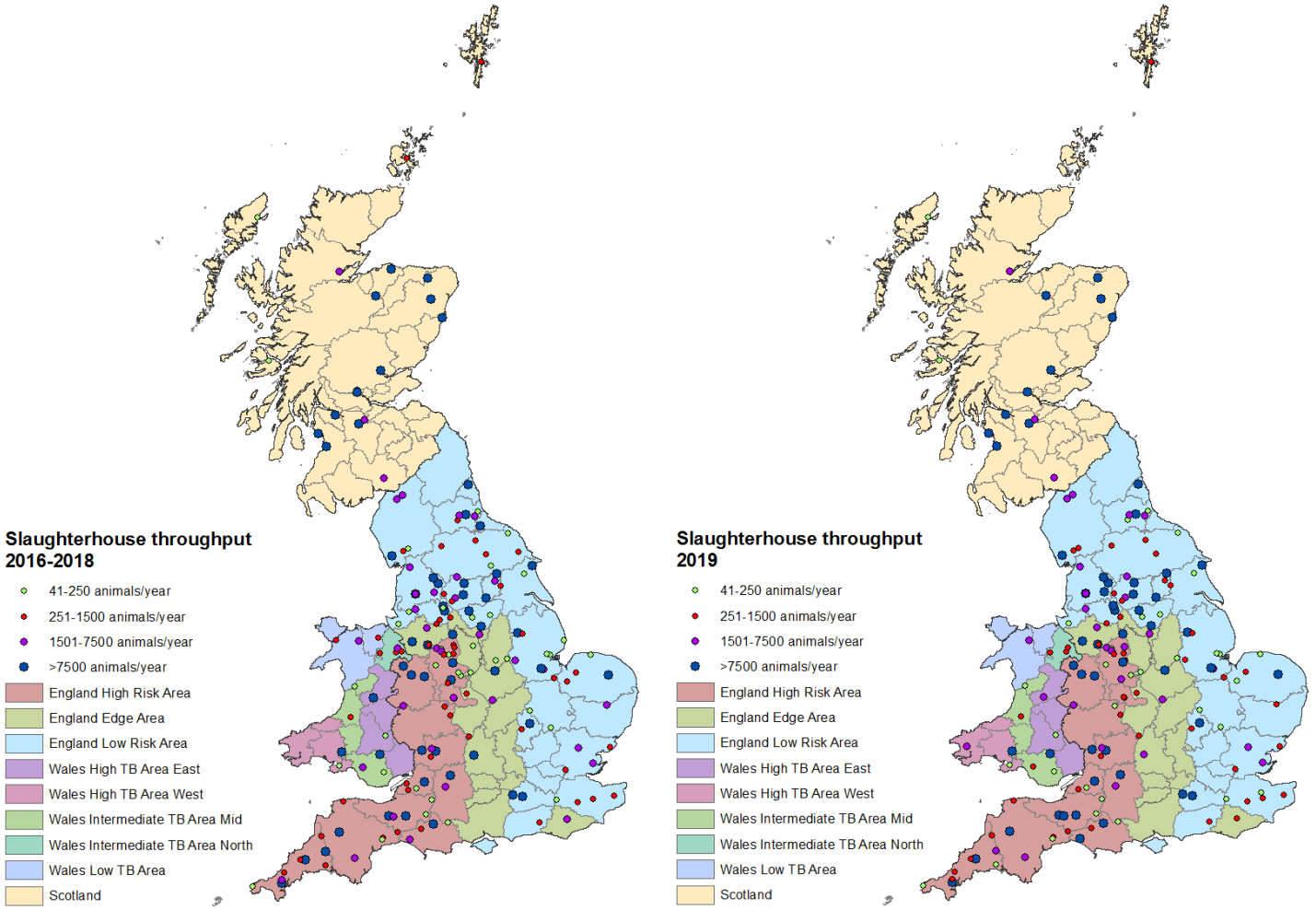


Figure 1.3: Number of slaughterhouse case samples submitted per 1,000 animals slaughtered, by slaughterhouse location (includes only 185 slaughterhouses where > 40 animals per year were processed) between 2016 and 2018 (left) and in 2019 (right).

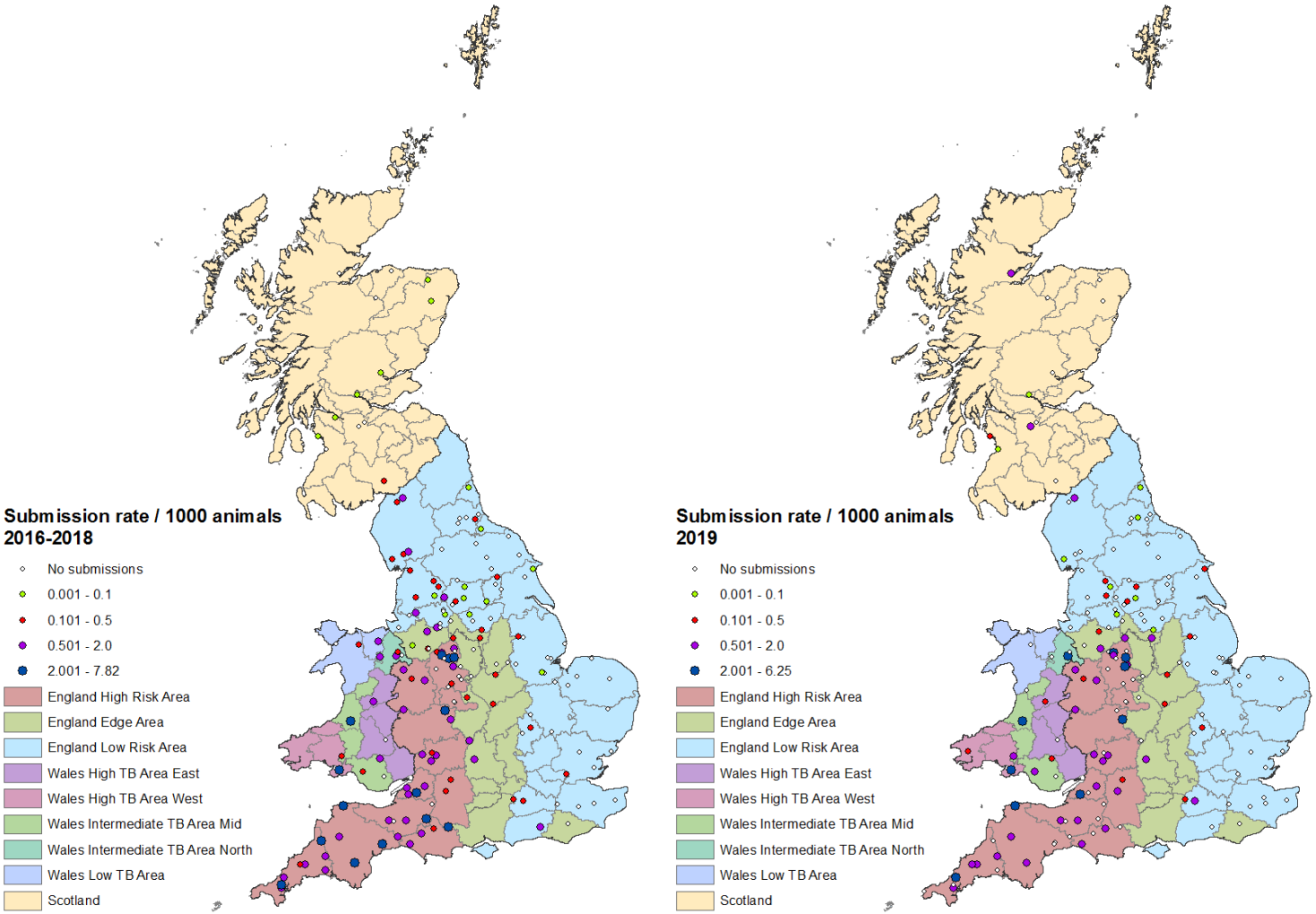
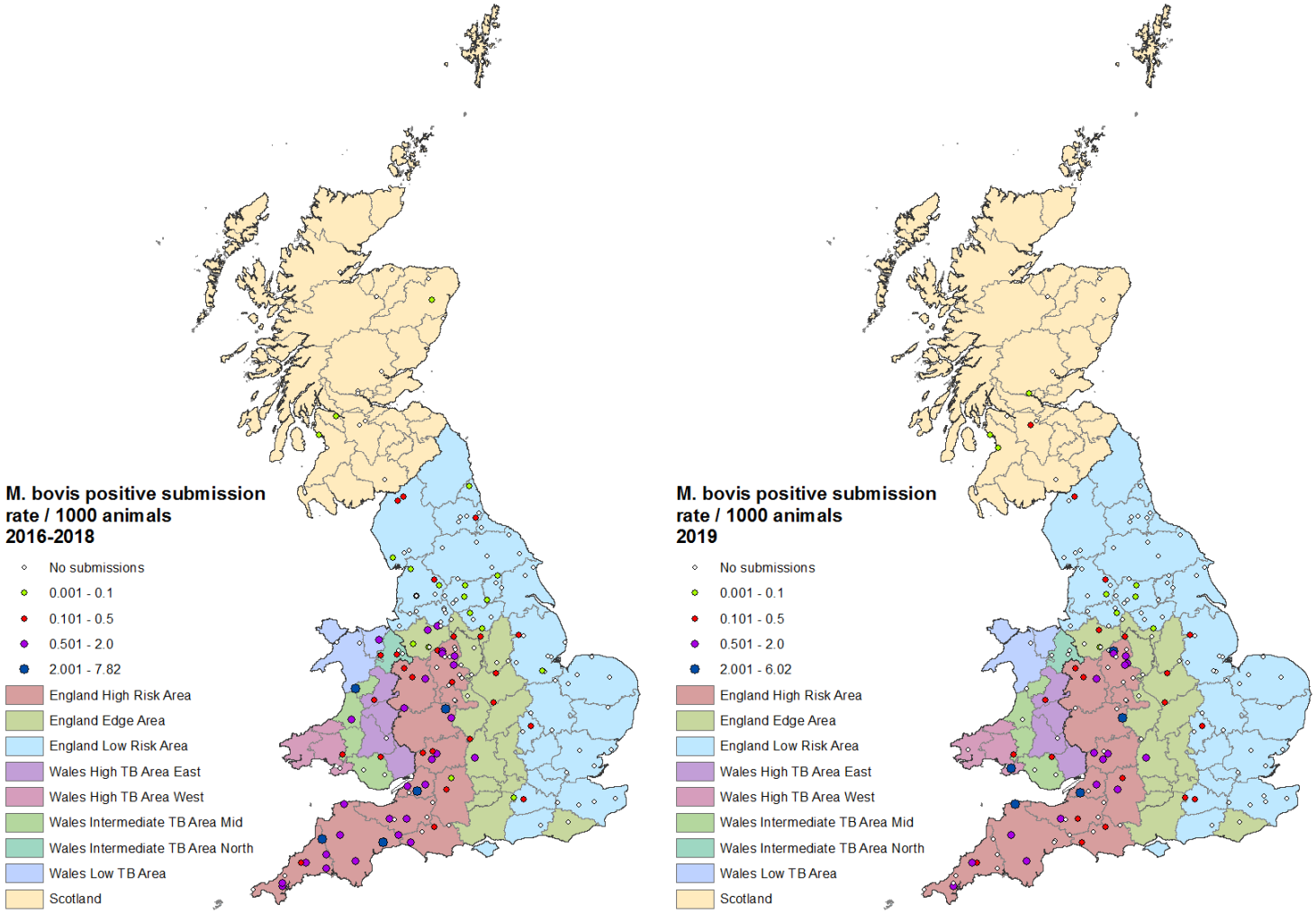


Figure 1.4: Number of culture-positive slaughterhouse case samples submitted per 1,000 animals slaughtered (includes only 185 slaughterhouses where > 40 animals were processed) between 2016 and 2018 (left) and 2019 (right).



Positive slaughterhouse cases

Of the 3,784 total TB slaughterhouse cases detected between 2016 and 2019, *M. bovis* was culture confirmed from 2,581 (68%) samples, leading to a positive submission rate of 0.28 per 1,000 animals slaughtered. This is a significant drop in the total positive submission rate compared to the last reporting period (0.46 per 1000 animals slaughtered), and was consistent over the four year period (2016-19), Figure 1.1c. The geographical distribution of *M. bovis* positive submissions per 1,000 animals slaughtered between 2016 and 2019 is shown in Figure 1.4a, and data for 2019 is shown in Figure 1.4b.

The number of slaughterhouse case samples submitted to the APHA between 2016 and 2019 by herd and slaughterhouse region is shown in Table 1.2. The total number of cases varied by herd region, with more samples submitted from herds located in the HRA of England than in any other region (n=2,556), as expected and consistent with previous reports. This table only presents animals with suspect lesions but may reflect the pattern of total throughput. Herds frequently submit animals to slaughterhouses outside their own region. This is particularly the case in herds for the Edge Area in England, most likely a result of the nature of the size and shape of the area itself. More slaughterhouse cases for animals originating in Wales were submitted by slaughterhouses in the HRA than slaughterhouses in Wales, most notably in the ITBAN region of Wales (71%) (Table 1.2).

Table 1.2: Number of slaughterhouse case samples submitted to APHA between 2016 and 2019, by herd and slaughterhouse region.

Slaughterhouse region		Herd origin HRA	Herd origin Edge	Herd origin LRA	Herd origin Scotland	Herd origin HTBE	Herd origin HTBW	Herd origin ITBM	Herd origin ITBN	Herd origin Low TB
England HRA	N	2,260	200	51	15	57	84	42	17	18
	%	88.42	42.92	20.56	18.99	52.78	42.42	58.33	70.83	60
England Edge Area	N	65	80	21	5	5	1	1	0	0
	%	2.54	17.17	8.47	6.33	4.63	0.51	1.39	0	0
England LRA	N	125	153	158	21	9	28	5	1	7
	%	4.89	32.83	63.71	26.58	8.33	14.14	6.94	4.17	23.33
Scotland	N	1	0	4	38	0	0	0	0	0
	%	0.04	0	1.61	48.1	0	0	0	0	0
Wales High TB Area East	N	5	1	0	0	7	2	2	0	2
	%	0.2	0.21	0	0	6.48	1.01	2.78	0	6.67
Wales High TB Area West	N	0	0	0	0	0	4	0	0	0
	%	0	0	0	0	0	2.02	0	0	0
Wales Intermediate TB Area Mid	N	100	31	14	0	30	79	22	0	1
	%	3.91	6.65	5.65	0	27.78	39.90	30.56	0	3.33
Wales Intermediate TB Area North	N	1	0	0	0	0	0	0	5	1
	%	0.21	0	0	0	0	0	0	20.83	3.33
Wales Low TB Area	N	0	0	0	0	0	0	0	1	1
	%	0	0	0	0	0	0	0	4.17	3.33
Total	N	2,556	108	198	72	24	248	30	79	30

Slaughterhouses that did not submit a sample

Between 2016 and 2019, 145 slaughterhouses out of the 261 that registered at least one bovine animal slaughter did not submit a suspected tuberculous sample to APHA for culture (56%) (Table 1.3). However, this falls to 71 out of 186 (38%) for slaughterhouses with a throughput greater than 40 animals. It is also important to note that some of the 145 slaughterhouses not submitting a sample may have notified APHA of a suspected slaughterhouse case where sample submission was not required. For example, when a slaughterhouse case is identified in a herd already restricted due to an OTF-W TB incident.

In the English HRA 10/57 slaughterhouses with a throughput greater than 40 animals failed to submit a single sample. In the HRA half (29/76) of the slaughterhouses that registered a movement-on between 2016 and 2019, did not submit a sample from an animal to APHA, but most of these (19/29) were slaughterhouses with very low throughput. It is also important to note that not all notifications of suspected slaughterhouse cases automatically lead to samples being submitted to APHA for culture. For example, when cases are identified in a herd already restricted due to an OTF-W incident.

None of the 45 CPHHs that were final destinations for animals but did not have a slaughterhouse ID submitted a sample. All of these had a throughput of 40 animals or less per year and notably 33% of these final destination CPHHs were in the HRA. The number of animals passing through these apparent lairages was 723, which represents less than 0.01% of the whole throughput between 2016 and 2019, so their contribution is negligible.

Five slaughterhouses with a very high throughput (>7500) did not submit a sample between 2016 and 2019; two in Scotland, two in the LRA and one in the HRA of England. The absence of samples from the slaughterhouse with high throughputs is of concern even if the cattle slaughtered are predominantly from Low TB (LTB) risk areas. This is because active TB test surveillance frequency is much lower than in high-risk areas and TB surveillance is predominately passive in these areas, and therefore dependent on slaughterhouse inspection.

Section 5 specifically aims to identify slaughterhouses that submitted fewer than the expected number of samples.

Table 1.3: Regional distribution of slaughterhouses that did not submit any samples between 2016 and 2019, by slaughterhouse (SLH) throughput categories (animals per year).

Region	<1 animal per year	1-40 animals per year	41-250 animals per year	251-1500 animals per year	1501-7500 animals per year	>7500 animals per year	Total SLH sending no subs	Total SLH	% with no subs
England High Risk Area	5	14	4	5	0	1	29	76	38.2%
England Edge Area	5	7	3	2	0	0	17	29	58.6%
England Low Risk Area	8	14	18	15	8	2	65	98	66.3%
Scotland	1	6	2	3	2	2	16	27	59.3%
Wales High TB Area East	0	0	1	0	0	0	1	2	50.0%
Wales High TB Area West	2	4	0	0	0	0	6	8	75.0%
Wales Intermediate TB Area Mid	0	2	1	0	0	0	3	8	37.5%
Wales Intermediate TB Area North	0	2	0	1	0	0	3	6	50.0%
Wales Low TB Area	1	3	0	1	0	0	5	7	71.4%
Total slaughterhouses sending no submissions	22	52	29	27	10	5	145	261	55.6%
Total slaughterhouses	100%	98%	73%	48%	29%	9%	56%		
% sending no submissions	22	53	40	56	34	56	261		

Proportion of culture-confirmed slaughterhouse case submissions and genotyping results

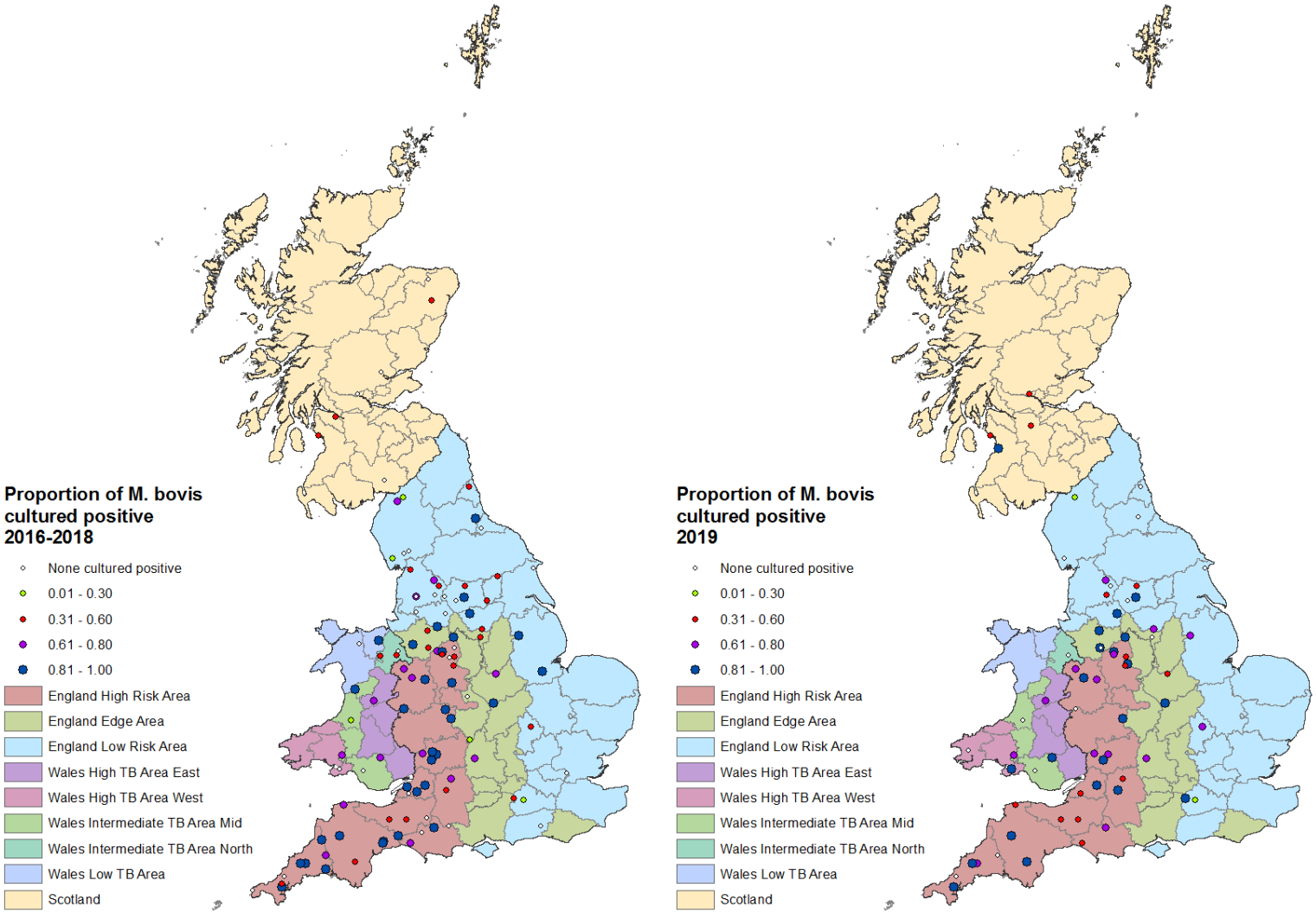
The proportions of slaughterhouse cases in which the presence of *M. bovis* was confirmed by culture are shown in Figures 1.5a (2016-2018) and b (2019). The number of slaughterhouses were the proportions exceed 0.80 decreased in 2019 compared to the 2016-18 period. In both time periods these slaughterhouses were mainly found in the English HRA. The median culture-positive slaughterhouse cases rate per 1000 for slaughterhouses that submitted a sample was 0.32 (IQR 0.08-0.94).

Genotyping, through the use of spologotyping, is a form of molecular epidemiology that can be used to identify the area in which an infection was acquired. The submission rate by different spoligotypes of *M. bovis* is given in Table 1.4. In all years between 2016 and 2019, spoligotypes 9, 11 and 17 were the most frequently isolated. This is the case for all culture-confirmed bovine TB samples, as well as those submitted as suspect samples from routine slaughterhouse inspection. The same spoligotypes were also the most prevalent between 2009 and 2015.

Table 1.4: The number of carcases with suspected TB lesions submitted to APHA (N) and confirmed as infected with *M. bovis* per 1,000 animals slaughtered (Rate) per year, by spoligotype. Spoligotypes are listed in order of decreasing overall frequency.

Spoligotype	2016 N	2016 Rate	2017 N	2017 Rate	2018 N	2018 Rate	2019 N	2019 Rate	Total N	Total Rate
17	144	0.063	95	0.041	137	0.059	110	0.047	486	0.052
9	129	0.056	133	0.058	116	0.050	99	0.042	477	0.051
11	134	0.058	104	0.045	103	0.044	83	0.035	424	0.046
25	79	0.034	65	0.028	76	0.033	71	0.030	291	0.031
10	20	0.009	38	0.017	24	0.010	31	0.013	113	0.012
21	35	0.015	27	0.012	21	0.009	24	0.010	107	0.012
15	21	0.009	14	0.006	16	0.007	17	0.007	68	0.007
35	14	0.006	17	0.007	19	0.008	13	0.006	63	0.007
22	11	0.005	9	0.004	12	0.005	19	0.008	51	0.005
12	15	0.007	7	0.003	9	0.004	11	0.005	42	0.005
20	10	0.004	3	0.001	5	0.002	8	0.003	26	0.003
13	3	0.001	3	0.001	1	0.000	2	0.001	9	0.001
75	3	0.001	0	0.000	1	0.000	0	0.000	4	0.000
51	2	0.001	0	0.000	1	0.000	0	0.000	3	0.000
74	2	0.001	0	0.000	0	0.000	0	0.000	2	0.000
73	2	0.001	0	0.000	0	0.000	0	0.000	2	0.000
65	0	0.000	1	0.000	0	0.000	1	0.000	2	0.000
87	1	0.000	0	0.000	0	0.000	0	0.000	1	0.000

Figure 1.5: The proportion of *M. bovis* culture positive slaughterhouse case submissions for the 185 slaughterhouses with a throughput of >40 animals per year between January 2016 and December 2018 (left) and from January to December 2019 (right).



Slaughterhouse case and TB test reactor detection rates

The number of positive submissions per 1,000 animals slaughtered is compared to the rate of reactors detected by live animal testing (reactors per 1,000 animals tested). The number of positive submissions per 1,000 animals slaughtered in GB decreased between 2013 and 2019 (Figure 1.6). In contrast, the number of reactors per 1,000 animals tested, excluding short-interval tests, increased between 2014 and 2017, decreasing again between 2017 and 2019 (Figure 1.6). Reactors per 1,000 animals tested varied more between 2009 and 2019 compared to positive submissions per 1,000 animals tested. The number of reactors is sensitive to changes in policies on TB control and can therefore vary temporally and spatially. The rate of passive detection in slaughtered animals may provide a more constant measure of TB risk, although there are other factors which can affect performance, such as animal throughput.

In 2019, over 80% of herds in the England Edge Area and all five TB areas of Wales received a herd-level TB test. In the England HRA the same percentage was 79%, followed by the LRA (28%) and Scotland (12%) (GB data report – E3, 2019). The routine herd testing interval varies between regions. Parts of the Wales High TB West and Edge Area in England carried out six-monthly testing in 2019. In the England HRA, parts of the Edge Area and the remainder of Wales, routine testing is annual. For the England LRA and Scotland, the default herd testing frequency is every four years.

For slaughterhouse surveillance, the rate of samples which were subsequently confirmed to be *M. bovis* positive in the English HRA has decreased significantly between 2016 and 2019. The rate in the other regions was more stable during these years, with the exception of Wales ITBN where the rate also decreased since 2015 (Figure 1.7). For live animal testing, there has been an overall decrease in the number of reactors in the last two years. This has been due specifically to decreases in the England HRA, and Wales High TB East, while other regions have been more stable (Figure 1.8). This decrease in the rate of reactors detected in the HRA, in combination with the decrease in the positive slaughterhouse rate, suggests that there is likely to be a true reduction of TB-infected animals in this area, and that the change is not solely an artefact of changing surveillance strategies. In the England Edge Area the number of reactors has increased since 2013, when annual surveillance testing was introduced. This increase is not reflected in the positive submission rate from slaughterhouse surveillance, which has remained stable.

In the Wales High TB East region the number of reactors has fallen for two consecutive years, while the number of positive submissions detected by slaughterhouse surveillance has increased since 2016. Although the proportion of positive submissions has increased over the last two years, the proportion of OTF-W incidents has been decreasing in the region and the increases in submissions reflect the low number of overall cases in the area (17 slaughterhouse confirmed cases in the HTBE region in 2019). In Scotland, the rate of positive submissions per 1,000 animals slaughtered, and the rate of samples which were

subsequently confirmed to be *M. bovis* has been very low and stable throughout the reporting period.

Figure 1.6: Detection rate of reactors per 1,000 animals tested in a live animal surveillance test (excluding short interval tests) and the detection rate of positive slaughterhouse case submissions per 1,000 animals slaughtered in GB, between 2009 and 2019.

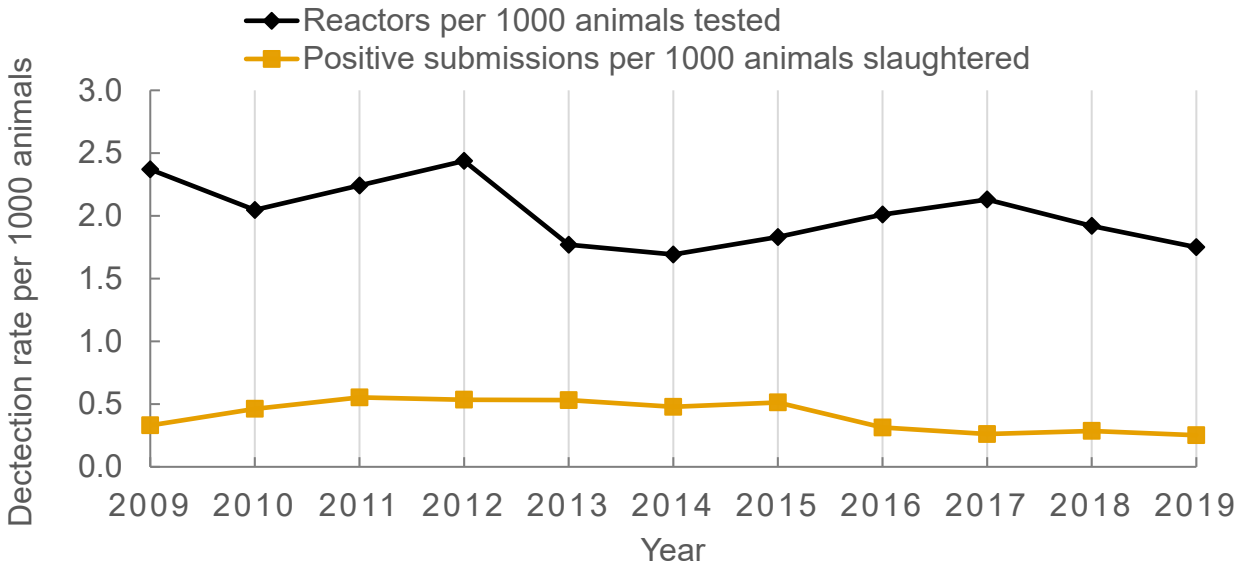


Figure 1.7: Positive slaughterhouse case submission rate per 1,000 animals slaughtered between January 2009 and December 2019, by risk region of herd of origin in England and Scotland (above) and in Wales (below).

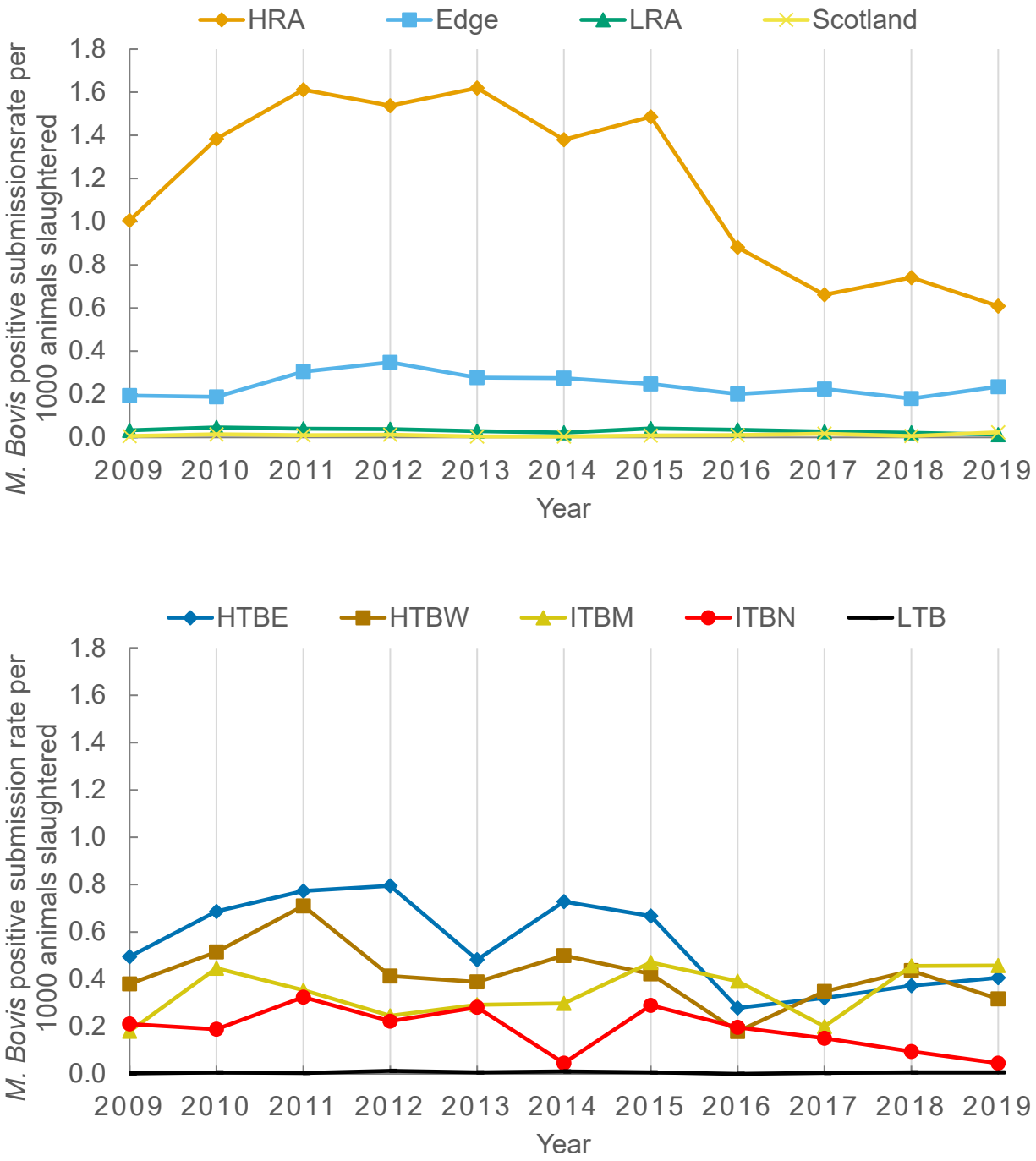
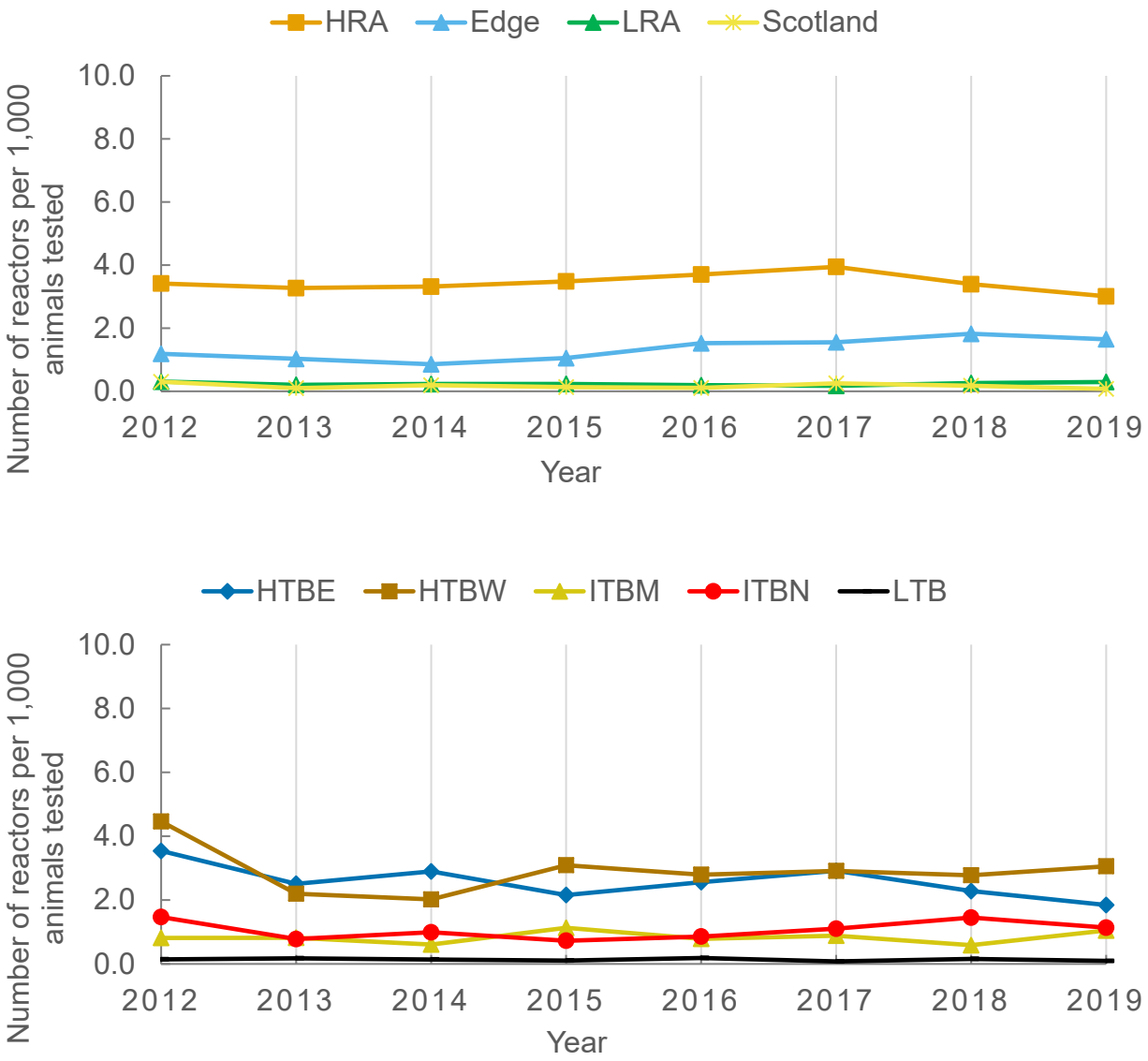


Figure 1.8: The number of reactors per 1,000 animals tested between January 2012 and December 2019, by risk region for herd of origin in England and Scotland (above) and in Wales (below).



Note: The way the number of reactors is recorded changed in 2012, and comparable data is not available before 2012.

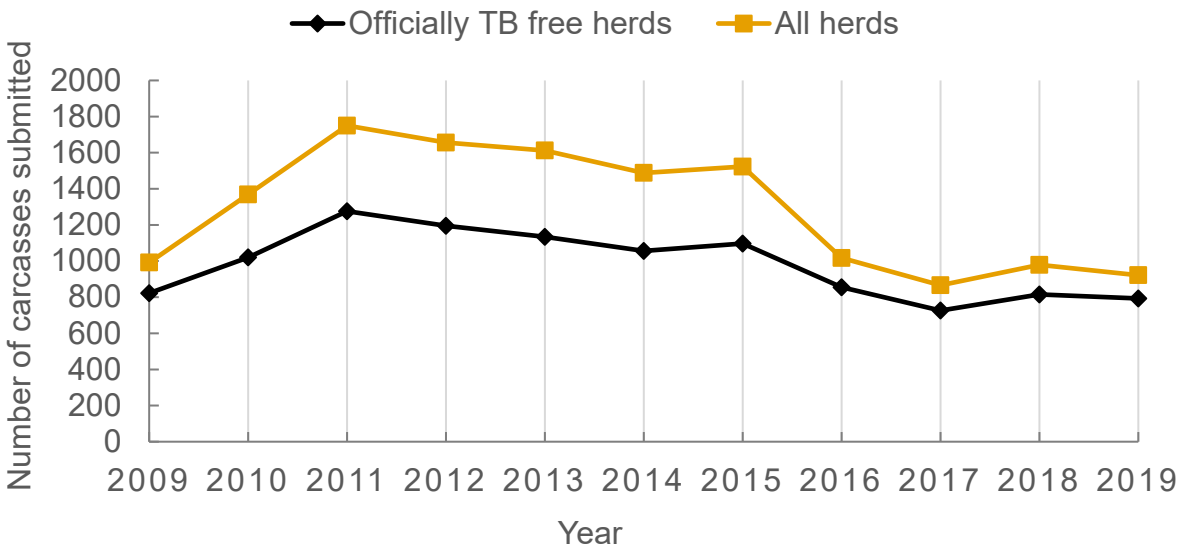
Section 2: Proportion of slaughterhouse cases confirmed positive by laboratory culture

AIM: To investigate the proportion of slaughterhouse cases that were confirmed positive by culture or histopathology and to identify the significant risk factors for *Mycobacterium bovis* culture-positive slaughterhouse cases.

Descriptive statistics

Between 2009 and 2019, 14,174 samples from animals with suspect lesions of TB were submitted to APHA for culture. Of these, 10,789 were submitted to APHA from OTF herds (i.e. herds that were not under TB movement restriction at the time of detection). More specifically, for the period of the current report (2016-2019) 3,784 samples with suspect lesions of TB were submitted for culture and 3,189 of these samples were from OTF herds. When comparing the current with the previous period (2013-2016), the numbers have decreased (5,639 samples and 4,138 of these from OTF herds). Both total slaughterhouse case submissions and submissions from unrestricted herds increased rapidly between 2006 and 2011, slightly decreased between 2011 and 2015, and rapidly decreased between 2015 and 2019 (Figure 2.1).

Figure 2.1: Number of slaughterhouse cases submitted to APHA for culture between 2009 and 2019, in total and from officially TB free herds being tested as part of the routine testing scheme.



Between 2016 and 2019 the overall proportion of slaughterhouse case samples submitted from OTF herds that were positive on culture (i.e. those from which *M. bovis* was isolated) was 62% (Table 2.1), and 68% for samples submitted from all slaughterhouse cases,

including OTF herds. This has fluctuated slightly between 2009 and 2019 with no obvious upward or downward trend (range = 59% in 2019 to 68% in 2010) (Figure 2.2a).

All slaughterhouse cases were submitted for histology where sufficient material was available (although culture was the priority). The overall proportion of submissions with positive histology results among those tested for histology was 70%. Although it had been declining since 2010, this proportion rose steeply in 2015 and 2016, before continuing to slowly decline (Figure 2.2a and Table 2.1).

Table 2.1 Histology and culture results from slaughterhouse case samples from OTF herds submitted to APHA between 2016 and 2019, where both culture and histology were performed. Culture positive samples are those where *M. bovis* was isolated after culture. Histology positive are those where histopathology was typical of a mycobacterial infection, with or without detection of acid fast bacteria.

	Culture positive	**Culture negative**	**Total**
Histology positive	1,195	107	1,302
Histology negative	70	493	563
Total	1,265	600	1,865

The proportion of slaughterhouse case samples that were confirmed positive by culture varied regionally. In the England HRA the percentage of culture-positive submissions remained stable at around 70% (range 67.2%-73.5%; Figure 2.2b). In the other risk areas, the percentage of submissions confirmed positive by culture varied across years, but has always been lowest in the England LRA, Wales LTB and Scotland, as would be expected given the much lower prevalence of bovine TB in those areas (and hence the lower positive predictive value of a suspected slaughterhouse case).

The percentage of slaughterhouse case submissions that were positive upon histology examination (among those tested) was stable in the England HRA and Wales TB East, (67-84% and 65-80%, respectively) between 2009 and 2019 (Figure 2.2c). In other risk areas the percentage of histology positive slaughterhouse cases fluctuated more widely, often due to low numbers of slaughterhouse case submissions. Overall, the number positive upon histology examination was lowest in the England LRA, Wales LTB and Scotland.

The proportion of slaughterhouse cases that are confirmed positive using either histology or culture confirmation methods are broadly similar. The overall sensitivity and specificity of histology relative to culture was 0.945 (0.937 in previous reporting period) and 0.822 (0.849 in previous reporting period), respectively (Table 2.1). This demonstrates an increase in the sensitivity of histology relative to culture (which can be explained by the fact that fewer samples were tested for histology the last years of the report period), but the specificity of histology has been maintained at the same levels. Histological diagnosis is more subjective than bacteriological culture: organisms other than *M. bovis* (e.g. *M.*

terrae, *M. microti* or *M. sinensis*) can appear similar in histological appearance and cause a false positive result. The degree of agreement between culture and histology (kappa-statistic measure) was estimated at 78%.

Figure 2.2a: Proportion of slaughterhouse case submissions processed between 2009 and 2019 that were positive by histological examination (either among tested for histology or among all submitted for TB lesions) or confirmed positive by culture and that originated from officially TB free (with unconfirmed slaughterhouse cases) herds.

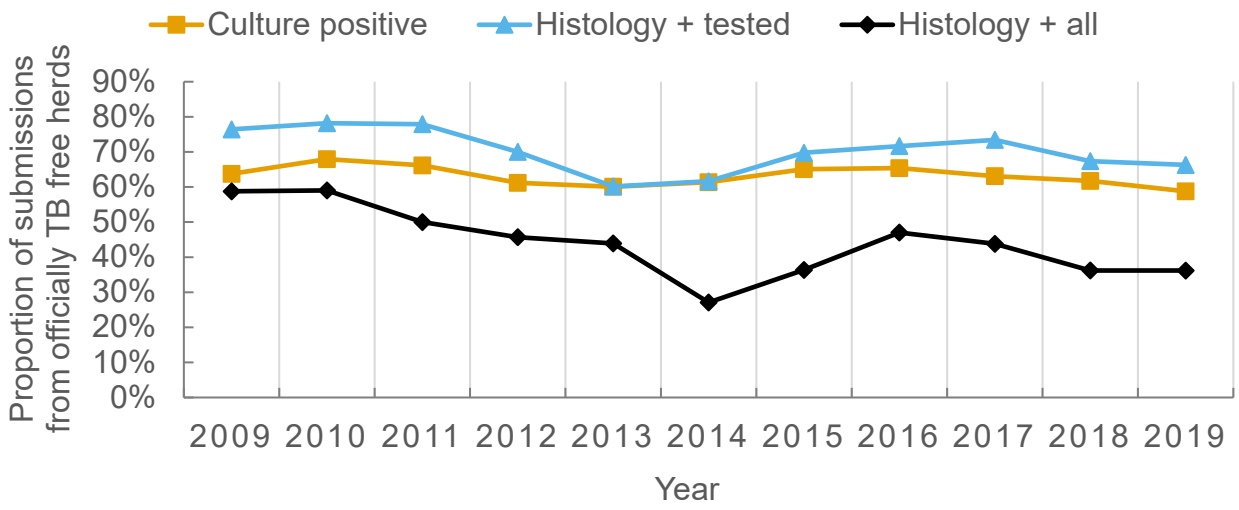
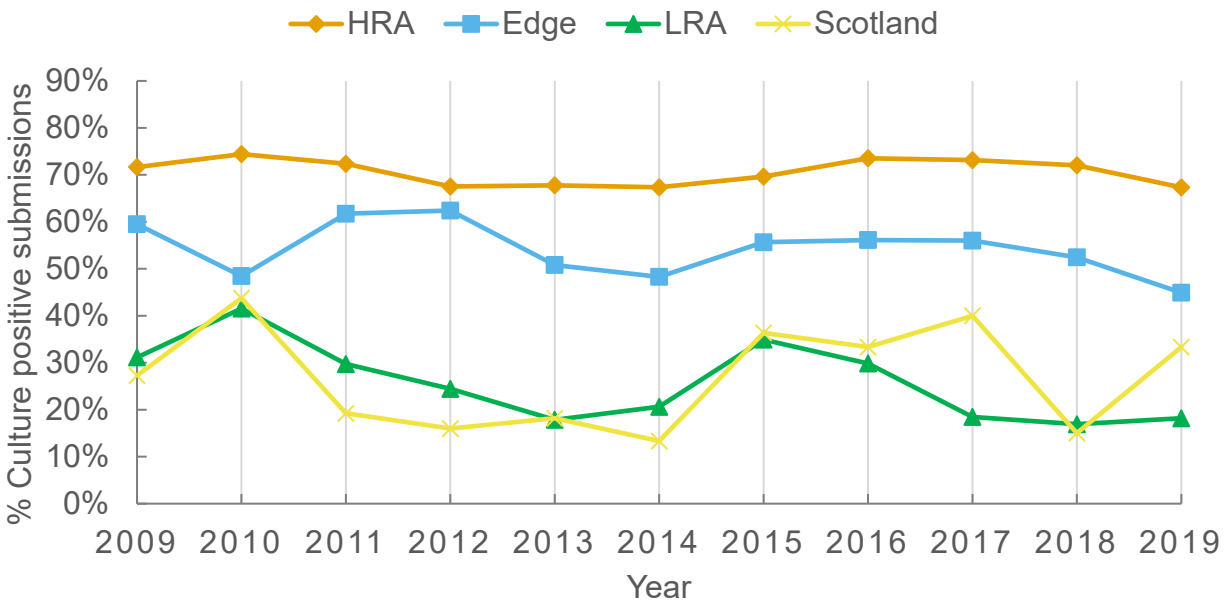


Figure 2.2b Proportion of slaughterhouse case submissions processed between 2009 and 2019 that were confirmed positive by culture and that originated from OTF herds, by risk region in England and Scotland (above) and in Wales (below).



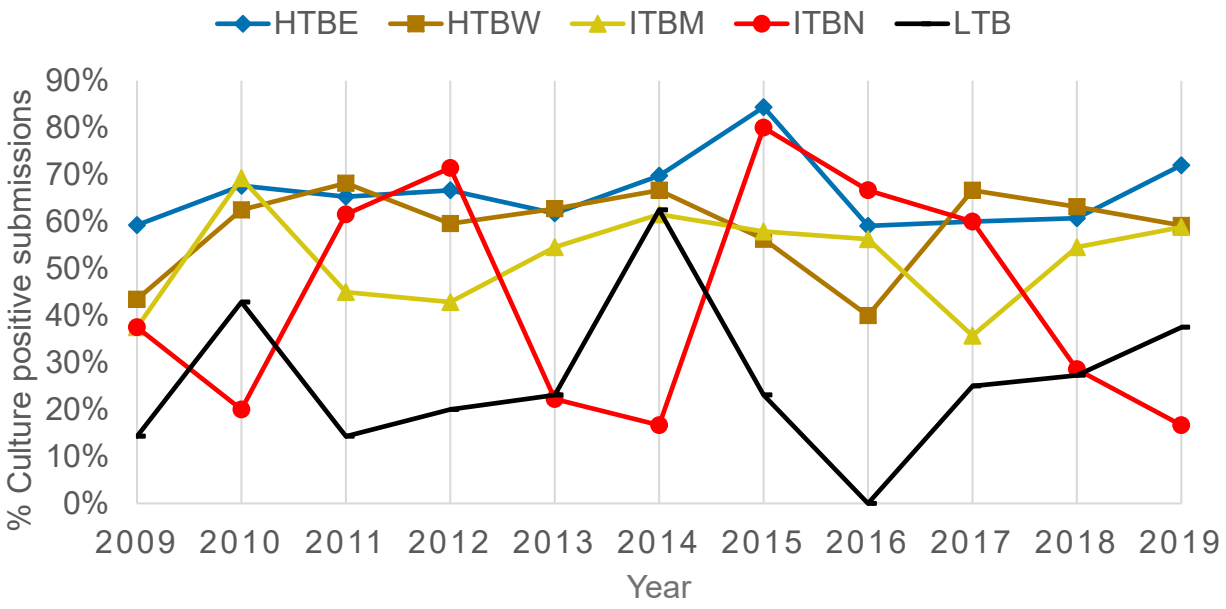
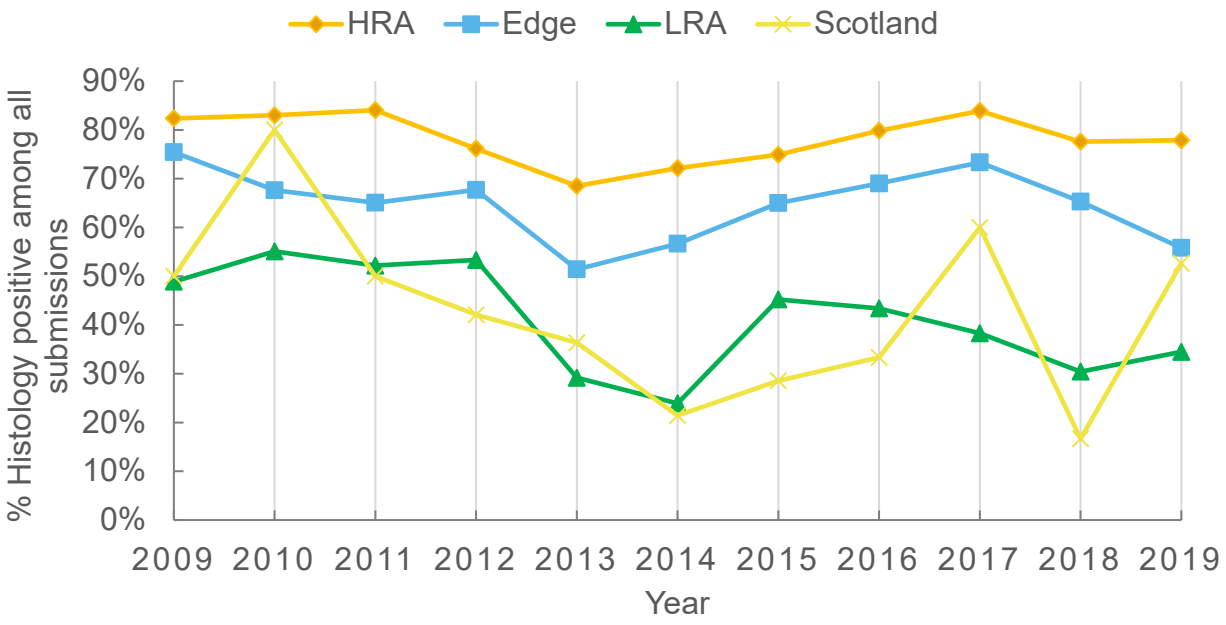
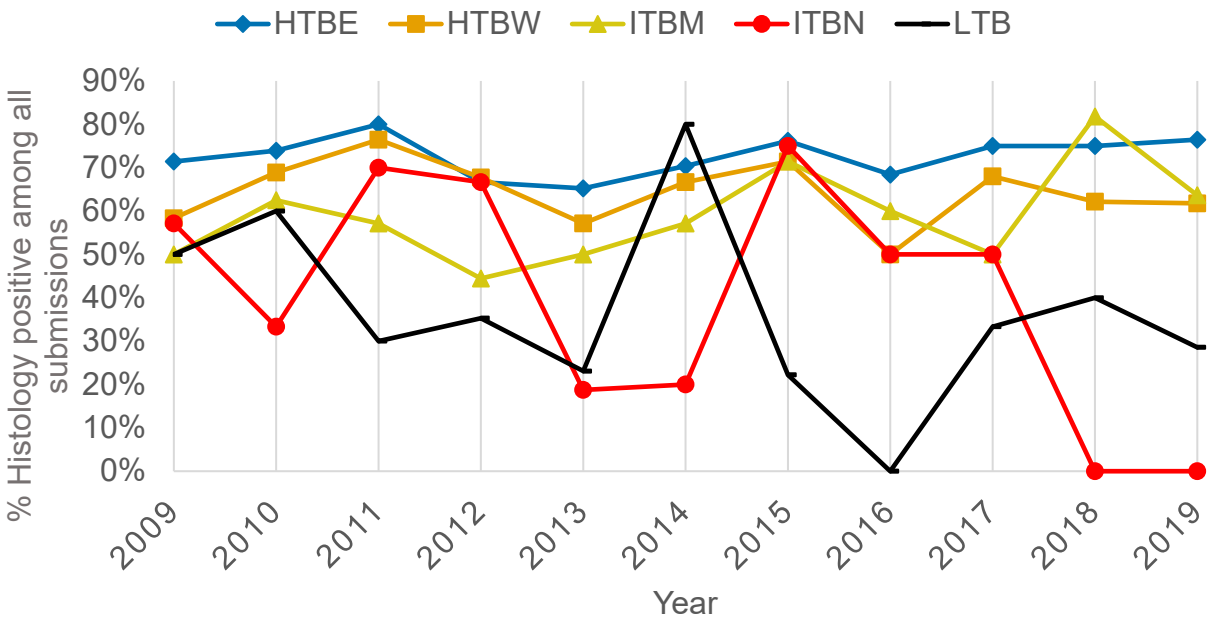


Figure 2.2c Proportion of slaughterhouse case submissions from herds that were not under movement restrictions and were examined by histology and determined to be positive between 2009 and 2019, by risk region in England and Scotland (above) and in Wales (below).





Analysis to investigate risk factors for confirmation of slaughterhouse cases leading to OTF-W TB incidents

Multivariable logistic regression was used to investigate risk factors for confirmation of slaughterhouse cases by bacteriological culture. TB incidents disclosed by culture-negative slaughterhouse cases (where skin herd tests are performed and disclose reactors before the slaughterhouse case returns a negative culture result) or culture-positive (OTF-W) slaughterhouse cases were categorised from animal level data. Slaughterhouse cases that occurred in herds already under movement restrictions due to a TB breakdown were excluded.

OTF-W TB incidents initiated by slaughterhouse cases were generated by grouping culture positive slaughterhouse cases that had the same breakdown ID. Herds with unconfirmed slaughterhouse cases were herds with slaughterhouse case submissions from which *M. bovis* was not isolated. Where more than one submission from the same CPH was recorded, all samples that were detected within seven days of each other were classified as the same TB incident (herds with culture-confirmed slaughterhouse cases) or "non-incident" (herds with unconfirmed slaughterhouse cases).

For this analysis, herd level data were obtained for 1,872 TB incidents and 1,135 "non-incidents" that occurred between 2016 and 2019. The number and percentage of non-incidents and OTF-W breakdowns triggered by slaughterhouse cases, categorised by slaughterhouse and herd risk region, TB history, year, herd type and herd size, are shown in Table 2.2.

The final multivariable model of the factors associated with the odds of TB incident confirmation following the identification of a slaughterhouse case is shown in Table 2.3. Standard errors were adjusted for 115 clusters in slaughterhouse ID. The model correctly classified 72.0% of the data, was an adequate description of the data (Hosmer-Lemeshow χ^2 (8 d.f.)=9.48, P=0.3032) and the area under the ROC curve was 0.71.

M. bovis was less likely to be confirmed in slaughterhouse case samples from herds that were located in regions other than the HRA of England.

The slaughterhouse region and herd region displayed collinearity and it was not possible to include them both in the same model. The inclusion of herd region reduced the AIC more than slaughterhouse region, so it was retained in the model.

Slaughterhouse cases from dairy herds had almost 1.3 higher odds of confirmation by culture than cases detected in beef herds. An increasing proportion of dairy throughput in a slaughterhouse also significantly increased the odds of a case leading to a TB incident, however when adjusted for other variables in the model this effect was not significant.

A slaughterhouse sample was less likely to result in an OTF-W incident if a TB herd test had taken place within the previous 90 days. The time elapsed since the last TB incident

was also significantly associated with the odds of a slaughterhouse case being confirmed and resulting in an OTF-W incident.

The animal throughput of the slaughterhouse in which a case was detected was significant in the model, with higher throughput levels increasing the odds of a confirmed slaughterhouse case.

The size of the herd and the number of submissions from the herd were both included in the previous model (2013-16), however they did not improve the AIC or provide a good fit for the 2016-19 data and were excluded from the final model in this report.

The year of submission was not significantly associated with the confirmation of *M. bovis* in a slaughterhouse sample, so it was not included in the model.

Table 2.2: Number and percentage of “non-incidents” and OTF-W TB incidents triggered by slaughterhouse cases, by slaughterhouse region, herd of origin region, TB history, death year, herd type and size and number of submissions, between 2016 and 2019.

	Non-incidents N (%)	OTF-W incidents N (%)	Total N (%)
Slaughterhouse region			
England High Risk Area	705 (62.1%)	1,457 (77.8%)	2,162 (71.9%)
England Edge Area	66 (5.8%)	87 (4.6%)	153 (5.1%)
England Low Risk Area	227 (20.0%)	188 (10%)	415 (13.8%)
Scotland	29 (2.6%)	10 (0.5%)	39 (1.3%)
Wales High TB Area East	7 (0.6%)	12 (0.6%)	19 (0.6%)
Wales High TB Area West	3 (0.3%)	1 (0.1%)	4 (0.1%)
Wales Intermediate TB Area Mid	93 (8.2%)	114 (6.1%)	207 (6.9%)
Wales Intermediate TB Area North	4 (0.4%)	2 (0.1%)	6 (0.2%)
Wales Low TB Area	1 (0.1%)	1 (0.1%)	2 (0.1%)
Total	1,135	1,872	3,007
Herd Region			
England High Risk Area	551 (48.7%)	1,388 (74.1%)	1,939 (64.5%)
England Edge Area	182 (16.1%)	200 (10.7%)	382 (12.7%)
England Low Risk Area	182 (16.1%)	51 (2.7%)	233 (7.8%)
Scotland	48 (4.2%)	20 (1.1%)	68 (2.3%)
Wales High TB Area East	36 (3.2%)	59 (3.2%)	95 (3.2%)
Wales High TB Area West	69 (6.1%)	101 (5.4%)	170 (5.7%)
Wales Intermediate TB Area Mid	31 (2.7%)	35 (1.9%)	66 (2.2%)
Wales Intermediate TB Area North	13 (1.1%)	10 (0.5%)	23 (0.8%)
Wales Low TB Area	20 (1.8%)	8 (0.4%)	28 (0.9%)
Total	1,132	1,872	3,004
Previous OTF-W incidents within 4 years			
no incident	699 (61.6%)	736 (39.3%)	1,435 (47.7%)
1-2 incidents	390 (34.4%)	1,000 (53.4%)	1,390 (46.2%)
3+ incidents	46 (4.1%)	136 (7.3%)	182 (6.1%)
Total	1,135	1,872	3,007
Previous OTF-S incidents within 4 years			
no incident	999 (88.0%)	1,643 (87.8%)	2,642 (87.9%)
1-2 incidents	135 (11.9%)	228 (12.2%)	363 (12.1%)
3+ incidents	1 (0.1%)	1 (0.1%)	2 (0.1%)
Total	1,135	1,872	3,007

Table 2.2 continued: Number and percentage of “non-incidents” and OTF-W TB incidents triggered by slaughterhouse cases, by slaughterhouse region, herd of origin region, TB history, death year, herd type and size and number of submissions, between 2016 and 2019

	Non-incidents N (%)	OTF-W incidents N (%)	Total N (%)
Death Year			
2016	284 (25.0%)	528 (28.2%)	812 (27.0%)
2017	252 (22.2%)	438 (23.4%)	690 (22.9%)
2018	296 (26.1%)	471 (25.2%)	767 (25.5%)
2019	303 (26.7%)	435 (23.2%)	738 (24.5%)
Total	1,135	1,872	3,007
Herd Type			
Beef	590 (52.0%)	1,091 (58.3%)	1,681 (55.9%)
Dairy	245 (21.6%)	779 (41.6%)	1,024 (34.1%)
Other/Mixed	295 (26.0%)	0 (0.0%)	295 (9.8%)
Not known	5 (0.4%)	2 (0.1%)	7 (0.2%)
Total	1,135	1,872	3,007
Herd Size			
0 or no data	91 (8.0%)	68 (3.6%)	159 (5.3%)
1-10	27 (2.4%)	24 (1.3%)	51 (1.7%)
11-50	92 (8.1%)	135 (7.2%)	227 (7.5%)
51-100	110 (9.7%)	220 (11.8%)	330 (11.0%)
101-200	211 (18.6%)	383 (20.5%)	594 (19.8%)
201-300	185 (16.3%)	312 (16.7%)	497 (16.5%)
301-500	197 (17.4%)	382 (20.4%)	579 (19.3%)
501-1000	175 (15.4%)	278 (14.9%)	453 (15.1%)
>1000	47 (4.1%)	70 (3.7%)	117 (3.9%)
Total	1,135	1,872	3,007
Submissions			
One	1,065 (93.8%)	1,780 (95.1%)	2,845 (94.6%)
More than one	70 (6.2%)	92 (4.9%)	162 (5.4%)
Total	1,135	1,872	3,007

Table 2.3: Results of uni- and multivariable logistic regression analyses to identify significant risk factors for confirmation of slaughterhouse cases by culture, in officially TB free herds between 2016 and 2019. (OR: Odds Ratio; aOR: adjusted OR).

Risk factor	N	crude OR	P-value	95% CI	aOR	P-value	95% CI
Herd region	3,004						
England High Risk Area	1,939	1.0 (Ref)	-	-	1.0 (Ref)	-	-
England Edge	382	0.44	<0.0001	0.28-0.67	0.69	0.123	0.43-1.11
England Low Risk Area	233	0.11	<0.0001	0.06-0.19	0.27	<0.0001	0.13-0.55
Scotland	68	0.17	<0.0001	0.09-0.31	0.80	0.737	0.21-2.98
Wales High TB Area East	95	0.65	0.189	0.34-1.24	0.58	0.075	0.32-1.06
Wales High TB Area West	170	0.58	<0.0001	0.44-0.77	0.46	<0.0001	0.35-0.62
Wales Intermediate TB Area Mid	66	0.45	0.001	0.28-0.73	0.60	0.107	0.33-1.11
Wales Intermediate TB Area North	23	0.31	0.001	0.15-0.61	0.25	0.016	0.08-0.78
Wales Low TB Area	28	0.16	<0.0001	0.06-0.39	0.16	0.003	0.05-0.53
Herd Type	3,007						
Beef	1,681	1.0 (Ref)	-	-	1.0 (Ref)	-	-
Dairy	1,024	1.72	<0.0001	1.28-2.31	1.27	0.036	1.02-1.58
Last test within 90 days	3,007						
No	2,211	1.0 (Ref)	-	-	1.0 (Ref)	-	-
Yes	796	0.70	0.002	0.55-0.88	0.42	<0.0001	0.35-0.51
Time since last incident in days	2,044	<1.00	<0.0001	1.00-1.00	<1.00	<0.0001	1.00-1.00
Number of on movements (prev. 12 months)	3,007	<1.00	<0.0001	1.00-1.00	<1.00	<0.0001	1.00-1.00
SLH throughput per year (animals)	3,007	>1.00	0.029	1.00-1.00	>1.00	0.031	1.00-1.00
Proportion of dairy at SLH	3,007	4.54	0.01	1.43-14.44	3.28	0.078	0.88-12.26

Note: Herd type observations categorised as ‘unknown’ were excluded from the model because there were zero unknown herds in the OTF-W submissions category, and so an OR was not calculated. For time since last incident, number of on movements and SLH throughput per year, the OR and 95% CI are presented as 1.0 because the number had a lot of decimals and was rounded. The P-value is <0.05, so the OR is significant.

Section 3: Proportion of new TB herd breakdowns initiated by slaughterhouse cases between 2016 and 2019

AIM: To examine the proportion of TB incidents that were detected by slaughterhouse surveillance (post-mortem meat inspection at routine slaughter) over time and to investigate significant risk factors for a TB incident to be detected in the slaughterhouse compared to tuberculin skin testing.

Between January 2016 and December 2019, there were 17,513 new breakdowns in GB, of which 11,277 were OTF-W (i.e. they had evidence of *M. bovis* infection detected by culture in at least one sample from an animal, or lesions were found at slaughter in at least one skin test reactor). Classification of TB breakdown herds as OTF-W due to epidemiological risk alone, as applied in Wales, is not used within this report. Of the 17,513 breakdowns, 1,986 were disclosed by slaughterhouse surveillance rather than by tuberculin skin testing of cattle on farms. Of these, 1,933 were OTF-W.

The number of TB incidents that were detected in the slaughterhouse or by skin testing in 2016 and 2019 is shown in Table 3.1a, while the same data for OTF-W incidents only are shown in Table 3.1b. The number of TB incidents by county between in 2009, 2016 and 2019 is shown in Figure 3.1. The trends over time between 2009 and 2019 are shown in Figure 3.2a. Between 2016 and 2019, the overall rate of slaughterhouse disclosure from all OTF-W incidents increased slightly from 18.1% to 18.5%. OTF-W incidents decreased in 2017 to 14.6%, but rose back up to prior levels in 2019. When looking at all TB incidents, there is a slight decrease from 12.2% to 11.7% between 2016 and 2019 respectively. There was a small increase in the proportion of the OTF-W TB incidents detected by slaughterhouse inspection in the HRA and Edge Area of England and in Scotland between 2016 and 2019. Contrastingly, there was a sharp reduction in the proportion of OTF-W TB incidents disclosed by slaughterhouse inspection in the LRA of England. Proportions for all Welsh regions remained stable, with the exception of an increase in the LTB area in Wales since 2016. This may be due to very small numbers of all OTF-W TB incidents being disclosed in this region, which causes an exaggeration of the trend seen.

Table 3.1a: Proportion of all TB incidents detected by post-mortem meat inspection in slaughterhouses in 2016 and 2019 by herd region for skin tests (ST) and slaughterhouse tests (SLH).

Herd Region	ST 2016	ST 2019	SLH 2016	SLH 2019	Total 2016	Total 2019	% detected in SLH 2016	% detected in SLH 2019
England - HRA	2,598	2,166	426	335	3,024	2,501	14.1%	13.4%
England - Edge	538	584	58	56	596	640	9.7%	8.8%
England - LRA	117	138	20	10	137	148	14.6%	6.8%
England - Total	3,253	2,888	504	401	3,757	3,289	13.4%	12.2%
Scotland	32	25	4	8	36	33	11.1%	24. 2%
Wales - HTBE	247	194	13	17	260	211	5.0%	8.1%
Wales - HTBW	304	281	15	27	319	308	4.7%	8.8%
Wales - ITBM	43	64	8	11	51	75	15.7%	14.7%
Wales - ITBN	34	44	4	1	38	45	10.5%	2.2%
Wales - LTB	38	20	1	3	39	23	2.6%	13.0%
Wales - Total	666	603	41	59	707	662	5.8%	8.9%
Total	3,951	3,516	549	468	4,500	3,984	12.2%	11.7%

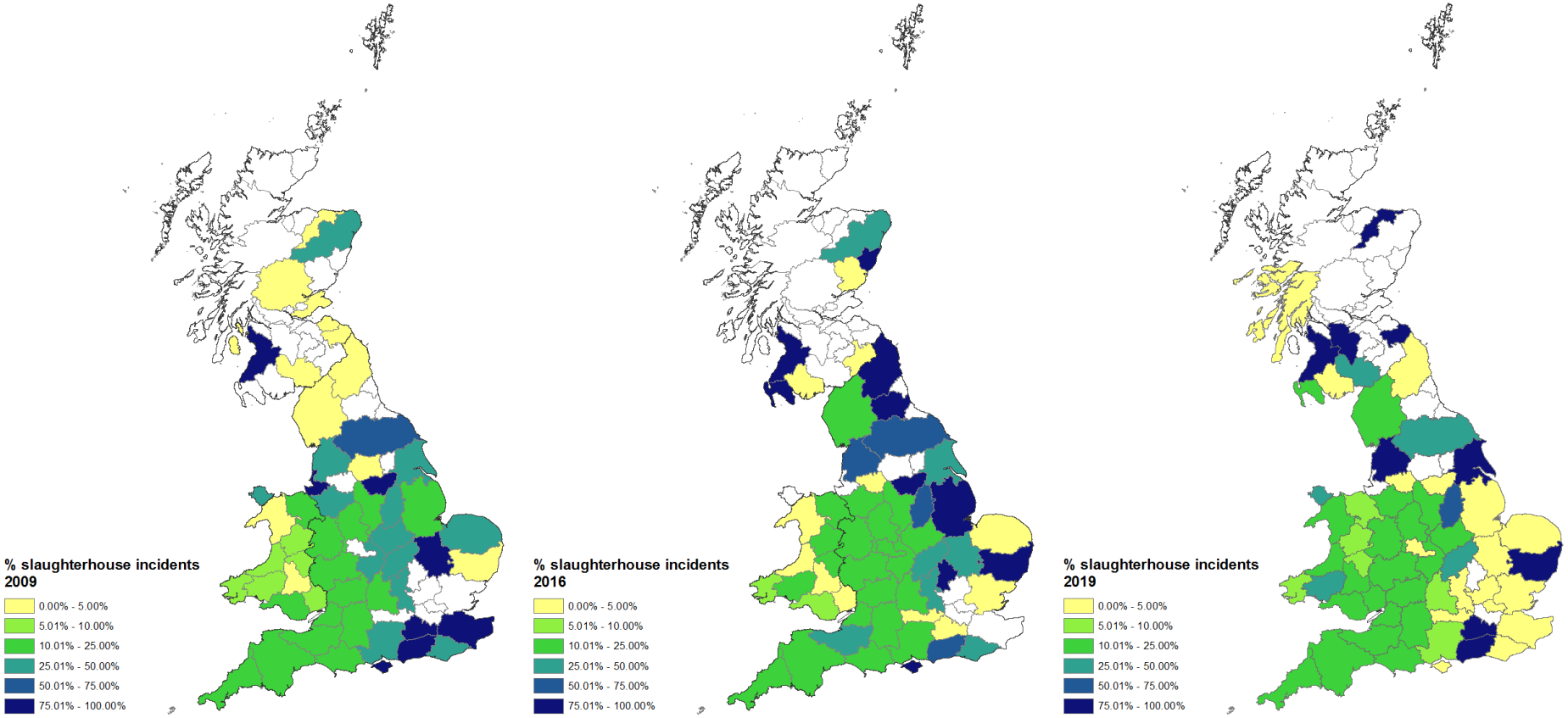
Table 3.1b: Proportion of OTF-W TB incidents detected by post-mortem meat inspection in slaughterhouses in 2016 and 2019 by herd region for skin tests (ST) and slaughterhouse tests (SLH).

Herd Region	ST	ST	SLH	SLH	Total	Total	% detected in SLH	% detected in SLH
Year	**2016**	**2019**	**2016**	**2019**	**2016**	**2019**	**2016**	**2019**
England - HRA	1,774	1,298	418	325	2,192	1,623	19.1%	20.0%
England - Edge	273	324	57	52	330	376	17.3%	13.8%
England - LRA	23	28	20	8	43	36	46.5%	22.2%
England - Total	2,070	1,650	495	385	2,565	2,035	19.3%	18.9%
Scotland	4	9	4	8	8	17	50.0%	47.1%
Wales - HTBE	163	128	13	16	176	144	7.4%	11.1%
Wales - HTBW	167	148	15	26	182	174	8.2%	14.9%
Wales - ITBM	15	21	8	11	23	32	34.8%	34.4%
Wales - ITBN	21	15	4	1	25	16	16.0%	6.3%
Wales - LTB	9	9	1	3	10	12	10.0%	25.0%
Wales - Total	375	321	41	57	416	378	9.9%	15.1%
Total	2,449	1,980	540	450	2,989	2,430	18.1%	18.5%

The proportion of OTF-W TB incidents detected in the slaughterhouse by county in 2009, 2016 and 2019 is shown in Figure 3.1. The <5% and >75% categories in the English LRA and in Scotland are frequently a result of low numbers of TB incidents.
Counties demonstrating unusually high proportions of OTF-W TB incidents disclosed in the slaughterhouse include Carmarthen (7% in 2009, 21% in 2016, and 26% in 2019), Ceredigion (8% in 2009, 3% in 2016 and 24% in 2019), Devonshire (22% in 2009, 19% in 2016 and 24% in 2019), Shropshire (20% in 2009, 20% in 2017 and 22% in 2019) and

Gwent (7% in 2009, 2% in 2016 and 19% in 2019). Further investigation may be warranted, given that some of these counties are within the annual testing area.

Figure 3.1: The proportion of OTF-W incidents that were detected in the slaughterhouse in each county in GB, in 2009, 2016 and 2019.



Historically, after fluctuations caused by the 2001 FMD epidemic, the proportion of OTF-W and all TB incidents that were detected in the slaughterhouse increased, with a peak in 2011 (OTF-W TB incidents=23%; all TB incidents=15%, Figure 3.2). The increase in cases between 2009 and 2011 coincided with a TB inspection training programme undertaken when the Food Standards Agency (FSA) took over responsibility for post-mortem inspection of all TB reactors. Since 2011, the proportion of TB incidents disclosed in the slaughterhouse began a slight decline with a sharper reduction in 2017 (OTF-W TB incidents=9.9%; all TB incidents=14.6%), although rates have begun to increase again in the last two years.

Figure 3.2: The proportion of TB incidents (OTF-W and total) detected during slaughterhouse inspection between 2009 and 2019.

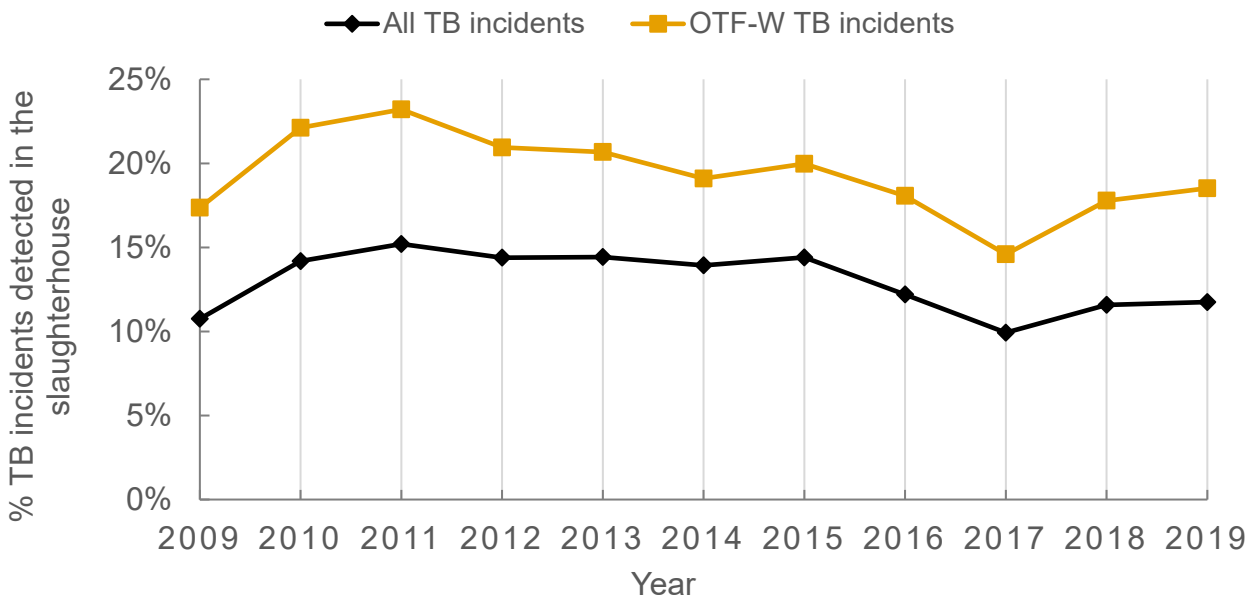
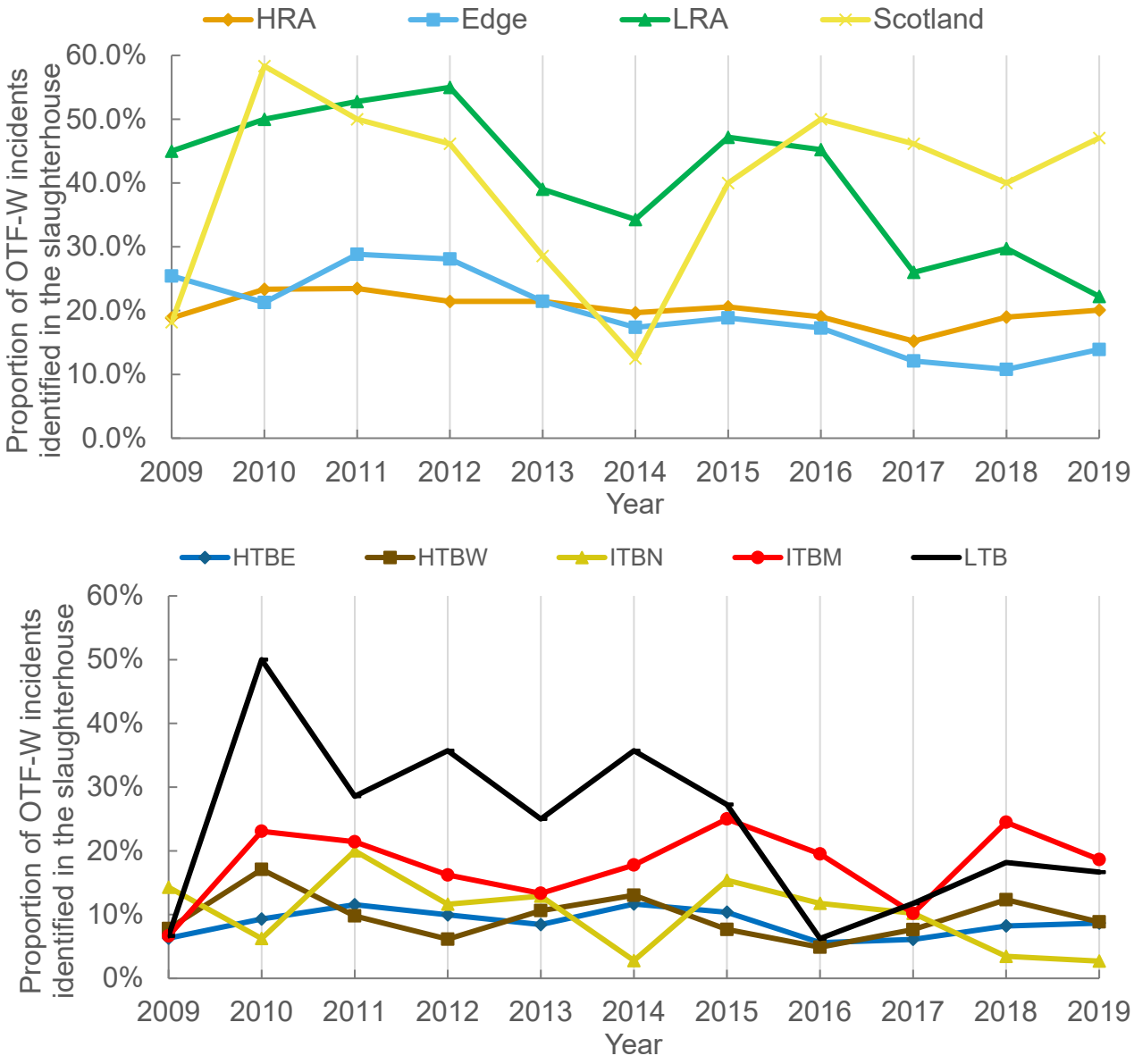


Figure 3.2a: The proportion of OTF-W incidents identified in the slaughterhouse in England and Scotland (above) and in Wales (below) from 2009 to 2019 [2].



When considering the proportion of all TB incidents detected by slaughterhouse surveillance, slaughterhouse cases were more common in larger herds and in herds in Scotland, the ITBM area of Wales and HRA of England, compared to other regions (Table 3.2). The very high percentage in herds with size either zero or unknown is likely to be because they are from finishing units without routine testing to generate a herd size. Some OTF-S cases are disclosed in the slaughterhouse. This may occur when *M. bovis* has not been isolated from the original slaughterhouse submission, but check testing discloses reactors in the herd.

The proportion of all TB incidents triggered by slaughterhouse cases in Wales was lower than in the other countries of GB (Wales 7.9%. England 12.0%, Scotland 15.3%). This was similar in the previous report. The high proportion of TB incidents in the ITBM region

compared to the rest of Wales is likely to be related to a reduced sensitivity of skin testing in this area (60% of TB incidents disclosed in the slaughterhouse occurred after clear skin tests by one practice).

Proportionately more OTF-W TB incidents were detected by slaughterhouse surveillance in Scotland, the ITBM area in Wales and the English LRA. At country level, the lowest rate of OTF-W TB incidents detected at slaughterhouse was in Wales (13.4%), followed by England (17.7%) and Scotland (45.8%). As was seen for all TB incidents, the proportion of OTF-W slaughterhouse TB incidents increased with increasing herd size (Table 3.3).

Table 3.2: All TB incidents first detected by skin testing (ST) and in the slaughterhouse (SLH) by year, confirmation status, herd size, herd region and herd type, between 2016 and 2019.

		ST N (%)	SLH N (%)	Total N
Year				
	2016	3,951 (87.8%)	549 (12.2%)	4,500
	2017	4,182 (90.1%)	461 (9.9%)	4,643
	2018	3,878 (88.4%)	508 (11.6%)	4,386
	2019	3,516 (88.3%)	468 (11.7%)	3,984
OTF status				
	OTF-W	9,344 (82.9%)	1,933 (17.1%)	11,277
	OTF-S	6,174 (99.2%)	51 (0.8%)	6,225
	Other	9 (81.8%)	2 (18.2%)	11
Herd size				
	1-50	2,656 (93.9%)	174 (6.1%)	2,830
	51-100	2,838 (92.7%)	223 (7.3%)	3,061
	101-200	3,911 (90.7%)	399 (9.3%)	4,310
	201-300	2,348 (87.7%)	329 (12.3%)	2,677
	>300	3,771 (82.7%)	790 (17.3%)	4,561
	0 or no data	3 (4.1%)	71 (95.9%)	74
Herd region				
	HRA	9,849 (87%)	1,470 (13%)	11,319
	Edge	2,400 (91.9%)	211 (8.1%)	2,611
	LRA	483 (89.8%)	55 (10.2%)	538
	Scotland	122 (84.7%)	22 (15.3%)	144
	HTBE	955 (93.5%)	66 (6.5%)	1,021
	HTBW	1,185 (91.9%)	104 (8.1%)	1,289
	ITBM	218 (85.8%)	36 (14.2%)	254
	ITBN	201 (94.4%)	12 (5.6%)	213
	LTB	114 (91.9%)	10 (8.1%)	124
Herd type				
	Beef	9,063 (88.7%)	1,155 (11.3%)	10,218
	Dairy	6,359 (88.5%)	828 (11.5%)	7,187
	Other	105 (97.2%)	3 (2.8%)	108
Total		15,527 (88.7%)	1,986 (11.3%)	17,513

Note: This includes 0 unclassified TB incidents in 2019. Herd sizes categories are derived from quintiles of herd sizes in all TB incidents.

Table 3.3: OTF-W TB incidents first detected by skin testing (ST) or in the slaughterhouse (SLH) by confirmation year, region, herd type, and herd size between 2016 and 2019.

		ST N (%)	SLH N (%)	Total N
Year				
	2016	2,449 (81.9%)	540 (18.1%)	2,989
	2017	2,635 (85.4%)	450 (14.6%)	3,085
	2018	2,280 (82.2%)	493 (17.8%)	2,773
	2019	1,980 (81.5%)	450 (18.5%)	2,430
Herd size				
	1-50	1,471 (89.5%)	172 (10.5%)	1,643
	51-100	1,627 (88.2%)	217 (11.8%)	1,844
	101-200	2,340 (85.9%)	383 (14.1%)	2,723
	201-300	1,430 (81.8%)	319 (18.2%)	1,749
	>300	2,475 (76.2%)	771 (23.8%)	3,246
	0 or no data	1 (1.4%)	71 (98.6%)	72
Herd region				
	HRA	6,437 (81.8%)	1,432 (18.2%)	7,869
	Edge	1,324 (86.6%)	204 (13.4%)	1,528
	LRA	114 (68.7%)	52 (31.3%)	166
	Scotland	26 (54.2%)	22 (45.8%)	48
	HTBE	611 (90.7%)	63 (9.3%)	674
	HTBW	621 (85.8%)	103 (14.2%)	724
	ITBM	76 (67.9%)	36 (32.1%)	112
	ITBN	97 (89.8%)	11 (10.2%)	108
	LTB	38 (79.2%)	10 (20.8%)	48
Herd type				
	Beef	5,546 (83.2%)	1,123 (16.8%)	6,669
	Dairy	3,742 (82.3%)	807 (17.7%)	4,549
	Other	56 (94.9%)	3 (5.1%)	59
Total		9,344 (82.9%)	1,933 (17.1%)	11,277

Time between last skin test and slaughterhouse detection

A comparison of the number of days between the last recorded herd level test and all or OTF-W TB incidents detected by skin tests or in the slaughterhouse is shown in Tables 3.4 and 3.5, respectively. It was almost twice as common for a herd with a TB slaughterhouse case to have been tested within 190 days prior to disclosure, than over 190 days. It should be noted that there would be fewer opportunities to identify a TB incident through skin testing within the 190 day period following a skin test due to test schedule protocol. This continues to support the hypothesis that some infection evades SICCT field testing. It also is continued evidence that slaughterhouse surveillance plays a useful role in the detection of infection.

In the absence of another method to distinguish herds exempt from testing, herds that had not had a test in 51 months prior to the TB incident (allowing 3 months for a herd in a 4 yearly tested area to be tested) and those that had no recorded test on Sam were assumed to be “Exempt herds”. However, this does not account for herds which are

officially exempt from surveillance testing can often undergo other types of targeted surveillance, such as tracing. The proportion of OTF-W incidents that were detected in the slaughterhouse was higher in “Exempt” herds (93 / 246 = 37.8%) than in herds that received routine skin testing (1,933/ 11,277= 17.1%) (Table 3.5). The vast majority (97.8%) of OTF-W TB incidents detected by skin testing have had a previous test within the past 15 months, reflecting the targeting of annual testing to higher risk areas.

Table 3.4: Time since the last recorded herd level test by TB incident origin for all TB incidents between 2016 and 2019 detected through skin testing (ST) and the slaughterhouse (SLH).

Time since last herd level test	**ST N (%)**	**SLH N (%)**	**Total N**
No test recorded	261 (1.7%)	64 (3.2%)	325
1-90 days	206 (1.3%)	460 (23.2%)	666
91-190 days	2,286 (14.7%)	620 (31.2%)	2,906
191 days-15 months	12,164 (78.3%)	763 (38.4%)	12,927
15-27 months	272 (1.8%)	24 (1.2%)	296
27-39 months	65 (0.4%)	18 (0.9%)	83
39-51 months	202 (1.3%)	7 (0.4%)	209
over 51 months	71 (0.5%)	30 (1.5%)	101
Total	15,527 (100%)	1,986 (100%)	17,513
"Exempt" herds	333 (2.1%)	94 (4.7%)	427

Note: Herds not tested within 51 months (allowing 3 months for a herd in a 4 yearly tested parish to be tested), new herds and those that had no recorded test on Sam were classified as “exempt herds”. Also, Scotland has been exempting low risk herds since 2013 but, as they are low risk, they shouldn’t have any TB incidents. Surveillance and Slaughterhouse % represents percentage of **total** (above).

Table 3.5: Time since the last recorded herd level test by TB incident origin for OTF-W TB incidents between 2016 and 2019 for incidents detected through skin testing (ST) and the slaughterhouse (SLH).

Time since last herd level test	**ST N (%)**	**SLH N (%)**	**Total N**
No test recorded	129 (1.4%)	64 (3.3%)	193
1-90 days	118 (1.3%)	450 (23.3%)	568
91-190 days	1,431 (15.3%)	591 (30.6%)	2,022
191 days-15 months	7,457 (79.8%)	750 (38.8%)	8,207
15-27 months	116 (1.2%)	24 (1.2%)	140
27-39 months	25 (0.3%)	18 (0.9%)	43
39-51 months	45 (0.5%)	7 (0.4%)	52
over 51 months	23 (0.2%)	29 (1.5%)	52
Total	9,344 (100%)	1,933 (100%)	11,277
"Exempt" herds	153 (1.6%)	93 (4.8%)	246

Note: Herds not tested within 51 months (allowing 3 months for a herd in a 4 yearly tested parish to be tested) and those that had no recorded test on Sam were assumed to be

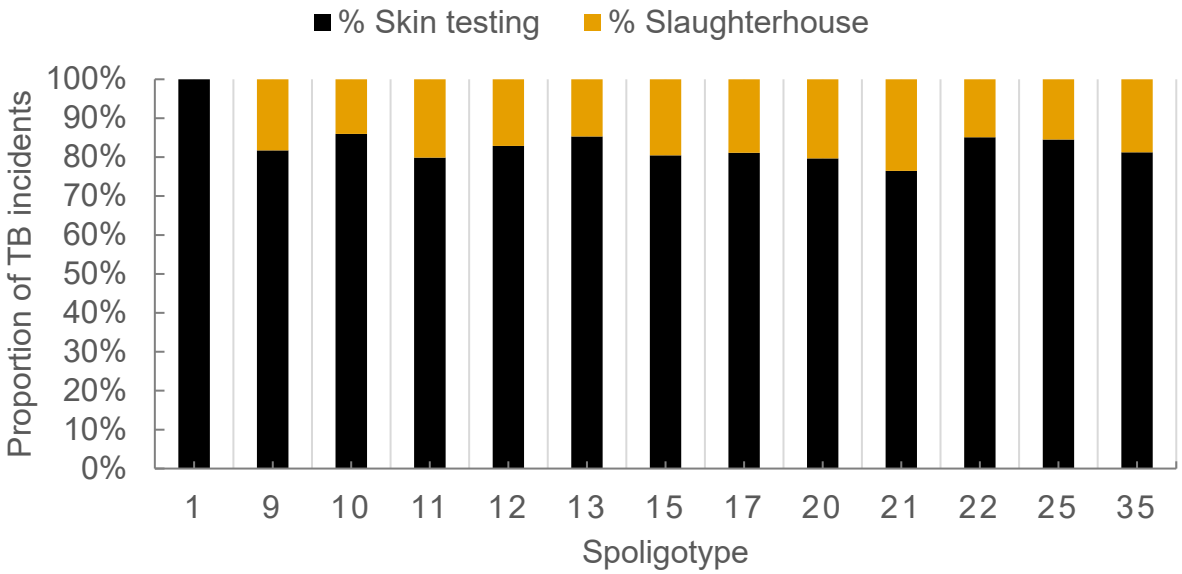
"exempt herds". Surveillance and Slaughterhouse % represents percentage of **total** (above).

TB incidents disclosed in the slaughterhouse, by spoligotype

A comparison of the frequency of different spoligotypes identified in reactors between TB incidents detected in the slaughterhouse and those detected by skin testing is shown in Figure 3.3. In total, 38 different spoligotypes were isolated between 2016 and 2019 and in two cases four types per TB incident were recorded. In TB incidents detected in the slaughterhouse, 4% (vs 2.0% in 2013-16) had multiple spoligotypes compared to 2% of those detected by skin testing. However, in the past seven years or so, genotyping (spoligotyping plus VNTR typing) has been routinely limited to one isolate per OTF-W TB incident.

Whole Genome Sequencing (WGS) has now replaced genotyping (April 2021), and a greater number of isolates will be sequenced from herds with multiple infected cattle, which will increase the level of information available about the genetic diversity of *M. bovis* isolates within TB incidents.

Figure 3.3: The proportion of TB incidents where spoligotypes with a frequency greater 0.1% were first detected by spoligotype, 2016 to 2019.



Multivariable analysis investigating risk factors for an incident to be detected in the slaughterhouse rather than by tuberculin skin testing

Multivariable logistic regression was used to investigate risk factors for an OTF-W incident to be detected in the slaughterhouse rather than by tuberculin skin testing on farms (Table 3.6). Only OTF-W TB incidents were used in the analysis to ensure comparison remained similar, as the vast majority of incidents triggered by slaughterhouse cases are culture positive by definition. The model correctly classified 89.4% of the data, was a good

description of the data (Hosmer-Lemeshow χ^2 (8 d.f.)=8.84, P=0.36), and the area under the ROC curve was 0.82. Standard errors were adjusted for 6,884 clusters within herds (CPHH).

TB incidents in herds located in the ITBM area of Wales were more likely to be detected in the slaughterhouse compared with TB incidents in herds in the HRA in England. TB incidents in the Edge Area of England and the High TB East area of Wales were less likely to have been disclosed in the slaughterhouse than those in the HRA of England. There was no strong evidence that the odds of detection at slaughterhouse compared to skin testing differed for any other regions compared to the England HRA ($p>0.05$). Results for the Edge Area in England were more statistically significant than in the previous report. The reasons behind this increase are likely to be multifactorial. One factor may be increased skin testing in the Edge Area leading to more infection being found on the farm and less by slaughterhouse testing.

Slaughterhouse cases were marginally less likely to be detected in spring compared to winter. The model suggested they were also more likely to be detected in summer and autumn compared to winter, although none of the seasonal results were statistically significant.

TB incidents occurring within 1 to 90 days of a test were 33 times more likely to be disclosed in the slaughterhouse than those that had no test or had been tested more than 15 months previously. This is consistent with the previous report and not unexpected as there would be fewer opportunities for a SICCT–disclosed TB incident as another skin test would be unlikely to be conducted within this timescale. TB incidents where the last test was a control test (see Appendix 2), or a 'VE-6M' test type were less likely to be triggered by slaughterhouse cases compared with those where the last test was routine herd tests. Control tests and VE-6M tests include check tests and short interval tests, and are likely to be targeted towards higher risk herds and herds with recent experience of a TB incident.

Herd size was positively associated with disclosure in the slaughterhouse, with TB incidents in larger herds more likely to be disclosed in the slaughterhouse. Herds with more than one reactor were less likely to be disclosed in slaughterhouse inspection. Herds in which the last TB incident was OTF-S were less likely to be detected in a slaughterhouse case compared to those that were OTF-W.

Herds with more than eight cattle movements onto the farm in the 12 months prior to the TB incident had an increased likelihood of being disclosed in the slaughterhouse and herds with more than 40 movements were almost twice as likely to be disclosed in the slaughterhouse. Time since the last TB incident was associated with slaughterhouse disclosure, with TB incidents in herds where the last TB incident was older having less chance of slaughterhouse disclosure, but this result was not statistically significant.

A separate logistic regression analysis was conducted to include *M. bovis* spoligotype data. Where multiple spoligotypes were detected in the same TB incident (292/10,385 TB incidents with a spoligotype) they were added to the data, with correction of the standard

errors for clustering within individual TB incidents. Only spoligotypes with a frequency greater than 0.1% among isolates were included as a factor. Only one spoligotype met this criterion, and so no further analysis was possible.

Table 3.6: Results of multivariable logistic regression analysis to identify factors associated with the odds that an OTF-W TB incident was disclosed by a slaughterhouse case (rather than a skin test), using data from 2016 to 2019. (*OR: Odds Ratio; aOR: adjusted OR)*.

	N	crude OR	P-value	95% CI	aOR	P-value	95% CI
Region	11,277						
HRA	7,869	1.0 (ref)			1.0 (ref)		
Edge	1,528	0.69	<0.0001	0.59-0.82	0.66	0.002	0.51-0.85
LRA	166	2.05	<0.0001	1.48-2.85	1.45	0.539	0.44-4.76
Scotland	48	3.80	<0.0001	2.14-6.75	4.28	0.082	0.83-22.05
HTBE	674	0.46	<0.0001	0.36-0.60	0.56	0.002	0.38-0.81
HTBW	724	0.75	0.01	0.60-0.93	0.82	0.218	0.60-1.12
ITBN	108	0.51	0.05	0.26-1.00	0.39	0.214	0.09-1.71
ITBM	112	2.13	0.002	1.32-3.44	2.29	0.018	1.15-4.54
LTB	48	1.18	0.641	0.58-2.40	0.91	0.941	0.07-11.73
Season	11,277						
winter	3,177	1.0 (ref)			1.0 (ref)		
spring	3,010	0.92	0.22	0.80-1.05	0.98	0.866	0.81-1.19
summer	2,205	1.25	0.00	1.09-1.44	1.23	0.05	1.00-1.51
autumn	2,885	1.01	0.89	0.88-1.15	1.12	0.258	0.92-1.36
Time since last test	11,277						
No test or >15 months	480	1.0 (ref)			1.0 (ref)		
1-90 days	568	9.08	<0.0001	6.81-12.10	33.13	<0.0001	15.23-72.07
91 days-15 months	10,229	0.36	<0.0001	0.29-0.44	1.29	0.482	0.64-2.62
Last test type	11,277						
Routine	3,745	1.0 (ref)			1.0 (ref)		
VE-12M	909	1.10	0.34	0.90-1.33	0.80	0.124	0.61-1.06
VE-6M	2,133	1.18	0.02	1.02- 1.35	0.71	0.005	0.56-0.90
Area Risk	1,560	1.14	0.10	0.98-1.33	0.84	0.174	0.66-1.08
Control	2,636	1.00	0.98	0.87-1.15	0.53	<0.0001	0.41-0.68
Other	96	0.82	0.51	0.45-1.48	1.37	0.745	0.20-9.24
No last test	193	2.59	<0.0001	1.89-3.54	N/A		
Herd size	11,277						
1-50	1,643	1.0 (ref)			1.0 (ref)		
51-200	4,567	1.29	0.006	1.07-1.55	1.57	0.004	1.15-2.13
201-300	1,749	1.91	<0.0001	1.55-2.34	2.86	<0.0001	2.04-4.01
>300	3,246	2.66	<0.0001	2.22-3.20	3.64	<0.0001	2.64-5.02
0 or no data	72	607.22	<0.0001	83.60-4410.17	N/A		
Reactors	11,277						
No reactors	903	1.0 (ref)			1.0 (ref)		
>1 reactors	10,374	0.03	<0.0001	0.02-0.03	0.027469	<0.0001	0.02-0.04
Last TB incident status	11,277						
OTFW	6,303	1.0 (ref)			1.0 (ref)		
OTFS	2,030	0.58	<0.0001	0.49-0.67	0.59	<0.0001	0.49-0.71
Unknown	10	0.48	0.485	0.06-3.79	0.03	<0.0001	0.01-0.11
No last TB incident	2934	0.90	0.065	0.80-1.01			
Number of on movements	11,277						
No movements	2,934	1.0 (ref)			1.0 (ref)		
1-7 movements	2,697	1.13	0.13	0.97-1.32	1.15	0.22	0.90-1.43
8-39 movements	2,504	1.21	0.02	1.03-1.42	1.27	0.044	1.01-1.59
>=40 movements	3,142	2.71	<0.0001	2.35-3.12	1.98	<0.0001	1.61-2.44
Time since last TB incident	8,343	1.00	0.24	1.0-1.0	1.00	0.247	1.0-1.0

Section 4: Identification of test reactors in the source herd following a culture positive slaughterhouse case between 2016 and 2019

AIM: To examine herds with slaughterhouse cases that have no subsequent reactors at the skin check test following detection, compared with those that do have reactors (to either the interferon-gamma or SICCT test) at subsequent check tests.

Slaughterhouse disclosed TB incidents with reactors detected at subsequent check tests

Between 2016 and 2019, 61.1% (1,182/1,933) of OTF-W TB incidents disclosed in the slaughterhouse had reactors at subsequent tuberculin skin herd tests, an increase of ~9% compared to the last reporting period (years, 2013 to 2016; 56.1%; 1,411/2,517).

Summary statistics describing the number and proportion of TB incidents detected in the slaughterhouse that had or did not have subsequent reactors, by year, herd size and type, region and possible exemption status, are shown in Table 4.1.

Reactors at follow-up TB testing appeared more likely when the slaughterhouse case originated from: larger herds; ITBN or LTB regions in Wales and the Edge Area in England; dairy herds; or 'non-exempt' herds (if a herd is exempt from testing, then it is less likely to have check testing; e.g. finishing herds).

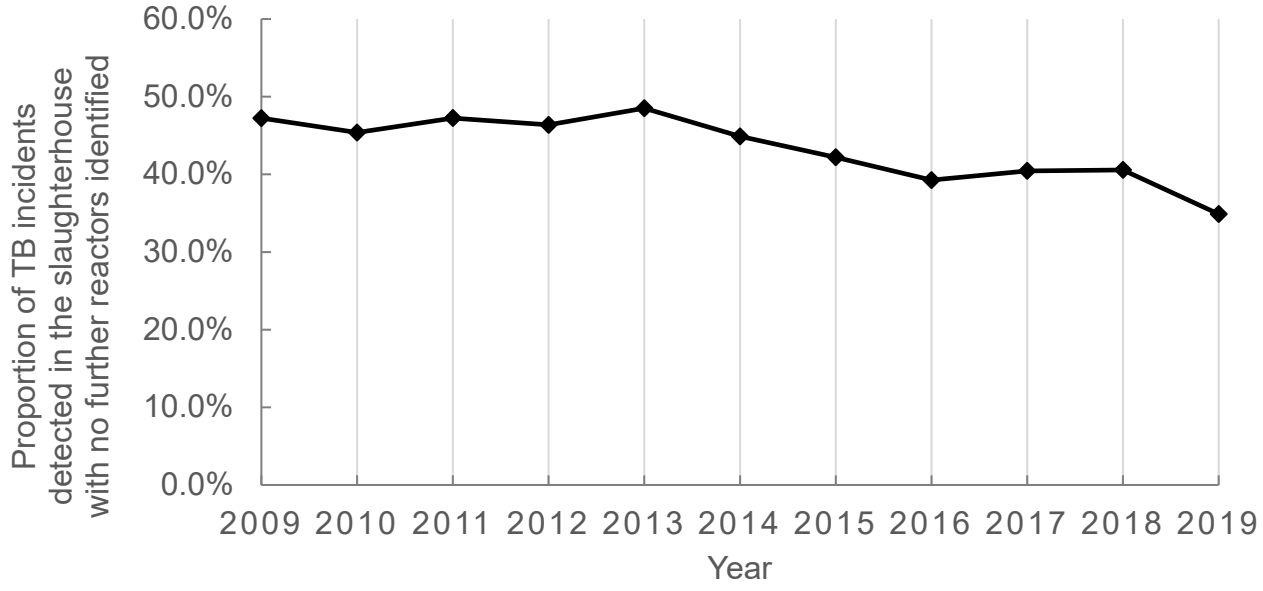
The annual proportion of TB incidents that were detected in slaughterhouses in GB that had **no** further reactors at all subsequent check tests up until the end of the reporting period is shown in Figure 4.1.

In the previous report, 54% of confirmed slaughterhouse-disclosed TB incidents in Northern Ireland had **no** subsequent reactors in 2016. That is compared to 39% in GB in 2016 (Table 4.1). The higher likelihood of finding reactors at subsequent testing in GB relative to NI may be due in part to the generally smaller herd sizes across the island of Ireland. The mean herd size in 2019 in Ireland is recorded as 80.7 animals (2019 National Farm Survey, Teagasc) compared to the mean herd size of 124.9 in GB in 2019. In GB, in herds with 100 animals or less, the proportion of OTF-W TB incidents disclosed in the slaughterhouse with **no** reactors rises to 60.2% and is even higher (69%) when restricted to herds with 50 animals or less (Table 4.1).

Table 4.1: OTF-W TB incidents disclosed in the slaughterhouse that had further reactors at testing (IFN-gamma or SICCT) compared with those that had no further reactors between 2016 and 2019. Numbers stratified by year, herd size and type, region and possible routine test exemption status (poss. exempt). (56 TB incidents with no reactors had not had their OTF status restored and could therefore still generate test reactors, between 2016 and 2019).

		No reactors N (%)	Reactors N (%)	Total N
Year				
	2016	212 (39.3%)	328 (60.7%)	540
	2017	182 (40.4%)	268 (59.6%)	450
	2018	200 (40.6%)	293 (59.4%)	493
	2019	157 (34.9%)	293 (65.1%)	450
Herd size		(0%)	(0%)	
	1-50	119 (69.2%)	53 (30.8%)	172
	51-100	115 (53%)	102 (47%)	217
	101-200	146 (38.1%)	237 (61.9%)	383
	201-300	88 (27.6%)	231 (72.4%)	319
	>300	214 (27.8%)	557 (72.2%)	771
	0 or no data	69 (97.2%)	2 (2.8%)	71
Herd region		(0%)	(0%)	
	HRA	566 (39.5%)	866 (60.5%)	1,432
	Edge	71 (34.8%)	133 (65.2%)	204
	LRA	20 (38.5%)	32 (61.5%)	52
	Scotland	8 (36.4%)	14 (63.6%)	22
	HTBE	25 (39.7%)	38 (60.3%)	63
	HTBW	37 (35.9%)	66 (64.1%)	103
	ITBM	20 (55.6%)	16 (44.4%)	36
	ITBN	2 (18.2%)	9 (81.8%)	11
	LTB	2 (20%)	8 (80%)	10
Herd type		(0%)	(0%)	
	Beef	542 (48.3%)	581 (51.7%)	1,123
	Dairy	207 (25.7%)	600 (74.3%)	807
	Other	2 (66.7%)	1 (33.3%)	3
Poss. exempt		(0%)	(0%)	
	No	671 (36.5%)	1,169 (63.5%)	1,840
	Yes	80 (86%)	13 (14%)	93
Total		751 (38.9%)	1,182 (61.1%)	1,933

Figure 4.1: The proportion of TB incidents that were detected in the slaughterhouse in GB and had no further reactors at all subsequent check tests until the end of the reporting period (63 TB incidents with no reactors had not had their OTF status restored and could therefore still generate test reactors, between 2009 and 2019).



The average (mean and median) number of reactors disclosed at the first whole herd test for OTF-W TB incidents first detected by skin testing or slaughterhouse surveillance are presented in Table 4.2. Reactor averages are stratified by herd region and year of detection. In GB overall and considering all years, OTF-W TB incidents detected by skin testing had two more reactors disclosed by the first whole herd test than those detected in the slaughterhouse (6.3 and 4.4 mean reactors, respectively).

A small number of TB incidents with a very high number of reactors detected can skew the mean data point and so the median number of reactors is also compared. When considering the median number of reactors, OTF-W incidents detected by skin testing found 4 (IQR 2-7) reactors at the first whole herd test, while for OTF-W incidents detected at slaughterhouse, the median number of reactors was 0 (IQR 0-4) (Table 4.2). Over half of all OTF-W incidents disclosed by slaughterhouse surveillance had no reactors detected by the first whole herd test, while for skin testing this was less than one per cent (0.3%).

The mean number of reactors detected by skin testing has remained relatively stable between 2016 and 2019, ranging from 6.1 to 6.4. For slaughterhouse-disclosed OTF-W incidents, the mean number of reactors disclosed at the first whole herd test has decreased over time. In 2016 the mean number of reactors detected by slaughterhouse surveillance was the same as the mean number detected by skin testing (6.3), however decreased annually to 3.6 in 2019 (Table 4.2). Reasons for differences in the number of reactors disclosed are complex and likely to be multifactorial.

The mean number of reactors was higher by skin testing than slaughterhouse surveillance for nearly all TB herd regions. In the England LRA and Scotland, the mean number of reactors was very similar for skin testing. In the ITBM area of Wales, the mean number of reactors was higher in slaughterhouse surveillance incidents than those detected by skin testing (skin testing 5.1, slaughterhouse surveillance 9.2). The same trends were seen in the upper IQR values (Table 4.2). This is likely to be related to reduced sensitivity of skin testing in this area.

Table 4.2 The mean, median and interquartile range (IQR) for the number of reactors disclosed at the first whole herd test conducted following an OTF-W TB incident, detected by skin testing and slaughterhouse surveillance (SLH), stratified by herd region and year.

	Skin testing OTF-W incidents	Skin testing Mean reactors per incident	Skin testing Median reactors per incident	Skin testing IQR	SLH OTF-W incidents	SLH Mean reactors per incident	SLH Median reactors per incident	SLH IQR
Herd region								
HRA	6,437	6.3	4	2-7	1,432	4.3	0	0-4
Edge	1,324	6.3	3	2-7	204	3.7	0	0-3
LRA	114	5.0	2	2-5	52	4.6	0	0-3
Scotland	611	5.5	3	2-6	63	3.3	0	0-3
HTBE	621	7.5	4	2-8	103	5.9	0	0-6
HTBW	76	5.1	3	2-6	36	9.2	0	0-6.5
ITBM	97	5.7	4	2-7	11	0.9	0	0-2
ITBN	38	4.5	2	2-4	10	1.0	0	0-2
LTB	26	9.5	3	2-7	22	9.3	0.5	0-4
Year								
2016	2,449	6.3	4	2-7	540	6.3	1	0-5
2017	2,635	6.4	4	2-7	450	5.1	0	0-4
2018	2,280	6.3	3	2-7	493	4.0	0	0-3
2019	1,980	6.1	3	2-7	450	3.6	0	0-3
Total	9,344	6.3	4	2-7	1,933	4.4	0	0-4

Multivariable analysis to investigate risk factors for TB incidents initiated by a slaughterhouse case to have reactors at subsequent skin tests

A multivariable logistic regression was conducted to investigate risk factors associated with the detection of reactors (to either the IFN-gamma or SICCT test) at subsequent check tests in closed TB herd incidents that were triggered by slaughterhouse surveillance. During 2016-2019, there were 751 such incidents in which no test reactors detected, and 1,182 in which at least one reactor was disclosed at subsequent testing. A total of 132 TB incidents that were initiated by slaughterhouse surveillance (6.8%) had not had their OTF status restored when the data was extracted for this report and were excluded from the analysis since they could have generated test reactors.

The full model is presented in Table 4.3. The model was a good fit for the data (Hosmer-Lemeshow χ^2 (8) = 2.84, P=0.944), but the amount of variation explained by the model was low (Pseudo R^2=6.6%). It is likely that there are other factors, not included here, that influence the detection of reactors at subsequent check tests in slaughterhouse cases.

TB incidents in dairy herds were twice as likely to have reactors at the check test as beef herds. There was a higher probability of detecting reactors at the check test in herds in the Edge and LRA of England than in herds in the HRA of England; while for the ITBM area of Wales it was lower still. Caution should be used when interpreting the higher probabilities of detecting reactors due to the wide confidence intervals surrounding the odds ratios.

TB incidents where more than 10 reactors were detected in the previous TB incident were over two and half times more likely than those that had no previous TB incident (in the previous 4 years) to have reactors after detection of the slaughterhouse case, but this could reflect larger herd sizes more than an increased risk because of TB incident exposure.

There was no evidence that the year in which a TB incident was detected, significantly associated with the disclosure of reactors at subsequent check tests. The number of movements onto the farm in the 12 months prior to the start of the TB incident was significantly associated with a lower probability of detecting reactors at the check test.

The inclusion of spoligotype into the model reduced the amount of variation explained by the model from 6.6% to 5.5% and there were no major changes to the significance of all included factors. All spoligotypes with a frequency greater than 0.1% were included. The probability of detecting reactors in TB incidents was significantly reduced where spoligotype 21 was detected (OR: 0.70, 95% CI: 0.49-1.00, $p<0.05$). No other spoligotype was significantly associated with ay change in risk of the detection of reactors.

However, these results should be interpreted with caution, given the low amount of variation explained by the model and the probable interdependence of some variables. It is likely the reason for the detection of reactors following TB incidents triggered at the

slaughterhouse is complex. The previous report highlighted that further work was necessary to better understand the complex reasons why subsequent TB reactors are detected in some TB incidents which originate in the slaughterhouse and not in others. The data presenting in this report further confirms the requirement for this work.

Table 4.3: Results of multivariable logistic regression analyses to identify factors associated with the odds of slaughterhouse TB incidents having further reactors vs. no further reactors, using data from 2016 to 2019. (Std. Err. Adjusted for 94 clusters in SLH ID; OR: Odds Ratio; aOR: adjusted OR).

	N	crude OR	P-value	95% CI	aOR	P-value	95% CI
Herd Type							
Beef	1,123	1.0 (ref)	-	-	1.0 (ref)	-	-
Dairy	807	2.31	<0.0001	1.83-2.92	1.98	<0.0001	1.55-2.54
Number of reactors in last breakdown							
0-1	1,033	1.0 (ref)	-	-	1.0 (ref)	-	-
2-5	418	1.29	0.034	1.02-1.64	1.29	0.057	0.99-1.68
6-10	185	1.56	0.007	1.13-2.14	1.52	0.019	1.07-2.15
>10	297	2.88	<0.0001	1.94-4.28	2.61	<0.0001	1.73-3.92
Herd region							
HRA	1,432	1.0 (ref)	-	-	1.0 (ref)	-	-
Edge	204	1.97	0.003	1.25-3.09	2.37	<0.0001	1.48-3.80
LRA	52	1.49	0.226	0.78-2.87	3.09	0.001	1.62-5.88
Scotland	22	1.13	0.803	0.42-3.03	2.51	0.053	0.99-6.38
HTBE	63	0.87	0.502	0.58-1.30	0.99	0.983	0.61-1.63
HTBW	103	1.07	0.773	0.69-1.64	0.96	0.86	0.65-1.43
ITBM	36	0.48	0.094	0.20-1.13	0.41	0.007	0.21-0.79
ITBN	11	2.79	0.152	0.69-11.36	3.41	0.181	0.57-20.59
LTB	10	2.44	0.308	0.44-13.55	6.77	0.075	0.82-55.72
Year							
2016	540	1.0 (ref)	-	-	1.0 (ref)	-	-
2017	450	0.92	0.637	0.66-1.28	0.90	0.526	0.65-1.24
2018	493	0.92	0.484	0.72-1.17	0.96	0.723	0.75-1.22
2019	450	1.02	0.893	0.81-1.28	1.08	0.56	0.83-1.40
Movements on per 100 animals	1,933	0.93	<0.0001	0.89-0.96	0.93	<0.0001	0.90-0.97

Section 5: Model to explore residual variation in detection rates of TB lesions between slaughterhouses

This section presents the output of the model created at Cambridge University to analyse slaughterhouse detection rates and subsequently updated with recent data by APHA. The aim of this analysis was to identify slaughterhouses that detect a lower than expected number of TB suspect cases at private, commercial slaughter of cattle [6].

The model is set to explore patterns in residual variation within detection rates between slaughterhouses, after accounting for individual animal-level risk factors. These include: sex, age, breed, days in high or low risk herds, contact with high or low risk herds, skin testing status, year, quarter, and risk area. Taking all these factors into account, the performance of a slaughterhouse in detecting and reporting a case can be compared to what might be expected according to the type of animals processed. These patterns can be summarised by the posterior mean odds ratio (OR); with slaughterhouses scoring positive posterior ORs detecting more tuberculous carcases at commercial slaughter of non-reactor cattle than the average expected. Conversely, a negative posterior ORs would indicate fewer than the average expected, are being detected. However, by design we would expect the ORs for the different slaughterhouses to be distributed above-and-below the average and, due to the large heterogeneity in throughputs, the ORs for some slaughterhouses will be better estimated than others.

The perceived reliability of this estimation is measured by the posterior variance, and those with a lower variance have a better estimation of the posterior mean. Therefore, although it makes sense to focus attention on slaughterhouses with large negative odds ratios, it is also sensible to account for how precisely each OR is estimated. This can be achieved by considering the 95% credible interval around the posterior mean using the variance, which allows for the ORs to be compared against some predefined baseline level (such as the average), or alternatively to each other.

Appendix 3 presents these figures for each slaughterhouse in GB. If the credible interval includes zero, then the model does not provide sufficient evidence that the slaughterhouse is reporting any more or less than predicted by the model, given the other factors. The size of the interval is mainly down to the throughput of the slaughterhouse; the higher the throughput the smaller the interval and hence the Greater the precision of the estimate.

There were 14 slaughterhouses with an upper credible interval below zero for the period 2016 to 2019. This provides evidence that these premises were not performing as expected. These have been highlighted in Appendix 3. For others with a low posterior mean, but with upper intervals above zero, they may appear to be performing poorly but with low precision of estimate. This is likely to be caused by large model variance due to a relatively low throughput.

Caution should still be observed in interpreting the biological rationale behind these values. A consistently low detection rate could be due to the slaughterhouse performing

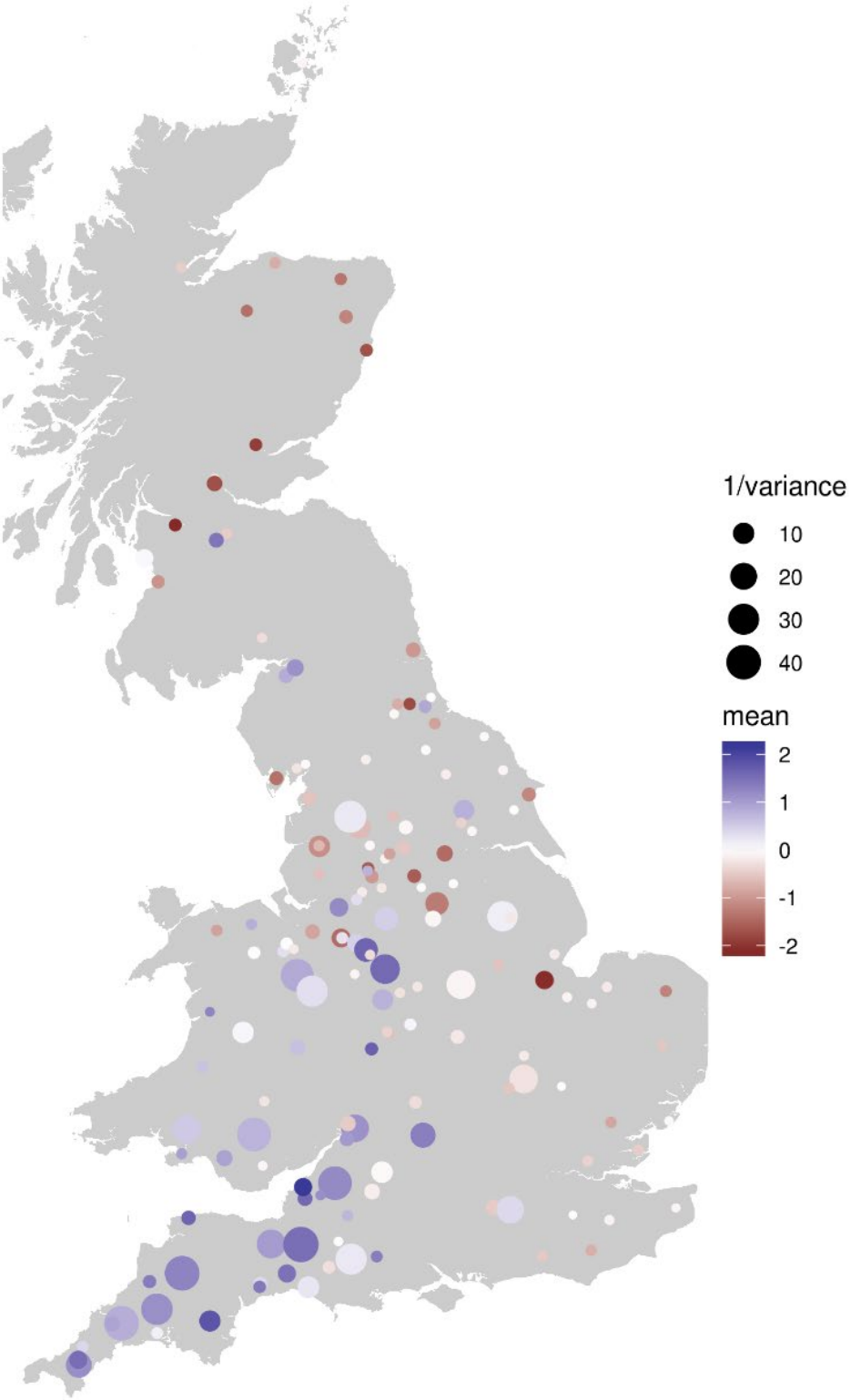
poorly at finding TB lesions, but could also be due to fewer than predicted TB infected animals passing through the slaughterhouse (due to multiple factors not accounted for by this model). The model should be used as a guide for further investigation, not as a definitive ranking of performance. Interestingly, there appears to be some spatial structure in the ORs, which may allow comparison of slaughterhouses within a region (Appendix 3).

Furthermore, in many systems, performance does oscillate from year-to-year. To account for this, performance should be measured across four-yearly periods. As a result of the above discussion, slaughterhouses may be recommended for further investigation on the basis of: (i) large negative OR, (ii) that OR being well estimated (by consideration of the posterior variance and/or 95% credible intervals, for which the 14 slaughterhouses previously referred to applies), (iii) comparison to slaughterhouses within the same region. The exact classification and selection of slaughterhouses for further investigation will depend on the relative importance assigned to each of the criteria above.

Figure 5.1 shows the posterior mean and variance from the model for each slaughterhouse in the GB map for the period 2016-19. The same data plotted against mean vs variance is shown in figure 5.2. Figure 5.3 presents the posterior mean and 95% credible interval for 2016-2019 for the 14 slaughterhouses performing significantly worse than expected in 2016-19 (i.e. having a negative posterior mean and a 95% upper interval below zero).

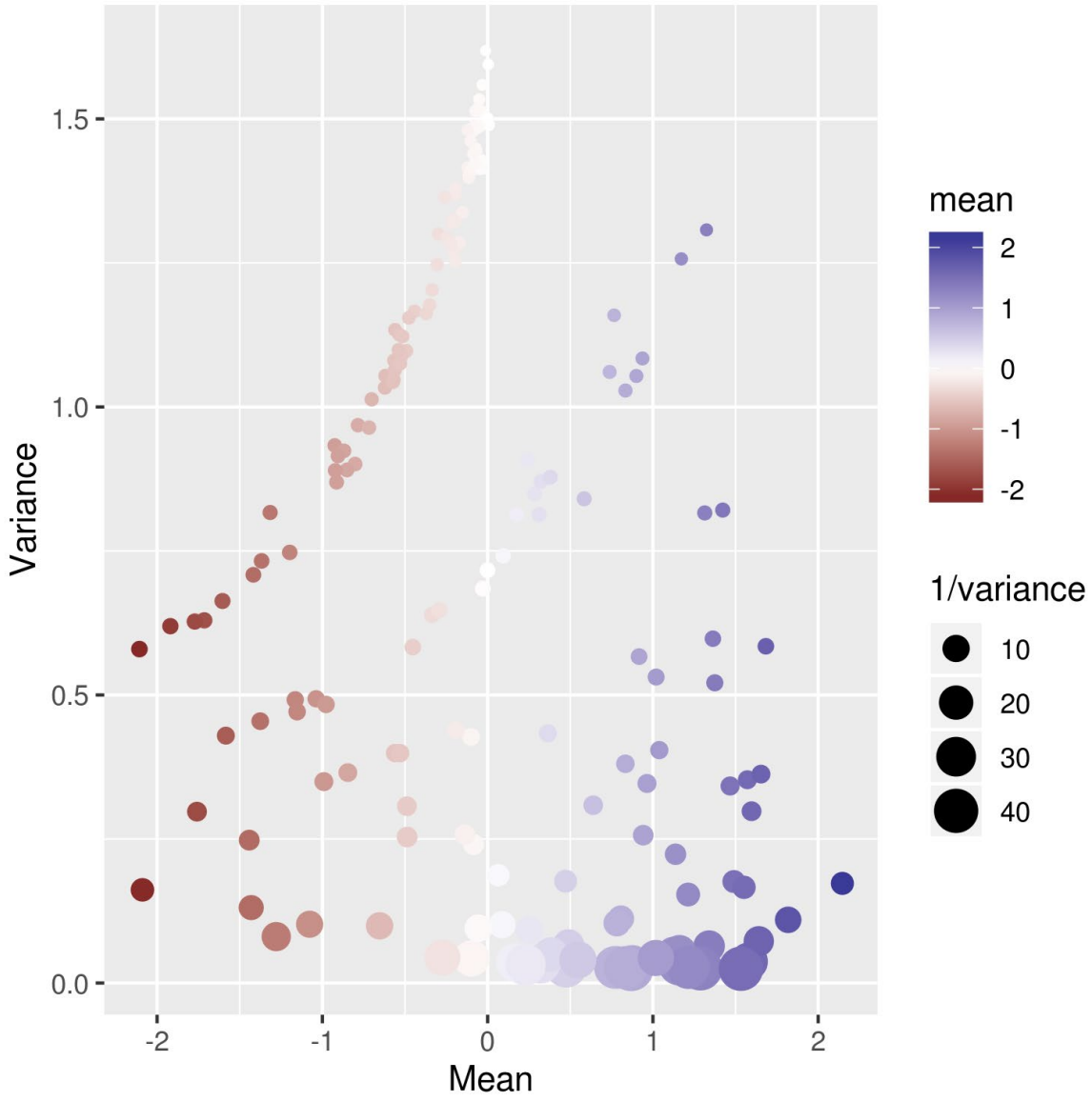
There are certain differences between the data input into the model, and that presented in the main body of this report. In the report all suspect case submissions to APHA are considered, whether subsequently positive by culture or negative. In the model suspect slaughterhouse cases are identified either as disclosers of a TB incident or within a TB incident, regardless of whether the lesions were submitted to APHA for culture, hence *M. bovis*-negative submissions which do not generate TB incidents do not contribute. This is partly because the model determines detection of positive cases; and current policy dictates that (in general) suspect slaughterhouse cases included within a TB incident are not submitted for culture. Therefore their true status remains unconfirmed (assumed to be *M. bovis* positive). The parameters of the model result in output data which are not directly comparable to the remainder of the report. Also, the model does not account for the herd type of origin, but uses measures that average risk over the lifetime of individual animals, based on time spent in high- or low-risk herds.

Figure 5.1: Map of GB with posterior mean and variance from the model for each slaughterhouse that processed cattle in 2016-2019.



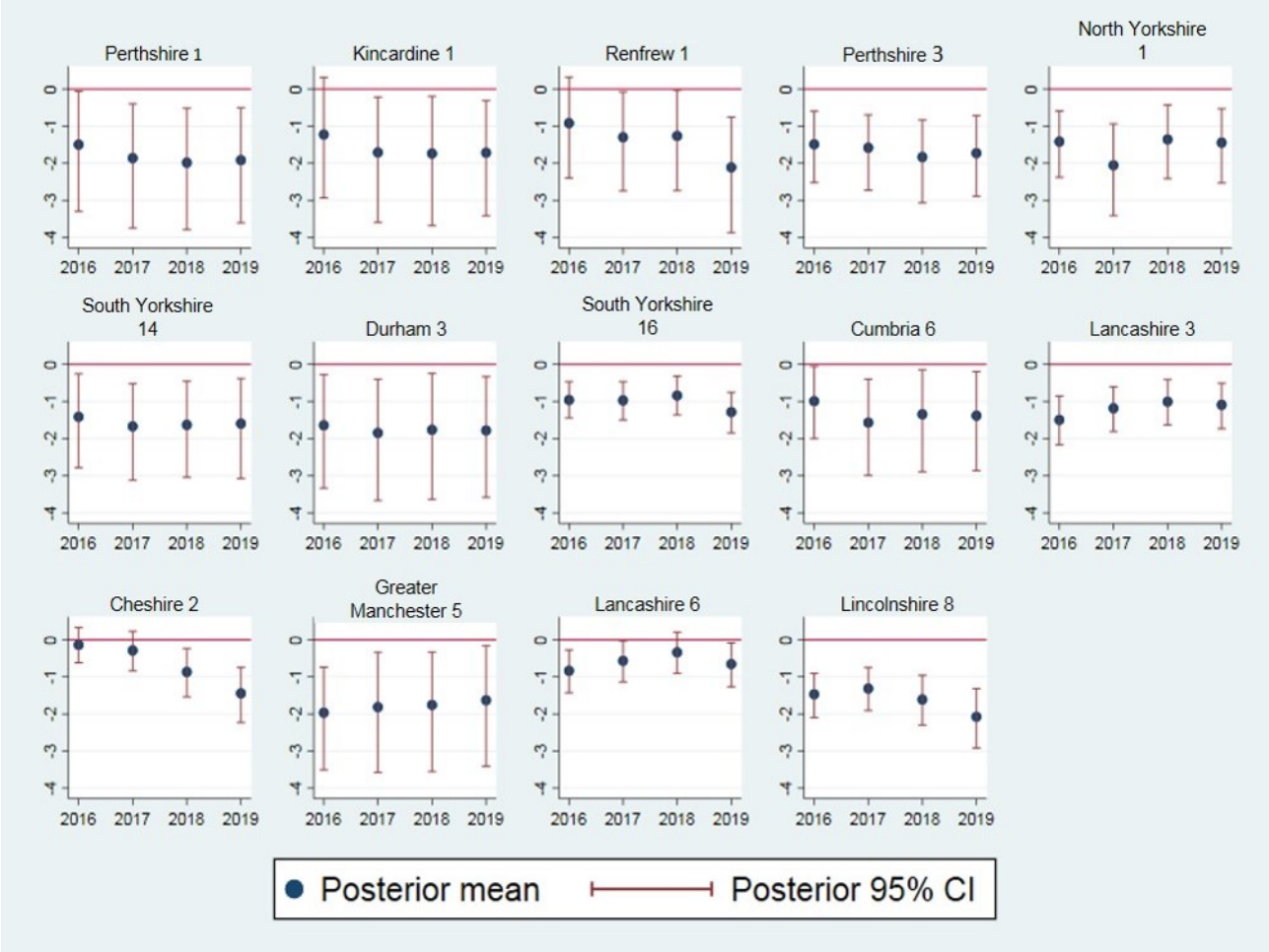
Note: (i) Smaller dot = higher variance = lower throughput and lower certainty about performance; (ii) Colour coded by posterior mean (red = underperforming, blue = over performing, white = performing as expected).

Figure 5.2: Posterior mean and variance from the model, plotted for every slaughterhouse in the 2016-2019 dataset.



Note: These are the same data as figure 5.1 but plotted against mean vs variance.

Figure 5.3: Posterior mean and 95% credible interval for the 14 cattle slaughterhouses performing significantly worse than expected during 2016-19 (model output).



References

[1] Fine, A. E., Bolin, C. A., Gardiner, J. C., & Kaneene, J. B. (2011). A Study of the Persistence of Mycobacterium bovis in the Environment under Natural Weather Conditions in Michigan, USA. Veterinary medicine international, 2011, 765430. https://doi.org/10.4061/2011/765430

[2] APHA, Bovine Tuberculosis in Great Britain: Surveillance data for 2019 and historical trends, 2019.

[3] A. V. PASCUAL-LINAZA, A. W. GORDON, L. A. STRINGER and F. D. MENZIES, Efficiency of slaughterhouse surveillance for the detection of bovine tuberculosis in cattle in Northern Ireland. Epidemiology & Infection, vol. 145, no. 5, pp. 995-1005, 2016.

[4] I. de Kantor and V. Ritacco, An update on bovine tuberculosis programmes in Latin American and Caribbean countries. Veterinary Microbiology, vol. 112, pp. 111-118, 2006.

[5] APHA, Analysis of bovine tuberculosis surveillance at routine slaughter of cattle in Great Britain (2013-2016), 2018.

[6] APHA, A study to identify factors associated with the detection of new TB incidents via abattoir surveillance in GB, 2017.

Appendices

Appendix 1: Throughput and submission data for each slaughterhouse in GB

Individual slaughterhouses have been anonymised by replacing their official ID number with a slaughterhouse code in the table below. Only slaughterhouses with a throughput of >15 animals for the period 2016-19 are displayed, with 14 slaughterhouses not presented.

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
Edge	CHESHIRE 1a	8,882	8,317	11,815	23,667	52,681	13,170.3	1	1	1.00	0.02	0.02
Edge	CHESHIRE 2	16,841	19,333	19,152	17,165	72,491	18,122.8	10	6	0.60	0.08	0.14
Edge	CHESHIRE 3	2,815	2,769	2,861	2,484	10,929	2,732.3	14	6	0.43	0.55	1.28
Edge	CHESHIRE 4	601	540	491	506	2,138	534.5	1	-	-	-	0.47
Edge	DERBYSHIRE 1a	6,111	5,713	5,696	5,282	22,802	5,700.5	11	4	0.36	0.18	0.48
Edge	DERBYSHIRE 1b	66	66	41	9	182	45.5	-	-	-	-	-
Edge	DERBYSHIRE 2a	423	356	363	437	1,579	394.8	-	-	-	-	-
Edge	DERBYSHIRE 2b	6,079	9,167	16,092	22,105	53,443	13,360.8	24	20	0.83	0.37	0.45
Edge	DERBYSHIRE 3	55	31	35	13	134	33.5	-	-	-	-	-
Edge	DERBYSHIRE 4	184	159	184	141	668	167.0	-	-	-	-	-
Edge	EAST SUSSEX 1	1,631	1,525	1,376	1,370	5,902	1,475.5	-	-	-	-	-
Edge	HAMPSHIRE 1	7,944	8,244	8,019	8,084	32,291	8,072.8	6	3	0.50	0.09	0.19
Edge	LEICESTERSHIRE 1	47,267	48,540	48,880	49,366	194,053	48,513.3	67	38	0.57	0.20	0.35
Edge	LEICESTERSHIRE 2	2,384	2,370	2,374	2,297	9,425	2,356.3	2	2	1.00	0.21	0.21
Edge	LEICESTERSHIRE 4	54	48	48	54	204	51.0	-	-	-	-	-
Edge	LEICESTERSHIRE 5	27	23	19	1	70	17.5	-	-	-	-	-
Edge	NOTTINGHAMSHIRE 2	63	55	31	1	150	37.5	-	-	-	-	-
Edge	OXFORDSHIRE 1	10,971	9,224	7,439	6,764	34,398	8,599.5	36	28	0.78	0.81	1.05
Edge	WARWICKSHIRE 1b	1,392	1,273	1,232	1,028	4,925	1,231.3	5	1	0.20	0.20	1.02
Edge	WARWICKSHIRE 2	889	769	621	657	2,936	734.0	1	-	-	-	0.34

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
HRA	AVON 1	321	481	747	961	2,510	627.5	8	2	0.25	0.80	3.19
HRA	AVON 2	43,865	44,025	48,260	49,978	186,128	46,532.0	272	231	0.85	1.24	1.46
HRA	AVON 3	1,878	1,654	516	-	4,048	1,012.0	7	7	1.00	1.73	1.73
HRA	AVON 4	54	58	55	45	212	53.0	1	1	1.00	4.72	4.72
HRA	CORNWALL 1	27,417	28,286	31,239	4,655	91,597	22,899.3	124	86	0.69	0.94	1.35
HRA	CORNWALL 2	70,996	66,837	67,749	71,716	277,298	69,324.5	181	148	0.82	0.53	0.65
HRA	CORNWALL 3	9,103	9,437	10,222	10,062	38,824	9,706.0	49	42	0.86	1.08	1.26
HRA	CORNWALL 4	49	41	43	44	177	44.3	1	-	-	-	5.65
HRA	CORNWALL 5	379	314	316	328	1,337	334.3	2	-	-	-	1.50
HRA	CORNWALL 6	843	949	1,011	1,092	3,895	973.8	3	3	1.00	0.77	0.77
HRA	CORNWALL 7	1,791	1,590	1,235	1,171	5,787	1,446.8	14	7	0.50	1.21	2.42
HRA	CORNWALL 8	483	377	281	277	1,418	354.5	3	3	1.00	2.12	2.12
HRA	CORNWALL 9	550	457	447	95	1,549	387.3	1	1	1.00	0.65	0.65
HRA	DEVON 2	520	313	572	683	2,088	522.0	7	4	0.57	1.92	3.35
HRA	DEVON 3	673	724	793	1,059	3,249	812.3	1	1	1.00	0.31	0.31
HRA	DEVON 4	44,813	43,569	45,960	75,280	209,622	52,405.5	292	248	0.85	1.18	1.39
HRA	DEVON 5	265	218	222	193	898	224.5	3	3	1.00	3.34	3.34
HRA	DEVON 6	2,282	2,181	2,318	2,507	9,288	2,322.0	20	13	0.65	1.40	2.15
HRA	DORSET 1	38,443	39,665	42,080	40,001	160,189	40,047.3	77	61	0.79	0.38	0.48
HRA	DORSET 2	5,741	4,151	6,919	7,555	24,366	6,091.5	22	14	0.64	0.57	0.90
HRA	DORSET 3	145	121	144	140	550	137.5	2	-	-	-	3.64
HRA	DORSET 4	1,169	1,173	1,096	1,025	4,463	1,115.8	2	-	-	-	0.45
HRA	GLOUCESTERSHIRE 1	64,441	70,908	70,697	66,779	272,825	68,206.3	220	153	0.70	0.56	0.81
HRA	GLOUCESTERSHIRE 3	7,386	7,426	7,879	7,957	30,648	7,662.0	43	37	0.86	1.21	1.40
HRA	GLOUCESTERSHIRE 4	636	624	606	717	2,583	645.8	2	2	1.00	0.77	0.77
HRA	GLOUCESTERSHIRE 5	6,414	6,103	5,042	5,247	22,806	5,701.5	3	3	1.00	0.13	0.13
HRA	HEREFORD & WORCESTER 1	1,615	1,396	1,843	1,886	6,740	1,685.0	4	3	0.75	0.45	0.59

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
HRA	HEREFORD & WORCESTER 2	305	290	266	186	1,047	261.8	3	3	1.00	2.87	2.87
HRA	HEREFORD & WORCESTER 3	-	308	696	444	1,448	362.0	3	3	1.00	2.07	2.07
HRA	SHROPSHIRE 1	104,493	99,132	106,727	102,129	412,481	103,120.3	412	346	0.84	0.84	1.00
HRA	SHROPSHIRE 2	50,903	59,429	64,004	62,654	236,990	59,247.5	146	101	0.69	0.43	0.62
HRA	SHROPSHIRE 3	72,333	69,278	69,479	68,425	279,515	69,878.8	97	78	0.80	0.28	0.35
HRA	SOMERSET 3	6,517	6,469	8,110	9,753	30,849	7,712.3	-	-	-	-	-
HRA	SOMERSET 5	75	134	279	150	638	159.5	-	-	-	-	-
HRA	SOMERSET 6	1,599	1,495	1,394	1,486	5,974	1,493.5	8	8	1.00	1.34	1.34
HRA	SOMERSET 7	169	177	145	146	637	159.3	1	-	-	-	1.57
HRA	SOMERSET 8	13,547	13,156	12,639	11,587	50,929	12,732.3	83	49	0.59	0.96	1.63
HRA	SOMERSET 9	59,954	69,762	71,640	69,419	270,775	67,693.8	386	206	0.53	0.76	1.43
HRA	STAFFORDSHIRE 1	3,711	-	-	-	3,711	927.8	-	-	-	-	-
HRA	STAFFORDSHIRE 11	94	91	109	101	395	98.8	-	-	-	-	-
HRA	STAFFORDSHIRE 12	18,950	15,006	16,222	21,213	71,391	17,847.8	139	73	0.53	1.02	1.95
HRA	STAFFORDSHIRE 13	7,040	6,448	5,904	4,885	24,277	6,069.3	48	20	0.42	0.82	1.98
HRA	STAFFORDSHIRE 15	237	181	335	347	1,100	275.0	-	-	-	-	-
HRA	STAFFORDSHIRE 16	612	549	550	547	2,258	564.5	7	3	0.43	1.33	3.10
HRA	STAFFORDSHIRE 17	-	-	-	543	543	135.8	1	1	1.00	1.84	1.84
HRA	STAFFORDSHIRE 18	-	-	2,040	3,372	5,412	1,353.0	-	-	-	-	-
HRA	STAFFORDSHIRE 2	815	613	347	-	1,775	443.8	1	-	-	-	0.56
HRA	STAFFORDSHIRE 20	19	17	21	18	75	18.8	-	-	-	-	-
HRA	STAFFORDSHIRE 4	299	244	199	178	920	230.0	-	-	-	-	-
HRA	STAFFORDSHIRE 5	9,439	17,985	16,624	4,779	48,827	12,206.8	11	9	0.82	0.18	0.23
HRA	STAFFORDSHIRE 6	6,930	6,908	6,058	5,145	25,041	6,260.3	8	5	0.63	0.20	0.32
HRA	STAFFORDSHIRE 7	84	48	45	19	196	49.0	1	-	-	-	5.10
HRA	STAFFORDSHIRE 8	167	194	203	208	772	193.0	2	2	1.00	2.59	2.59
HRA	STAFFORDSHIRE 9	84	77	32	-	193	48.3	-	-	-	-	-

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
HRA	WEST MIDLANDS 1	332	714	617	823	2,486	621.5	-	-	-	-	-
HRA	WEST MIDLANDS 2	2,001	1,476	1,234	898	5,609	1,402.3	-	-	-	-	-
HRA	WILTSHIRE 1	31,521	28,344	28,534	29,905	118,304	29,576.0	18	10	0.56	0.08	0.15
HRA	WILTSHIRE 2	2,953	2,623	2,472	2,925	10,973	2,743.3	5	4	0.80	0.36	0.46
LRA	BEDFORDSHIRE 1	48,845	56,722	65,062	69,555	240,184	60,046.0	65	39	0.60	0.16	0.27
LRA	BEDFORDSHIRE 2	687	661	626	658	2,632	658.0	-	-	-	-	-
LRA	CAMBRIDGESHIRE 1	294	283	264	263	1,104	276.0	-	-	-	-	-
LRA	CAMBRIDGESHIRE 2	90	93	84	80	347	86.8	-	-	-	-	-
LRA	CAMBRIDGESHIRE 3	126	104	110	117	457	114.3	-	-	-	-	-
LRA	CLEVELAND 1	16,323	7,790	-	-	24,113	6,028.3	2	-	-	-	0.08
LRA	CUMBRIA 1	4,205	6,426	7,148	5,881	23,660	5,915.0	4	3	0.75	0.13	0.17
LRA	CUMBRIA 2	6,989	5,697	6,134	6,473	25,293	6,323.3	20	4	0.20	0.16	0.79
LRA	CUMBRIA 3	1,101	936	913	969	3,919	979.8	1	-	-	-	0.26
LRA	CUMBRIA 4	175	164	185	255	779	194.8	1	-	-	-	1.28
LRA	CUMBRIA 6	20,259	18,954	20,458	23,498	83,169	20,792.3	13	1	0.08	0.01	0.16
LRA	DURHAM 1	355	347	267	220	1,189	297.3	-	-	-	-	-
LRA	DURHAM 2	6,084	6,123	6,115	5,934	24,256	6,064.0	-	-	-	-	-
LRA	DURHAM 3	16,117	16,901	16,512	15,903	65,433	16,358.3	1	-	-	-	0.02
LRA	DURHAM 4	119	85	117	106	427	106.8	-	-	-	-	-
LRA	DURHAM 5	2,884	2,853	2,619	2,448	10,804	2,701.0	1	1	1.00	0.09	0.09
LRA	ESSEX 1	4,019	3,819	3,846	3,794	15,478	3,869.5	-	-	-	-	-
LRA	ESSEX 2	2,202	2,082	1,934	1,824	8,042	2,010.5	-	-	-	-	-
LRA	ESSEX 3	367	348	308	272	1,295	323.8	-	-	-	-	-
LRA	GREATER LONDON 1	1,654	1,364	1,219	820	5,057	1,264.3	1	-	-	-	0.20
LRA	GREATER MANCHESTER 1	6,619	7,153	9,471	12,204	35,447	8,861.8	2	1	0.50	0.03	0.06
LRA	GREATER MANCHESTER 2	2,896	2,956	2,979	2,430	11,261	2,815.3	7	-	-	-	0.62
LRA	GREATER MANCHESTER 3	42	43	36	29	150	37.5	-	-	-	-	-

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
LRA	GREATER MANCHESTER 4	598	237	-	-	835	208.8	-	-	-	-	-
LRA	GREATER MANCHESTER 5	15,129	14,986	14,244	13,845	58,204	14,551.0	-	-	-	-	-
LRA	GREATER MANCHESTER 6	455	267	289	268	1,279	319.8	1	1	1.00	0.78	0.78
LRA	GREATER MANCHESTER 7	216	-	-	-	216	54.0	-	-	-	-	-
LRA	HUMBERSIDE 1	24,343	21,107	20,373	22,097	87,920	21,980.0	7	-	-	-	0.08
LRA	HUMBERSIDE 2	319	311	406	448	1,484	371.0	-	-	-	-	-
LRA	HUMBERSIDE 4	85	84	86	80	335	83.8	-	-	-	-	-
LRA	HUMBERSIDE 5	28	26	16	12	82	20.5	-	-	-	-	-
LRA	KENT 1	760	555	1,260	577	3,152	788.0	-	-	-	-	-
LRA	KENT 3	121	125	117	99	462	115.5	-	-	-	-	-
LRA	KENT 4	299	294	297	254	1,144	286.0	-	-	-	-	-
LRA	KENT 5	390	359	332	338	1,419	354.8	-	-	-	-	-
LRA	KENT 6	37	36	29	49	151	37.8	-	-	-	-	-
LRA	LANCASHIRE 2	553	1,577	13,314	14,534	29,978	7,494.5	3	1	0.33	0.03	0.10
LRA	LANCASHIRE 3	80,050	75,095	62,762	60,187	278,094	69,523.5	16	12	0.75	0.04	0.06
LRA	LANCASHIRE 5	2,390	2,907	3,207	3,324	11,828	2,957.0	1	-	-	-	0.08
LRA	LANCASHIRE 6	69,657	69,068	68,027	71,707	278,459	69,614.8	23	11	0.48	0.04	0.08
LRA	LANCASHIRE 7	113,381	117,152	108,307	104,783	443,623	110,905.8	109	80	0.73	0.18	0.25
LRA	LANCASHIRE 8	8,488	5,744	4,690	3,790	22,712	5,678.0	3	1	0.33	0.04	0.13
LRA	LINCOLNSHIRE 1	272	12	-	-	284	71.0	-	-	-	-	-
LRA	LINCOLNSHIRE 2	35	43	48	53	179	44.8	-	-	-	-	-
LRA	LINCOLNSHIRE 3	54,089	54,900	55,205	57,492	221,686	55,421.5	72	57	0.79	0.26	0.32
LRA	LINCOLNSHIRE 4	1,743	1,678	1,615	1,359	6,395	1,598.8	-	-	-	-	-
LRA	LINCOLNSHIRE 5	4,480	4,034	3,617	3,505	15,636	3,909.0	-	-	-	-	-
LRA	LINCOLNSHIRE 6	261	252	157	99	769	192.3	-	-	-	-	-
LRA	LINCOLNSHIRE 7	951	919	848	772	3,490	872.5	-	-	-	-	-

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
LRA	LINCOLNSHIRE 8	91,111	88,858	90,411	92,094	362,474	90,618.5	5	5	1.00	0.01	0.01
LRA	MERSEYSIDE 1	149	81	-	-	230	57.5	-	-	-	-	-
LRA	MERSEYSIDE 2	109	119	120	90	438	109.5	-	-	-	-	-
LRA	NORFOLK 1	10,033	9,963	9,306	9,598	38,900	9,725.0	-	-	-	-	-
LRA	NORFOLK 3	278	303	297	318	1,196	299.0	-	-	-	-	-
LRA	NORFOLK 4	260	252	241	247	1,000	250.0	-	-	-	-	-
LRA	NORFOLK 5	164	132	112	122	530	132.5	-	-	-	-	-
LRA	NORFOLK 6	44	-	-	-	44	11.0	-	-	-	-	-
LRA	NORFOLK 7	8	9	4	20	41	10.3	-	-	-	-	-
LRA	NORTH YORKSHIRE 1	28,575	27,645	26,501	27,685	110,406	27,601.5	3	1	0.33	0.01	0.03
LRA	NORTH YORKSHIRE 10	408	-	-	-	408	102.0	-	-	-	-	-
LRA	NORTH YORKSHIRE 12	386	398	448	377	1,609	402.3	-	-	-	-	-
LRA	NORTH YORKSHIRE 13	250	254	283	278	1,065	266.3	-	-	-	-	-
LRA	NORTH YORKSHIRE 2	621	650	584	-	1,855	463.8	-	-	-	-	-
LRA	NORTH YORKSHIRE 3	83	144	95	102	424	106.0	-	-	-	-	-
LRA	NORTH YORKSHIRE 5	30,475	29,684	29,851	29,922	119,932	29,983.0	16	9	0.56	0.08	0.13
LRA	NORTH YORKSHIRE 6	1,079	1,043	689	551	3,362	840.5	-	-	-	-	-
LRA	NORTH YORKSHIRE 7	1,737	1,558	1,515	1,362	6,172	1,543.0	-	-	-	-	-
LRA	NORTH YORKSHIRE 9	33	-	-	-	33	8.3	-	-	-	-	-
LRA	SOUTH YORKSHIRE 14	13,744	12,931	13,389	14,482	54,546	13,636.5	1	1	1.00	0.02	0.02
LRA	SOUTH YORKSHIRE 15	180	199	184	186	749	187.3	-	-	-	-	-
LRA	SOUTH YORKSHIRE 16	49,782	55,599	59,291	61,544	226,216	56,554.0	21	9	0.43	0.04	0.09
LRA	SOUTH YORKSHIRE 17	130	133	132	134	529	132.3	-	-	-	-	-
LRA	SUFFOLK 1	46	13	-	-	59	14.8	-	-	-	-	-
LRA	SUFFOLK 2	3,222	3,031	2,867	1,205	10,325	2,581.3	-	-	-	-	-
LRA	SURREY 1	37,004	36,313	35,362	36,325	145,004	36,251.0	92	24	0.26	0.17	0.63
LRA	TYNE & WEAR 1	20,115	24,669	27,274	31,264	103,322	25,830.5	5	2	0.40	0.02	0.05

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
LRA	WEST SUSSEX 1	818	918	918	923	3,577	894.3	2	-	-	-	0.56
LRA	WEST YORKSHIRE 1	10,026	11,621	17,346	18,670	57,663	14,415.8	2	2	1.00	0.03	0.03
LRA	WEST YORKSHIRE 3	482	453	497	536	1,968	492.0	1	-	-	-	0.51
LRA	WEST YORKSHIRE 4	13,800	13,943	14,092	13,279	55,114	13,778.5	4	2	0.50	0.04	0.07
LRA	WEST YORKSHIRE 5	377	283	352	429	1,441	360.3	-	-	-	-	-
LRA	WEST YORKSHIRE 6	3,675	4,221	4,543	4,231	16,670	4,167.5	4	-	-	-	0.24
LRA	WEST YORKSHIRE 7	2,683	2,252	2,025	2,466	9,426	2,356.5	-	-	-	-	-
HTBE	POWYS 1	227	192	201	200	820	205.0	-	-	-	-	-
HTBE	POWYS 2	11,588	9,026	11,248	7,319	39,181	9,795.3	19	12	0.63	0.31	0.48
HTBW	PEMBROKESHIRE 1	-	-	-	3,223	3,223	805.8	1	-	-	-	0.31
HTBW	WEST GLAMORGAN 1	166	176	208	164	714	178.5	3	1	0.33	1.40	4.20
ITBM	DYFED 1	479	465	486	470	1,900	475.0	5	1	0.20	0.53	2.63
ITBM	DYFED 3	34,652	35,844	35,542	40,188	146,226	36,556.5	75	46	0.61	0.31	0.51
ITBM	MID GLAMORGAN 1	2,147	2,210	2,109	1,494	7,960	1,990.0	3	-	-	-	0.38
ITBM	MID GLAMORGAN 2	85,002	78,968	81,810	94,123	339,903	84,975.8	193	131	0.68	0.39	0.57
ITBM	MID GLAMORGAN 3	124	108	93	92	417	104.3	-	-	-	-	-
ITBM	NORTH POWYS 1	40	42	46	46	174	43.5	1	1	1.00	5.75	5.75
ITBN	CLWYD 1	722	739	787	839	3,087	771.8	4	1	0.25	0.32	1.30
ITBN	CLWYD 2	2,125	1,935	1,409	1,315	6,784	1,696.0	1	-	-	-	0.15
ITBN	CLWYD 4	2,205	-	-	1	2,206	551.5	-	-	-	-	-
ITBN	CLWYD 5	1,253	1,253	1,199	1,217	4,922	1,230.5	2	1	0.50	0.20	0.41
LTB	ANGLESEY 1	41	37	35	34	147	36.8	-	-	-	-	-
LTB	CLWYD 3	484	394	302	-	1,180	295.0	1	1	1.00	0.85	0.85
LTB	CLWYD 6	16	-	-	-	16	4.0	-	-	-	-	-
LTB	GWYNEDD 1	1,455	200	-	-	1,655	413.8	-	-	-	-	-
LTB	GWYNEDD 3	2,446	2,493	2,401	2,223	9,563	2,390.8	1	-	-	-	0.10
LTB	GWYNEDD 5	12	13	7	41	73	18.3	-	-	-	-	-

Region	SLH code	Through-put 2016	Through-put 2017	Through-put 2018	Through-put 2019	Through-put 16-19	Throughput/ year	Subs 2016-19	Positive subs 2016-19	Proportion confirmed	Positive sub rate /1000	Sub rate /1000
Scotland	ABERDEENSHIRE 1	35,300	35,563	34,400	33,140	138,403	34,600.8	1	-	-	-	0.01
Scotland	ABERDEENSHIRE 3	37,258	35,720	37,988	37,848	148,814	37,203.5	5	2	0.40	0.01	0.03
Scotland	ARGYLL 1	138	134	140	135	547	136.8	-	-	-	-	-
Scotland	ARGYLL 2	17	8	10	10	45	11.3	-	-	-	-	-
Scotland	AYRSHIRE 1	43,903	44,509	43,914	42,407	174,733	43,683.3	1	1	1.00	0.01	0.01
Scotland	AYRSHIRE 2	50,111	48,404	54,832	59,218	212,565	53,141.3	16	8	0.50	0.04	0.08
Scotland	BERWICKSHIRE 1	-	-	11	8	19	4.8	-	-	-	-	-
Scotland	DUMFRIESHIRE 1	1,435	2,284	2,187	2,197	8,103	2,025.8	1	-	-	-	0.12
Scotland	INVERNESS-SHIRE 2	17	3	1	1	22	5.5	1	-	-	-	45.45
Scotland	KINCARDINE 1	70,981	67,720	69,586	69,876	278,163	69,540.8	-	-	-	-	-
Scotland	LANARKSHIRE 1	3,839	3,665	3,988	3,694	15,186	3,796.5	-	-	-	-	-
Scotland	LANARKSHIRE 2	9,321	8,639	8,528	7,957	34,445	8,611.3	6	3	0.50	0.09	0.17
Scotland	MORAY 1	10,013	10,476	2,529	-	23,018	5,754.5	-	-	-	-	-
Scotland	MORAY 2	11,551	11,936	12,262	11,463	47,212	11,803.0	-	-	-	-	-
Scotland	ORKNEY 1	755	732	16	-	1,503	375.8	-	-	-	-	-
Scotland	PERTHSHIRE 1	76,601	73,322	71,286	68,171	289,380	72,345.0	2	-	-	-	0.01
Scotland	PERTHSHIRE 2	1,969	1,894	159	6	4,028	1,007.0	-	-	-	-	-
Scotland	PERTHSHIRE 3	92,013	93,238	91,858	92,653	369,762	92,440.5	5	1	0.20	0.00	0.01
Scotland	RENFREW 1	20,490	19,645	19,993	17,308	77,436	19,359.0	3	1	0.33	0.01	0.04
Scotland	ROSS & CROMARTY 1	128	148	141	164	581	145.3	-	-	-	-	-
Scotland	ROSS & CROMARTY 2	4,270	4,604	5,176	5,212	19,262	4,815.5	3	-	-	-	0.16
Scotland	SHETLAND 1	376	363	342	309	1,390	347.5	-	-	-	-	-

Appendix 2: TB test types

Code	Type Code	Description	When & Why	Group	Surveillance Stream
PBT	WH	Yorkshire only, from early 80's. Appear to be RHTs			
UNKNOWN	IA	Test used for Breakdowns of unknown origin. Not necessarily IA but likely to be missing SLH Cases.		Other	Area & Herd Risk
VE-12M	WH	12 months post-6M test	Carried out 12 months after 6M if that test was clear. Or six-12 months after the last SI of a breakdown with unconfirmed disease in four yearly testing areas. Scotland :Carried out between six and 12 months following lifting of restrictions in an OTF-W herd	Herd Risk	Area & Herd Risk
VE-6M	WH	6 Month test	Carried out six months from the date of the clear short interval test which led to the lifting of restrictions. Not required in OTF-S herds in four yr testing areas.	Herd Risk	Area & Herd Risk
VE-90D	WH	90 day test for AFU herd		Control	Area & Herd Risk
VE-AI	IA	AI animal test	Carried out on bulls, teasers and embryo donors prior to admission to an Artificial Insemination Centre.	Movement Risk 1	Proactive
VE-ANTIBODY	IA	Ancillary blood test			
VE-ASG	WH	Testing of restricted isolated groups of cattle within a breakdown or non-breakdown herd at RVL discretion	To be used for the testing of restricted isolated groups of cattle within a breakdown or non-breakdown herd at RVL, SVL or VLW discretion. It should only be used to identify these groups from other ongoing testing on the premises i.e. SIs (breakdown herds) or other (non-breakdown herds)	Other	Area & Herd Risk
VE-BHH	IA	For TB Bull Hirers test (carried out on hire bulls requiring annual testing).	Carried out on hire bulls requiring annual testing.	Movement Risk 1	Proactive
VE-CLINICAL	IA	Ancillary blood test			
VE-CON	WH	Contiguous test	Carried out on herds contiguous to OTF-W herds outside their regular test frequency. Scotland :Risk based - limited to an epidemiological link	Area Risk	Area & Herd Risk
VE-CON12	WH	12 months post CON6-Contiguous test	Carried out 12 months after a CON Wales :or CON6 (if the latter has been carried out)	Area Risk	Area & Herd Risk
VE-CON6	WH	6 months post Contiguous test	Carried out at the VLW's discretion six months after a CON	Area Risk	Area & Herd Risk
VE-CT	WH	Check test		Control	Area & Herd Risk

Code	Type Code	Description	When & Why	Group	Surveillance Stream
VE-CT(EM)	WH	Carried out outside the normal testing frequency for the herd, to determine its disease status when there is a suspicion of infection.	Carried out outside the normal testing frequency for the herd, to determine its disease status when there is a suspicion of infection. This will come after, for instance: Back tracing of OTF-W reactors found in another herd	Control	Area & Herd Risk
VE-CT(I-I)	WH	As VE-CT(EM) except it will be for voluntary slaughter of an IR identified in an IR-only herd, id of a clinical case of TB, Disclosure of lesions suggestive of TB at SLH, knackers yard etc. ID of reactors at routine herd test that included adults only etc	Carried out outside the normal testing frequency for the herd, to determine its disease status when there is a suspicion of infection. This will come after, for instance: Voluntary slaughter of an IR identified in an IR-only herd, Identification of a clinical case of TB, Disclosure of lesions suggestive of TB at a slaughterhouse, knackers yard, hunt kennel, VLA regional lab, etc. Identification of reactors at a routine herd test that included adults only, For any other reason at the RVL's, SVL's or VLW's discretion	Control	Area & Herd Risk
VE-CT(RTA)	WH	Check test following an RTA incident - only up to 2007		Area Risk	Area & Herd Risk
VE-CT-HS1	WH	1st hotspot check test	Test carried out if a holding is within a 3km radius of an incident, which triggers a potential hotspot area.	Area Risk	Area & Herd Risk
VE-CT-HS2	WH	2nd hotspot check test	Test carried out 12 months after the CT-HS1 test.	Area Risk	Area & Herd Risk
VE-CT-LRA-SA	WH	Voluntary herd tests carried out in four yearly testing herds meeting certain criteria at the owner's request		Movement Risk 1	Proactive
VE-CT-NH1	WH	1st new herd check test	Test carried out when a new or reformed herd has been identified, (Scotland that includes any cattle born or kept in a high incidence area (one or two yearly testing parishes). Following completion, herds will revert to the four yearly parish testing interval) within 12 months of arrival of the first animal. Reformed herds following depopulation for TB reasons will require a second check test (CT-NH2) after 12 months, all other herds will revert to routine testing in line with the area testing interval for that holding.	New Herds	Routine
VE-CT-NH2	WH	2nd new herd check test	Test carried out 12 months after a VE-CT-NH1 test on reformed herds following depopulation for TB reasons.	New Herds	Routine
VE-CT-NH3	WH	3rd new herd check test		New Herds	Routine
VE-CT-RH1	WH	1st reformed herd check test - only up to 2011		New Herds	Area & Herd Risk

Code	Type Code	Description	When & Why	Group	Surveillance Stream
VE-CT-RH2	WH	2nd reformed herd check test - only up to 2011		New Herds	Area & Herd Risk
VE-CT-RH3	WH	3rd reformed herd check test - only up to 2011		New Herds	Area & Herd Risk
VE-CTW1	WH	For welsh herds not due a test 1/10/08-31/12/09	Whole Herd Test equivalent allocated to herds in Wales that would not normally be subject to annual testing had a PTI review taken place. Previously used as part of the TB Health Check Wales which ended in December 2009. No longer available as of 01/04/12	Routine	
VE-CTW2	WH	WHT for welsh herds prev. due RHT 1/10/08-31/12/09	Whole herd test equivalent allocated to herds in Wales than would normally be subject to a Routine Herd Test (RHT) had a PTI review taken place. Previously used as part of the TB Health Check Wales which ended in December 2009	Routine	
VE-DTG	IA	Delayed Testing Group; testing for the detached animals, in connection with a VE-PSI group.	To be used for a group of low risk cattle away at grass keep, following a VRA and authorisation. It must be used in conjunction with Partial Short Interval Test (PSI).	Control	Area & Herd Risk
VE-EX	IA	Export Test	Test on cattle exported from Great Britain	Movement Risk 1	Proactive
VE-EXEMPT(S)	WH	Herds scheduled for a routine test but exempt under Scottish policy as low risk			Routine
VE-IA12	WH	Routine 12M test within the Welsh IAA area only	Tests carried out on all herds within the IAA every 6 months. Test codes are alternated i.e. IA6 is used at six months, IA12 at twelve months, IA6 at 18 months.	Routine	Routine
VE-IA6	WH	Routine 6M test within the Welsh IAA area only	Tests carried out on all herds within the IAA every 6 months. Test codes are alternated i.e. IA6 is used at six months, IA12 at twelve months, IA6 at 18 months.	Routine	Routine
VE-IASI	WH	2nd SI test for OTF-S herds within the Welsh IAA area only.	Test code used for the second SI test on herds within the IAA that remain OTF-S. From 1 May 2013 this test code will no longer be required.	Control	Area & Herd Risk
			Test code used for the second SI test on herds within the IAA that remain OTF-S. From 1 May 2013 this test code will no longer be required.		

Code	Type Code	Description	When & Why	Group	Surveillance Stream
VE-IFN	WH	Gamma-Interferon trial blood test		Control	Area & Herd Risk
VE-IFN_2x_IR	IA	IFN TB Test 2xIR - Investigation & Intervention		IR	Area & Herd Risk
VE-IFN_ANOM	IA	IFN Anomalous Reactions Procedure	In-vitro blood test for bovine TB, used to supplement the intradermal tuberculin test in a range of situations. The test is carried out on RVL, SVL or VLW instruction on eligible TB incidents where certain criteria are met.	Control	Area & Herd Risk
VE-IFN_FLEX	WH	IFN test of unknown purpose at present (new test)			
VE-IFN_LOW_IN	WH	IFN OTF-W TB Breakdown in Lower TB Incidence Area - Investigation and Interpretation	In-vitro blood test for bovine TB, used to supplement the intradermal tuberculin test in a range of situations. The test is carried out on RVL, SVL or VLW instruction on eligible TB incidents where certain criteria are met	Control	Area & Herd Risk
VE-IFN_NBCP	WH	Gamma testing in breakdown herds in badger culling areas	Carried out 60 days after removal (or effective isolation) of the last reactor, or following confirmation of disease whilst the herd is under TB movement restriction. In OTF-S (2) or OTF-W breakdowns, if there are no reactors or IRs at the first SI test carried out, the subsequent SI test should be carried out a minimum of 60 days from the previous TT1 date of the previous test.	Movement Risk 1	
VE-IFN_NSR	WH	IFN Non-Specific Reactor Herd - Investigation and Intervention	In-vitro blood test for bovine TB, used to supplement the intradermal tuberculin test in a range of situations. The test is carried out on RVL, SVL or VLW instruction on eligible TB incidents where certain criteria are met	Control	Area & Herd Risk
VE-IFN_OTH_SP	WH	IFN test performed due to disease in other species		Control	Area & Herd Risk
VE-IFN_PBCP	WH	IFNg testing at persistent OTF-W breakdowns in badger culling areas			
VE-IFN_PERSI	WH	IFN OTF-W Herd with Persistent Infection - Investigation and Intervention	In-vitro blood test for bovine TB, used to supplement the intradermal tuberculin test in a range of situations. The test is carried out on RVL, SVL or VLW instruction on eligible TB incidents where certain criteria are met	Control	Area & Herd Risk
VE-IFN_PRI	WH	Private IFN Test	In-vitro blood test for bovine TB, used to supplement the intradermal tuberculin test in a range of situations. The test is carried out on RVL, SVL or VLW instruction on eligible TB incidents where certain criteria	Control	Area & Herd Risk

Code	Type Code	Description	When & Why	Group	Surveillance Stream
VE-IFN_SLHERD	WH	IFN Whole or Partial Slaughter of Reactor Herds - Investigation and Intervention	In-vitro blood test for bovine TB, used to supplement the intradermal tuberculin test in a range of situations. The test is carried out on RVL, SVL or VLW instruction on eligible TB incidents where certain criteria are met	Control	Area & Herd Risk
VE-IR	IA	Inconclusive Reactor Retest	Carried out on inconclusive reactors identified at an earlier test. To be conducted at least 60 days later. Currently, one retest of the same IR animal is permitted.	IR	Area & Herd Risk
VE-OT	WH	Other test		Routine	Routine
VE-PII	IA	Post Irish Import	Test on cattle imported from Northern Ireland and the Republic of Ireland 60 days after arrival. Scotland :(Cattle from Northern Ireland should be tested as POSTMTS 60-120 days after arrival to Scotland)	Movement Risk 1	Proactive
VE-PIO	IA	Post Other Import	Carried out post-import as prescribed by the conditions of the import license.	Movement Risk 1	Proactive
VE-PIU	IA	Presumably a post-import test-old, one-off error?			
VE-POSTLRANC	IA	To be used for post-movement testing in the LRA by OVs as instructed by APHA when a breach has been disclosed. Not to be used when a required pre-movement test has not taken place – POSTMT should be used then)		Movement Risk 2	Proactive
VE-POSTLRAOV	IA	To be used for post-movement testing in the lRA by OVs. Not to be used when a required pre-movement test has not taken place – POSTMT should be used then.		Movement Risk 2	Proactive
VE-POSTMOVNC	IA	Post Movement TB Test LRA (Eng) and LTBA (Wales) - Non-Compliance			
VE-POSTMOVOV	IA	Post Movement TB Test LRA (Eng) and LTBA (Wales)			
VE-POSTMT	IA	Post movement testing	This code is to be used for a post-movement test to be carried out in circumstances where cattle have been moved into a holding without a required pre-movement test.	Movement Risk 2	Proactive

Code	Type Code	Description	When & Why	Group	Surveillance Stream
VE-POSTMTS	IA	Post movement testing Scotland	This is a post-movement test carried out 60-120 days after arrival to Scotland from England or Wales (exceptions apply).	Movement Risk 2	Proactive
VE-POSTMTS(NI)	IA	Post-movement tests carried out 60-120 days after arrival in Scotland from Northern Ireland	Post-movement tests carried out 60-120 days after arrival in Scotland from Northern Ireland	Movement Risk 2	Proactive
VE-PR	IA	Private test		Movement Risk 1	Proactive
VE-PRI	IA	Private test	A test commissioned and paid for by the owner and carried out by an OV with the RVLs, SVLs or VLWs agreement.	Movement Risk 2	Proactive
VE-PRMT	IA	Pre-movement testing	This code is to be used for a pre-movement test to be carried out 60 days or less prior to movement of an animal(s) from an annually tested herd.	Movement Risk 2	Proactive
VE-PRMTS	IA	Pre-movement testing Scotland	This test should be carried out on cattle that have arrived into Scotland that should have had a pre-movement test before departure.	Movement Risk 2	Proactive
VE-PSI	WH	Partial Short Interval test; some animals are detached and cannot be tested. New 2012	Carried out 60 days after removal (or effective isolation) of the last reactor, or following confirmation of disease whilst the herd is under TB movement restriction. In OTF-S (2) or OTF-W breakdowns, if there are no reactors or IRs at the first SI test carried out, the subsequent SI test should be carried out a minimum of 60 days from the TT1 date of the previous test. To be used for the main herd when delayed testing has been authorised for a group of low risk cattle away at grass keep. It must be used in conjunction with Delayed Test Group (DTG)	Control	Area & Herd Risk
VE-RAD	WH	Radial Herd Test. Stock eligibility will be as with CON tests - all bovines except calves under 6 weeks old	Carried out on herds within a 3km radius of a herd with its Officially TB Free status withdrawn in the Low Incidence Area or in the Cheshire and Derbyshire Edge Area	Area Risk	Area & Herd Risk
VE-RAD12	WH	12 months post Radial Herd Test. Stock eligibility will be as with CON tests - all bovines except calves under 6 weeks old	Carried out 12 months after a RAD6 in the Low Incidence Area. Not required in Cheshire and Derbyshire Edge Area as revert to routine annual testing	Area Risk	Area & Herd Risk
VE-RAD6	WH	6 months post Radial Herd Test. Stock eligibility will be as with CON tests - all bovines except calves under 6 weeks old	Carried out six months after a RAD/Clear Herd Test in the Low Incidence Area or in the Cheshire and Derbyshire Edge Area	Area Risk	Area & Herd Risk
VE-RHT	WH	Routine Whole herd test		Routine	Routine

Code	Type Code	Description	When & Why	Group	Surveillance Stream
VE-RHT12 (S)	WH	For herds that are on 12 monthly testing intervals. Eligibility is as per 48 month Routine Herd Tests	A routine surveillance test carried out every 12 months. Herds sustained by a regular intake of imported cattle from Northern Ireland, Republic of Ireland, Isle of Man and non-Officially Tuberculosis Free (OTF). Member States must be tested on an annual basis.	Routine	Routine
VE-RHT24/36	WH	Carried out in parishes with a 24, 36 month testing interval		Routine	Routine
VE-RHT24/36/48	WH	Carried out in parishes with a 24, 36, 48-month testing interval		Routine	Routine
VE-RHT48	WH	Routine surveillance test carried out every 48 months	Carried out in parishes with a 48 month testing interval. Scotland: New and reformed herds must commence routine testing no earlier than six months, and no later than 12 months, after the arrival of the first animal onto the holding.	Routine	Routine
VE-SI	WH	Short Interval test	Carried out 60 days after removal (or effective isolation) of the last reactor, or following confirmation of disease whilst the herd is under TB movement restriction. In OTF-S (2) or OTF-W breakdowns, if there are no reactors or IRs at the first SI test carried out, the subsequent SI test should be carried out a minimum of 60 days from the previous TT1 date of the previous test.	Control	Area & Herd Risk
VE-SLH	IA	Slaughterhouse case		SLH	Slaughterhouse
VE-TBU	WH	Carried out every 90 days on Approved Finishing Units (AFU's) with grazing or every 6 months on AFU's without grazing (This is the former VE-90D)	Test carried out every 90 days on Approved Finishing Units (AFU's) with grazing. (This is the former VE-90D)	Control	Area & Herd Risk
VE-TR	IA	Traced Bovine Test	Test of bovines that have moved from OTF-W herds prior to service of restrictions	Movement Risk 1	Area & Herd Risk
VE-UNK	IA	Unknown type; added at DSG as appears to be missing from Sam			
VE-WHT	WH	Whole herd test	Carried out routinely every 12 months in annual testing areas and in individual herds requiring annual testing, e.g. producer-retailer dairy herds, bull hirers, heifer rearers, city/open farms, AI centres, etc. Can also be carried out via RVL discretion in 48 month testing areas. Scotland: Can also be carried out via SVL discretion in 48 month parishes. In CHESHIRE EDGE AREA every 6 months (Jan16).	Routine	Routine

Code	Type Code	Description	When & Why	Group	Surveillance Stream
VE-WHT2	WH	Yearly test in 2 yearly testing parishes	Can be carried out via SVL discretion in 48 month parishes.	Routine	Routine

Appendix 3: Performance posterior Mean, Standard Deviation and lower-upper 95% credible interval bounds for all slaughterhouses.

Slaughterhouses with a significantly lower than expected number of positive submissions between 2016 and 2019 have been highlighted.

Individual slaughterhouses have been anonymised by replacing their official ID number with a slaughterhouse code in the table below.

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
Edge	CHESHIRE 1a	-0.38	0.49	-1.41	0.53	-0.80	0.60	-2.09	0.26	-0.75	0.62	-2.02	0.39	-0.87	0.60	-2.16	0.20
Edge	CHESHIRE 2	-0.14	0.24	-0.62	0.33	-0.29	0.27	-0.84	0.22	-0.87	0.33	-1.57	-0.26	-1.44	0.39	-2.23	-0.75
Edge	CHESHIRE 3	1.63	0.35	0.94	2.32	1.60	0.34	0.91	2.26	1.23	0.39	0.44	1.97	1.21	0.39	0.44	1.97
Edge	CHESHIRE 4	-0.61	0.95	-2.57	1.15	-0.56	1.08	-2.90	1.40	-0.62	1.06	-2.85	1.27	0.29	0.91	-1.55	1.94
Edge	DERBYSHIRE 1a	-0.41	0.49	-1.43	0.49	0.04	0.44	-0.86	0.87	-0.26	0.52	-1.38	0.69	-0.09	0.50	-1.13	0.86
Edge	DERBYSHIRE 2a	-0.05	1.14	-2.41	2.21	-0.41	1.14	-2.82	1.68	-0.14	1.23	-2.61	2.25	-0.22	1.17	-2.69	1.94
Edge	DERBYSHIRE 2b	0.49	0.28	-0.07	1.05	0.58	0.27	0.04	1.10	0.52	0.28	-0.04	1.07	0.49	0.26	-0.05	1.00
Edge	DERBYSHIRE 4	-0.29	1.03	-2.34	1.70	-0.31	1.14	-2.63	1.79	-0.23	1.22	-2.79	2.06	-0.23	1.16	-2.59	1.94
Edge	DERBYSHIRE 5	1.10	0.18	0.74	1.46	1.36	0.46	0.47	2.26								
Edge	EAST SUSSEX 1	-0.44	0.99	-2.46	1.47	-0.88	0.98	-2.93	0.88	-0.72	1.05	-2.98	1.16	-0.76	0.98	-2.83	1.03
Edge	HAMPSHIRE 1	-1.06	0.56	-2.21	-0.05	-1.11	0.60	-2.40	-0.06	-0.39	0.50	-1.46	0.52	-0.50	0.51	-1.54	0.41
Edge	HAMPSHIRE 2	0.68	0.44	-0.21	1.53	-0.01	0.70	-1.49	1.25	-0.36	1.19	-2.85	1.98				
Edge	LEICESTERSHIRE 1	0.14	0.20	-0.23	0.53	0.07	0.20	-0.31	0.47	0.12	0.21	-0.28	0.53	-0.10	0.20	-0.50	0.29
Edge	LEICESTERSHIRE 2	-1.21	0.86	-3.01	0.29	-0.68	0.75	-2.28	0.64	-0.72	0.74	-2.30	0.57	-0.21	0.66	-1.62	0.94
Edge	NOTTINGHAMSHIRE 1	0.27	0.87	-1.54	1.91												
Edge	OXFORDSHIRE 1	0.98	0.21	0.57	1.40	1.26	0.22	0.83	1.68	1.55	0.24	1.09	2.01	1.34	0.25	0.85	1.82
Edge	WARWICKSHIRE 1a	0.02	1.17	-2.28	2.33	-0.22	1.15	-2.62	1.96								
Edge	WARWICKSHIRE 1b	0.87	0.49	-0.10	1.81	1.14	0.52	0.11	2.12	-0.03	0.68	-1.49	1.23	-0.32	0.80	-1.98	1.12
Edge	WARWICKSHIRE 2	-1.00	0.89	-2.93	0.58	-0.79	1.05	-2.97	1.10	-0.84	1.01	-3.01	0.98	0.10	0.88	-1.72	1.69
HRA	AVON 1	1.28	0.62	0.07	2.48	1.43	0.65	0.10	2.66	1.49	0.67	0.18	2.79	1.59	0.60	0.40	2.74
HRA	AVON 2	1.58	0.15	1.31	1.88	1.47	0.15	1.17	1.77	1.44	0.17	1.11	1.77	1.21	0.16	0.89	1.53
HRA	AVON 3	2.08	0.31	1.47	2.68	1.99	0.33	1.34	2.63	2.12	0.38	1.36	2.86	2.16	0.42	1.35	2.96

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
HRA	AVON 4					1.27	1.16	-1.00	3.57	1.24	1.17	-1.06	3.58	1.16	1.14	-1.06	3.37
HRA	CORNWALL 1	1.19	0.16	0.89	1.51	1.27	0.17	0.95	1.59	1.29	0.18	0.96	1.65	1.15	0.18	0.81	1.50
HRA	CORNWALL 2	1.00	0.15	0.73	1.29	1.16	0.16	0.86	1.47	1.11	0.17	0.78	1.45	0.83	0.16	0.53	1.15
HRA	CORNWALL 3	1.39	0.21	0.98	1.82	1.16	0.23	0.72	1.59	1.15	0.24	0.68	1.62	1.17	0.24	0.71	1.64
HRA	CORNWALL 4	0.89	1.05	-1.14	2.98												
HRA	CORNWALL 5	0.47	0.78	-1.11	1.95	0.14	0.87	-1.64	1.80	-0.42	1.16	-2.83	1.72	0.40	0.93	-1.47	2.12
HRA	CORNWALL 6	1.75	0.46	0.85	2.65	1.58	0.48	0.64	2.50	0.98	0.57	-0.16	2.07	0.93	0.58	-0.27	2.02
HRA	CORNWALL 7	1.46	0.35	0.75	2.15	1.78	0.38	1.05	2.51	1.73	0.40	0.94	2.48	1.53	0.41	0.70	2.34
HRA	CORNWALL 8	0.48	0.73	-1.06	1.84	1.96	0.64	0.70	3.26	1.94	0.70	0.53	3.30	1.37	0.74	-0.13	2.78
HRA	CORNWALL 9	0.57	0.78	-0.99	2.06	0.57	0.77	-1.04	2.02	0.59	0.75	-0.90	2.02	0.15	0.90	-1.76	1.79
HRA	DEVON 2	1.54	0.53	0.51	2.57	1.85	0.53	0.82	2.89	1.76	0.58	0.61	2.90	1.64	0.62	0.37	2.87
HRA	DEVON 3	1.43	0.51	0.44	2.43	1.54	0.50	0.56	2.53	1.31	0.55	0.25	2.39	0.37	0.67	-1.02	1.60
HRA	DEVON 4	1.62	0.15	1.35	1.92	1.67	0.15	1.37	1.97	1.65	0.16	1.33	1.98	1.29	0.16	0.99	1.60
HRA	DEVON 5	1.71	0.61	0.52	2.95	1.95	0.63	0.74	3.19	1.60	0.71	0.18	3.02	1.41	0.82	-0.18	2.99
HRA	DEVON 6	1.03	0.36	0.32	1.71	1.66	0.33	1.00	2.32	1.88	0.33	1.23	2.53	1.82	0.32	1.18	2.46
HRA	DORSET 1	0.47	0.16	0.16	0.79	0.58	0.17	0.26	0.91	0.38	0.19	0.02	0.75	0.23	0.18	-0.13	0.60
HRA	DORSET 2	-0.70	0.39	-1.51	0.06	0.03	0.35	-0.67	0.70	0.21	0.33	-0.45	0.84	0.25	0.31	-0.36	0.83
HRA	DORSET 3	-0.27	1.10	-2.50	1.83	-0.28	1.20	-2.70	1.99	1.54	0.93	-0.35	3.44	1.36	0.92	-0.43	3.11
HRA	DORSET 4	-0.13	0.66	-1.50	1.09	-0.07	0.69	-1.50	1.17	0.22	0.72	-1.30	1.55	-0.30	0.79	-1.97	1.15
HRA	GLOUCESTERSHIRE 1	0.08	0.17	-0.25	0.42	0.05	0.17	-0.27	0.39	0.35	0.18	0.01	0.70	0.47	0.16	0.16	0.79
HRA	GLOUCESTERSHIRE 3	1.51	0.20	1.13	1.91	1.51	0.21	1.11	1.92	1.40	0.22	0.97	1.83	1.13	0.22	0.71	1.56
HRA	GLOUCESTERSHIRE 4	1.09	0.54	-0.02	2.12	0.87	0.61	-0.37	2.04	0.76	0.69	-0.67	2.04	1.04	0.63	-0.20	2.23
HRA	GLOUCESTERSHIRE 5	-0.22	0.41	-1.01	0.57	-0.77	0.54	-1.93	0.19	-0.62	0.57	-1.85	0.42	-0.49	0.55	-1.65	0.49
HRA	HEREFORD & WORCESTER 1	0.79	0.51	-0.23	1.74	1.04	0.51	0.03	2.06	1.19	0.47	0.25	2.08	0.64	0.56	-0.52	1.70
HRA	HEREFORD & WORCESTER 2	1.29	0.72	-0.19	2.63	1.47	0.75	-0.10	2.91	2.03	0.73	0.62	3.49	1.68	0.76	0.16	3.13
HRA	HEREFORD & WORCESTER 3									0.71	1.06	-1.38	2.80	1.04	0.70	-0.39	2.42
HRA	SHROPSHIRE 1	0.87	0.15	0.59	1.18	0.91	0.15	0.61	1.21	1.04	0.16	0.73	1.38	0.86	0.15	0.56	1.17
HRA	SHROPSHIRE 2	0.88	0.19	0.51	1.27	0.93	0.19	0.57	1.30	0.86	0.19	0.49	1.21	0.87	0.17	0.54	1.21
HRA	SHROPSHIRE 3	0.83	0.15	0.55	1.13	0.65	0.16	0.33	0.97	0.63	0.18	0.27	0.99	0.32	0.18	-0.03	0.68

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
HRA	SOMERSET 1	-0.42	1.03	-2.43	1.53												
HRA	SOMERSET 2	-0.09	1.08	-2.26	2.08												
HRA	SOMERSET 3	-1.25	0.81	-2.92	0.19	-1.36	0.88	-3.27	0.19	-1.32	0.91	-3.24	0.27	-1.43	0.86	-3.33	0.08
HRA	SOMERSET 5	1.72	0.66	0.47	3.08	2.19	0.76	0.75	3.78	1.89	0.70	0.51	3.32	0.74	1.03	-1.41	2.67
HRA	SOMERSET 6	1.02	0.43	0.14	1.81	0.98	0.47	0.03	1.87	1.81	0.41	0.98	2.61	1.49	0.42	0.67	2.27
HRA	SOMERSET 7	-0.12	1.08	-2.29	1.95	-0.28	1.18	-2.70	1.93	-0.26	1.22	-2.76	2.06	-0.02	1.22	-2.46	2.40
HRA	SOMERSET 8	1.40	0.19	1.04	1.78	1.32	0.19	0.93	1.70	1.29	0.20	0.92	1.70	1.02	0.20	0.63	1.41
HRA	SOMERSET 9	1.38	0.15	1.10	1.68	1.58	0.15	1.29	1.87	1.69	0.16	1.37	2.01	1.53	0.15	1.25	1.84
HRA	STAFFORDSHIRE 1	-0.35	1.01	-2.48	1.49	-0.55	1.04	-2.67	1.30	-0.51	1.08	-2.76	1.43	-0.32	1.10	-2.55	1.78
HRA	STAFFORDSHIRE 11	-0.22	1.08	-2.42	1.85	-0.31	1.19	-2.72	1.97	-0.13	1.25	-2.52	2.33	-0.09	1.23	-2.58	2.29
HRA	STAFFORDSHIRE 12	1.16	0.20	0.79	1.56	1.17	0.21	0.77	1.58	1.42	0.21	1.01	1.84	1.58	0.20	1.21	1.97
HRA	STAFFORDSHIRE 13	1.48	0.24	1.00	1.95	1.58	0.25	1.09	2.07	1.63	0.26	1.11	2.12	1.64	0.27	1.11	2.17
HRA	STAFFORDSHIRE 14	0.04	0.84	-1.69	1.60	-0.10	1.23	-2.60	2.21								
HRA	STAFFORDSHIRE 15	0.95	0.75	-0.51	2.43	1.43	0.90	-0.35	3.18	0.50	0.98	-1.46	2.37	-0.33	1.13	-2.69	1.74
HRA	STAFFORDSHIRE 16	1.69	0.62	0.51	2.89	1.88	0.55	0.84	2.98	1.96	0.53	0.95	3.00	1.58	0.55	0.48	2.66
HRA	STAFFORDSHIRE 17													0.94	1.03	-1.13	2.95
HRA	STAFFORDSHIRE 18									-0.76	1.04	-2.97	1.11	-0.92	0.94	-2.98	0.73
HRA	STAFFORDSHIRE 2	-0.04	1.11	-2.27	2.07	0.45	0.97	-1.54	2.31	0.49	0.96	-1.46	2.29	0.31	0.94	-1.64	2.12
HRA	STAFFORDSHIRE 3	-0.17	1.11	-2.37	1.95												
HRA	STAFFORDSHIRE 4	-0.40	1.07	-2.62	1.58	-0.35	1.10	-2.65	1.70	-0.27	1.14	-2.59	1.85	-0.27	1.10	-2.49	1.86
HRA	STAFFORDSHIRE 5	1.30	0.25	0.81	1.80	1.40	0.25	0.93	1.90	1.27	0.28	0.71	1.81	0.79	0.33	0.12	1.43
HRA	STAFFORDSHIRE 6	-0.33	0.42	-1.19	0.47	-0.28	0.51	-1.38	0.62	0.43	0.42	-0.42	1.21	0.47	0.41	-0.38	1.25
HRA	STAFFORDSHIRE 7	0.88	0.99	-1.08	2.70	-0.22	1.20	-2.62	2.09								
HRA	STAFFORDSHIRE 8	-0.30	1.04	-2.42	1.63	0.93	1.10	-1.32	2.97	0.60	1.01	-1.45	2.53	1.44	0.89	-0.34	3.11
HRA	WEST MIDLANDS 1	-0.46	0.97	-2.55	1.32	-0.34	1.13	-2.66	1.75	-0.61	1.08	-2.88	1.38	-0.60	1.05	-2.74	1.38
HRA	WEST MIDLANDS 2	-0.39	1.05	-2.61	1.56	-0.64	1.02	-2.72	1.24	-0.53	1.08	-2.80	1.47	-0.42	1.06	-2.68	1.48
HRA	WILTSHIRE 1	0.07	0.27	-0.47	0.59	-0.09	0.31	-0.73	0.49	-0.37	0.34	-1.07	0.26	-0.06	0.31	-0.68	0.53
HRA	WILTSHIRE 2	0.49	0.42	-0.36	1.29	0.07	0.50	-0.97	1.01	-0.34	0.58	-1.53	0.70	-0.16	0.53	-1.28	0.79
HTBE	POWYS 1	-0.12	1.09	-2.31	2.01	-0.18	1.20	-2.71	2.06	-0.04	1.24	-2.59	2.33	-0.26	1.14	-2.54	1.89

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
HTBE	POWYS 2	0.46	0.24	-0.02	0.94	0.58	0.25	0.08	1.07	0.33	0.29	-0.26	0.88	0.09	0.31	-0.55	0.68
HTBW	DYFED 2	0.39	0.25	-0.09	0.89	0.62	0.34	-0.02	1.24	0.30	0.55	-0.87	1.32				
HTBW	PEMBROKESHIRE 1													-0.56	1.02	-2.78	1.30
HTBW	WEST GLAMORGAN 1	0.72	0.98	-1.19	2.57	1.05	1.05	-1.04	3.06	-0.25	1.18	-2.59	1.97	0.98	1.02	-1.06	2.93
HTBW	WEST GLAMORGAN 2	-0.71	0.92	-2.56	1.01												
ITBM	DYFED 1	0.49	0.91	-1.41	2.19	1.30	0.84	-0.40	2.89	1.24	0.85	-0.44	2.82	0.61	0.93	-1.31	2.22
ITBM	DYFED 3	0.35	0.21	-0.07	0.76	0.34	0.20	-0.07	0.74	0.41	0.22	-0.02	0.85	0.55	0.20	0.16	0.95
ITBM	MID GLAMORGAN 1	0.78	0.51	-0.26	1.75	0.67	0.55	-0.52	1.70	0.38	0.61	-0.98	1.48	0.95	0.51	-0.08	1.89
ITBM	MID GLAMORGAN 2	0.67	0.16	0.38	0.99	0.79	0.16	0.47	1.11	0.88	0.17	0.54	1.21	0.77	0.16	0.46	1.08
ITBM	MID GLAMORGAN 3	-0.15	1.07	-2.27	1.93	-0.12	1.21	-2.58	2.21	-0.12	1.26	-2.56	2.29	-0.09	1.19	-2.54	2.31
ITBM	NORTH POWYS 1									1.44	1.21	-0.94	3.89	1.29	1.19	-1.04	3.68
ITBN	CLWYD 1	0.27	0.90	-1.59	1.95	0.27	0.89	-1.60	1.85	0.24	0.91	-1.66	1.92	0.31	0.89	-1.53	1.91
ITBN	CLWYD 2	-0.81	0.89	-2.72	0.80	0.09	0.86	-1.69	1.66	-0.13	0.83	-1.91	1.36	-0.02	0.83	-1.79	1.44
ITBN	CLWYD 4	-0.35	1.04	-2.42	1.61	-0.48	1.11	-2.78	1.53	-0.28	1.18	-2.69	1.95	-0.20	1.18	-2.58	2.05
ITBN	CLWYD 5	1.40	0.70	-0.08	2.74	0.71	0.74	-0.83	2.04	0.70	0.77	-0.93	2.07	-0.01	0.82	-1.76	1.44
LRA	BEDFORDSHIRE 1	-0.51	0.21	-0.92	-0.11	-0.52	0.22	-0.95	-0.08	-0.27	0.22	-0.71	0.16	-0.27	0.21	-0.67	0.13
LRA	BEDFORDSHIRE 2	-0.58	0.94	-2.54	1.11	-0.79	1.03	-2.95	1.05	-0.51	1.12	-2.89	1.51	-0.55	1.04	-2.66	1.39
LRA	CAMBRIDGESHIRE 1	-0.02	1.13	-2.29	2.19	-0.22	1.21	-2.74	2.04	-0.11	1.27	-2.66	2.30	-0.09	1.18	-2.44	2.09
LRA	CAMBRIDGESHIRE 2	-0.04	1.16	-2.32	2.27	-0.07	1.30	-2.62	2.56	-0.05	1.28	-2.58	2.48	-0.01	1.26	-2.59	2.40
LRA	CAMBRIDGESHIRE 3	0.02	1.18	-2.27	2.39	0.01	1.30	-2.63	2.75	-0.03	1.32	-2.55	2.56	-0.20	1.15	-2.50	1.98
LRA	CLEVELAND 1	-0.76	0.71	-2.26	0.50	-0.75	0.76	-2.39	0.60	-1.16	0.93	-3.22	0.45	-0.90	0.94	-2.93	0.71
LRA	CUMBRIA 1	-0.46	0.97	-2.54	1.28	1.18	0.62	-0.13	2.33	1.11	0.63	-0.21	2.24	0.84	0.61	-0.45	1.95
LRA	CUMBRIA 2	-0.99	0.67	-2.45	0.18	0.36	0.54	-0.80	1.35	0.93	0.50	-0.09	1.85	1.13	0.47	0.16	2.02
LRA	CUMBRIA 3	1.21	0.83	-0.51	2.71	0.90	1.00	-1.24	2.68	-0.27	1.19	-2.69	1.96	-0.25	1.16	-2.60	1.96
LRA	CUMBRIA 4	0.01	1.16	-2.33	2.25	-0.07	1.24	-2.57	2.36	-0.05	1.25	-2.53	2.39	-0.05	1.23	-2.54	2.27
LRA	CUMBRIA 6	-0.99	0.49	-1.99	-0.05	-1.57	0.66	-2.99	-0.40	-1.32	0.69	-2.84	-0.14	-1.38	0.68	-2.86	-0.20
LRA	DURHAM 1	-0.05	1.10	-2.28	2.07	-0.09	1.25	-2.55	2.38	-0.05	1.27	-2.58	2.30	-0.07	1.22	-2.52	2.29
LRA	DURHAM 2	-0.69	0.94	-2.69	0.97	-0.94	0.96	-2.99	0.78	-0.73	1.01	-2.88	1.00	-0.78	0.97	-2.88	0.96
LRA	DURHAM 3	-1.64	0.79	-3.34	-0.27	-1.85	0.85	-3.67	-0.41	-1.75	0.85	-3.55	-0.29	-1.78	0.85	-3.58	-0.33

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
LRA	DURHAM 4	-0.03	1.18	-2.42	2.35	-0.02	1.27	-2.54	2.50	-0.06	1.30	-2.69	2.42	0.02	1.23	-2.36	2.45
LRA	DURHAM 5	0.98	0.77	-0.61	2.37	1.74	0.63	0.46	2.93	1.81	0.65	0.44	2.98	0.88	0.77	-0.72	2.29
LRA	ESSEX 1	-0.74	0.93	-2.70	0.93	-1.02	0.97	-3.09	0.67	-0.89	0.99	-3.07	0.80	-0.86	0.99	-3.05	0.86
LRA	ESSEX 2	-0.61	0.95	-2.58	1.15	-0.73	1.03	-2.89	1.17	-0.61	1.09	-2.88	1.34	-0.48	1.04	-2.57	1.48
LRA	ESSEX 3	-0.01	1.13	-2.19	2.19	-0.09	1.25	-2.52	2.29	-0.05	1.26	-2.57	2.40	-0.06	1.22	-2.58	2.21
LRA	GREATER LONDON 1	-0.40	1.02	-2.53	1.52	-0.51	1.08	-2.75	1.46	-0.86	1.04	-3.10	0.98	-0.43	1.06	-2.75	1.54
LRA	GREATER MANCHESTER 1	-0.82	0.72	-2.36	0.45	-0.97	0.72	-2.55	0.28	-1.41	0.90	-3.42	0.15	-0.99	0.72	-2.54	0.29
LRA	GREATER MANCHESTER 2	-0.22	1.04	-2.32	1.73	-0.47	1.06	-2.70	1.41	-0.65	1.04	-2.80	1.23	-0.60	1.06	-2.88	1.24
LRA	GREATER MANCHESTER 4	-0.55	0.95	-2.52	1.17	-0.51	1.10	-2.74	1.49	-0.34	1.14	-2.72	1.81	-0.19	1.15	-2.51	2.04
LRA	GREATER MANCHESTER 5	-1.96	0.71	-3.51	-0.74	-1.81	0.84	-3.57	-0.34	-1.77	0.82	-3.55	-0.32	-1.63	0.83	-3.41	-0.16
LRA	GREATER MANCHESTER 6	0.71	0.97	-1.34	2.52	0.29	0.93	-1.62	2.01	0.32	0.95	-1.61	2.15	0.33	0.95	-1.60	2.12
LRA	GREATER MANCHESTER 7	0.59	1.02	-1.43	2.58	0.73	1.08	-1.46	2.86	0.83	1.12	-1.40	3.06	0.77	1.10	-1.33	3.01
LRA	HUMBERSIDE 1	-0.84	0.47	-1.83	-0.01	-1.04	0.53	-2.18	-0.05	-1.27	0.71	-2.78	-0.02	-1.16	0.67	-2.59	0.01
LRA	HUMBERSIDE 2	-0.01	1.17	-2.32	2.32	-0.06	1.25	-2.52	2.38	-0.05	1.24	-2.51	2.35	-0.07	1.20	-2.47	2.25
LRA	HUMBERSIDE 4	-0.08	1.14	-2.33	2.12	-0.04	1.29	-2.60	2.47	0.03	1.28	-2.49	2.54	-0.02	1.23	-2.46	2.39
LRA	KENT 1	-0.08	1.16	-2.32	2.17	-0.30	1.13	-2.67	1.78	-0.33	1.13	-2.64	1.80	-0.39	1.08	-2.71	1.55
LRA	KENT 2	-1.31	0.82	-3.08	0.17	-1.24	0.94	-3.31	0.43	-0.31	1.18	-2.68	1.89				
LRA	KENT 3	-0.01	1.19	-2.33	2.30	-0.03	1.23	-2.44	2.37	-0.02	1.31	-2.61	2.59	-0.02	1.27	-2.51	2.47
LRA	KENT 4	-0.14	1.08	-2.33	1.96	-0.26	1.18	-2.52	1.94	-0.30	1.20	-2.77	2.07	-0.12	1.14	-2.39	2.17
LRA	KENT 5	-0.18	1.08	-2.30	1.82	-0.25	1.15	-2.60	1.89	-0.13	1.20	-2.56	2.19	-0.08	1.25	-2.60	2.37
LRA	LANCASHIRE 1	0.14	0.28	-0.45	0.67	-0.01	0.30	-0.61	0.58	-0.22	0.49	-1.28	0.66				
LRA	LANCASHIRE 2	-0.05	1.18	-2.38	2.27	-0.13	1.24	-2.57	2.19	-0.92	0.96	-2.92	0.86	-0.48	0.79	-2.18	0.91
LRA	LANCASHIRE 3	-1.49	0.34	-2.17	-0.86	-1.18	0.31	-1.81	-0.60	-1.02	0.30	-1.64	-0.45	-1.09	0.31	-1.73	-0.51
LRA	LANCASHIRE 4	-0.12	1.13	-2.38	1.99	-0.44	1.13	-2.74	1.58	-0.29	1.20	-2.68	1.96				
LRA	LANCASHIRE 5	0.03	0.84	-1.71	1.59	-0.69	1.03	-2.85	1.13	-0.54	1.11	-2.83	1.46	-0.67	0.99	-2.74	1.15
LRA	LANCASHIRE 6	-0.84	0.29	-1.43	-0.27	-0.57	0.28	-1.14	-0.03	-0.35	0.28	-0.93	0.18	-0.65	0.31	-1.27	-0.09
LRA	LANCASHIRE 7	-0.30	0.18	-0.63	0.06	0.07	0.17	-0.27	0.40	0.13	0.18	-0.23	0.49	0.22	0.17	-0.12	0.56
LRA	LANCASHIRE 8	-0.64	0.60	-1.89	0.43	-0.90	0.62	-2.23	0.22	-0.73	0.63	-2.10	0.40	-0.57	0.64	-1.94	0.54

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
LRA	LINCOLNSHIRE 1	-0.12	1.10	-2.37	1.96	-0.02	1.23	-2.50	2.34	0.00	1.27	-2.42	2.55				
LRA	LINCOLNSHIRE 3	0.04	0.18	-0.31	0.41	0.12	0.19	-0.26	0.49	0.23	0.20	-0.15	0.61	0.17	0.19	-0.21	0.55
LRA	LINCOLNSHIRE 4	-0.88	0.89	-2.76	0.74	-0.95	0.98	-3.00	0.82	-0.64	1.09	-2.93	1.33	-0.57	1.04	-2.72	1.36
LRA	LINCOLNSHIRE 5	-1.01	0.85	-2.82	0.49	-1.09	0.95	-3.07	0.54	-1.05	0.97	-3.18	0.58	-0.88	0.94	-2.89	0.77
LRA	LINCOLNSHIRE 6	-0.04	1.09	-2.25	2.04	-0.22	1.20	-2.61	2.09	-0.15	1.22	-2.63	2.15	-0.19	1.16	-2.58	2.03
LRA	LINCOLNSHIRE 7	-0.47	1.00	-2.55	1.36	-0.43	1.11	-2.70	1.56	-0.26	1.21	-2.72	1.97	-0.23	1.10	-2.59	1.83
LRA	LINCOLNSHIRE 8	-1.47	0.30	-2.10	-0.91	-1.31	0.30	-1.91	-0.75	-1.61	0.33	-2.29	-0.97	-2.08	0.41	-2.92	-1.32
LRA	MERSEYSIDE 1	0.02	1.13	-2.26	2.30	-0.20	1.21	-2.63	2.10	-0.20	1.23	-2.70	2.14				
LRA	MERSEYSIDE 2	-0.17	1.08	-2.37	1.94	-0.21	1.21	-2.60	2.11	-0.15	1.25	-2.66	2.30	-0.02	1.24	-2.53	2.34
LRA	NORFOLK 1	-1.09	0.85	-2.89	0.43	-1.21	0.91	-3.20	0.37	-1.04	0.97	-3.10	0.66	-1.21	0.92	-3.15	0.41
LRA	NORFOLK 3	-0.46	1.00	-2.54	1.47	-0.58	1.08	-2.88	1.39	-0.36	1.13	-2.68	1.73	-0.20	1.13	-2.43	1.98
LRA	NORFOLK 4	-0.01	1.18	-2.37	2.28	-0.12	1.24	-2.54	2.34	-0.03	1.25	-2.53	2.38	-0.12	1.22	-2.54	2.16
LRA	NORFOLK 5	-0.12	1.13	-2.42	2.04	-0.08	1.26	-2.54	2.41	0.01	1.32	-2.61	2.44	-0.02	1.25	-2.48	2.49
LRA	NORFOLK 6	-0.29	1.06	-2.42	1.74	-0.12	1.28	-2.68	2.44	-0.04	1.30	-2.70	2.46				
LRA	NORTH YORKSHIRE 1	-1.42	0.45	-2.38	-0.59	-2.05	0.63	-3.41	-0.94	-1.39	0.51	-2.48	-0.47	-1.44	0.51	-2.53	-0.53
LRA	NORTH YORKSHIRE 10	-0.28	1.05	-2.41	1.66	-0.22	1.15	-2.64	1.93	-0.10	1.24	-2.61	2.25	-0.05	1.23	-2.52	2.35
LRA	NORTH YORKSHIRE 11	-0.42	1.01	-2.43	1.51	-0.40	1.12	-2.67	1.65								
LRA	NORTH YORKSHIRE 12	-0.02	1.17	-2.32	2.25	-0.06	1.25	-2.60	2.28	-0.11	1.23	-2.47	2.32	-0.15	1.20	-2.54	2.19
LRA	NORTH YORKSHIRE 13	-0.14	1.09	-2.31	1.99	-0.07	1.25	-2.53	2.28	-0.12	1.25	-2.64	2.34	-0.04	1.19	-2.41	2.22
LRA	NORTH YORKSHIRE 2	-0.07	1.15	-2.42	2.18	-0.11	1.23	-2.65	2.18	-0.12	1.20	-2.49	2.19	-0.10	1.17	-2.41	2.16
LRA	NORTH YORKSHIRE 3	0.01	1.19	-2.24	2.42	-0.08	1.25	-2.62	2.36	0.02	1.32	-2.52	2.62	-0.05	1.24	-2.48	2.44
LRA	NORTH YORKSHIRE 5	1.14	0.29	0.56	1.69	0.62	0.32	0.00	1.22	0.69	0.33	0.02	1.31	0.80	0.34	0.13	1.44
LRA	NORTH YORKSHIRE 6	-0.19	1.08	-2.33	1.89	-0.27	1.19	-2.73	1.94	-0.16	1.23	-2.66	2.17	-0.17	1.17	-2.55	2.02
LRA	NORTH YORKSHIRE 7	-0.26	1.04	-2.34	1.73	-0.39	1.12	-2.67	1.62	-0.33	1.17	-2.78	1.81	-0.43	1.07	-2.72	1.52
LRA	NORTH YORKSHIRE 9	-0.05	1.16	-2.30	2.27	-0.05	1.31	-2.66	2.38								
LRA	SOUTH YORKSHIRE 14	-1.41	0.65	-2.79	-0.25	-1.67	0.66	-3.12	-0.52	-1.65	0.68	-3.14	-0.48	-1.60	0.68	-3.08	-0.38
LRA	SOUTH YORKSHIRE 15	-0.03	1.17	-2.36	2.26	-0.04	1.30	-2.62	2.43	-0.03	1.30	-2.60	2.48	-0.03	1.24	-2.54	2.33
LRA	SOUTH YORKSHIRE 16	-0.96	0.25	-1.44	-0.47	-0.97	0.26	-1.50	-0.47	-0.83	0.26	-1.38	-0.34	-1.28	0.28	-1.85	-0.75

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
LRA	SOUTH YORKSHIRE 17	-0.02	1.15	-2.26	2.30	-0.02	1.23	-2.39	2.36	-0.09	1.27	-2.64	2.40	-0.03	1.25	-2.48	2.36
LRA	SUFFOLK 2	-0.57	0.96	-2.56	1.22	-0.55	1.06	-2.81	1.30	-0.54	1.09	-2.86	1.44	-0.54	1.07	-2.76	1.40
LRA	SURREY 1	-0.29	0.26	-0.80	0.22	-0.14	0.25	-0.64	0.32	-0.27	0.27	-0.81	0.28	0.38	0.21	-0.05	0.80
LRA	TYNE & WEAR 1	-0.80	0.60	-2.03	0.25	-0.88	0.60	-2.15	0.19	-0.73	0.61	-2.03	0.36	-1.00	0.59	-2.29	0.06
LRA	WEST SUSSEX 1	-0.17	1.09	-2.40	1.93	-0.50	1.15	-2.87	1.60	-0.46	1.13	-2.83	1.61	-0.52	1.07	-2.73	1.42
LRA	WEST YORKSHIRE 1	-0.58	0.54	-1.72	0.42	-1.10	0.61	-2.38	0.00	-0.87	0.62	-2.18	0.23	-0.54	0.62	-1.83	0.58
LRA	WEST YORKSHIRE 2	0.04	0.54	-1.07	1.02	0.43	1.00	-1.60	2.33								
LRA	WEST YORKSHIRE 3	-0.02	1.14	-2.31	2.18	-0.16	1.20	-2.54	2.12	-0.28	1.22	-2.73	2.01	-0.06	1.18	-2.45	2.26
LRA	WEST YORKSHIRE 4	-1.05	0.88	-2.88	0.54	-0.77	0.74	-2.32	0.58	-0.81	0.76	-2.46	0.51	-0.07	0.66	-1.50	1.12
LRA	WEST YORKSHIRE 5	-0.09	1.12	-2.30	2.05	-0.16	1.21	-2.67	2.11	-0.17	1.28	-2.84	2.22	-0.11	1.19	-2.51	2.18
LRA	WEST YORKSHIRE 6	-0.89	0.91	-2.82	0.74	-0.78	1.01	-2.90	1.07	-0.94	1.01	-3.08	0.85	-0.90	0.95	-2.91	0.78
LRA	WEST YORKSHIRE 7	0.70	0.98	-1.30	2.51	-0.48	1.08	-2.69	1.51	-0.47	1.13	-2.86	1.58	-0.60	0.99	-2.68	1.17
LTB	CLWYD 3	0.32	0.88	-1.51	1.95	0.70	0.96	-1.30	2.43	0.56	0.98	-1.45	2.41	0.82	1.01	-1.24	2.75
LTB	GWYNEDD 1	-0.59	0.98	-2.62	1.22	-0.37	1.15	-2.74	1.83	-0.70	1.08	-3.06	1.26	-0.54	1.04	-2.74	1.40
LTB	GWYNEDD 3	-0.29	0.74	-1.87	1.03	-0.35	0.78	-2.05	0.99	-1.06	0.94	-3.05	0.64	-0.90	0.96	-2.94	0.79
Scotland	ABERDEENSHIRE 1	-0.54	0.74	-2.13	0.78	-1.37	0.90	-3.31	0.21	-1.38	0.90	-3.35	0.22	-1.35	0.85	-3.18	0.20
Scotland	ABERDEENSHIRE 3	-0.30	0.51	-1.34	0.67	-0.62	0.56	-1.82	0.38	-0.69	0.65	-2.08	0.48	-1.19	0.70	-2.69	0.01
Scotland	ARGYLL 1	0.00	1.21	-2.39	2.39	-0.06	1.21	-2.39	2.36	-0.05	1.28	-2.60	2.46	-0.05	1.21	-2.41	2.36
Scotland	AYRSHIRE 1	-1.30	0.81	-3.02	0.12	-1.65	0.86	-3.52	-0.15	-1.61	0.85	-3.44	-0.13	-1.04	0.72	-2.61	0.18
Scotland	AYRSHIRE 2	-0.98	0.58	-2.18	0.08	-1.06	0.61	-2.37	0.02	-0.46	0.52	-1.54	0.50	0.07	0.42	-0.77	0.87
Scotland	DUMFRIESHIRE 1	-0.20	1.07	-2.44	1.81	-0.30	1.15	-2.67	1.87	-0.33	1.17	-2.74	1.81	-0.32	1.13	-2.71	1.72
Scotland	FIFE 1	-0.07	1.17	-2.33	2.25												
Scotland	KINCARDINE 1	-1.23	0.82	-2.93	0.32	-1.71	0.85	-3.60	-0.22	-1.72	0.84	-3.56	-0.25	-1.72	0.79	-3.41	-0.32
Scotland	LANARKSHIRE 1	-0.38	1.04	-2.53	1.57	-0.51	1.08	-2.80	1.45	-0.55	1.11	-2.82	1.42	-0.47	1.05	-2.71	1.42
Scotland	LANARKSHIRE 2	-0.50	1.01	-2.57	1.36	-0.80	1.02	-2.93	0.97	-0.73	1.06	-3.03	1.11	1.45	0.59	0.25	2.49
Scotland	MORAY 1	-0.44	1.01	-2.40	1.45	-0.81	0.97	-2.84	0.93	-0.80	1.05	-3.03	1.05	-0.78	0.94	-2.71	0.91
Scotland	MORAY 2	-1.31	0.84	-3.06	0.17	-1.34	0.89	-3.22	0.24	-1.51	0.90	-3.51	0.08	-1.40	0.88	-3.30	0.11
Scotland	ORKNEY 1	0.02	1.15	-2.30	2.24	-0.13	1.20	-2.50	2.22	-0.14	1.25	-2.60	2.23	-0.09	1.18	-2.36	2.25
Scotland	PERTHSHIRE 1	-1.50	0.82	-3.29	-0.06	-1.86	0.83	-3.74	-0.40	-1.96	0.84	-3.76	-0.50	-1.92	0.80	-3.61	-0.50

Region	Slaughterhouse code	13-16 Mean	13-16 SD	13-16 LCI	13-16 UCI	14-17 Mean	14-17 SD	14-17 LCI	14-17 UCI	15-18 Mean	15-18 SD	15-18 LCI	15-18 UCI	16-19 Mean	16-19 SD	16-19 LCI	16-19 UCI
Scotland	PERTHSHIRE 2	-0.22	1.09	-2.37	1.84	-0.31	1.14	-2.61	1.78	-0.28	1.18	-2.76	1.87	-0.22	1.14	-2.58	1.90
Scotland	PERTHSHIRE 3	-1.49	0.49	-2.52	-0.60	-1.58	0.51	-2.73	-0.70	-1.85	0.55	-3.07	-0.89	-1.73	0.55	-2.89	-0.71
Scotland	RENFREW 1	-0.92	0.69	-2.39	0.32	-1.30	0.69	-2.75	-0.08	-1.26	0.67	-2.67	-0.07	-2.11	0.79	-3.87	-0.75
Scotland	ROSS & CROMARTY 1	-0.02	1.17	-2.31	2.26	-0.05	1.31	-2.59	2.52	0.00	1.32	-2.59	2.57	0.01	1.23	-2.41	2.34
Scotland	ROSS & CROMARTY 2	-0.23	1.06	-2.34	1.72	-0.42	1.09	-2.66	1.53	-0.54	1.10	-2.84	1.46	-0.47	1.01	-2.61	1.41
Scotland	SHETLAND 1	0.02	1.17	-2.24	2.32	-0.07	1.24	-2.54	2.30	-0.09	1.28	-2.61	2.37	-0.13	1.20	-2.45	2.18