Animal & Plant Health Agency

Asiantaeth Iechyd Anifeiliaid a Phlanhigion

# Epidemiology of bovine tuberculosis in Wales

## Annual surveillance report

For the period

January to December 2018

***Commissioned by the Welsh Government under Project SB4500***

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# Summary

This report is presented in eight sections in which the cattle population and testing regime are summarised, and various measures of disease are used to describe the epidemiology of bovine TB in Wales in 2018. The following summary highlights the main findings described in each section and the data suggests that progress continues to be made in Wales to tackle bovine TB through the comprehensive TB eradication programme introduced in 2008.

### Welsh cattle population characteristics and TB tests applied to this population

Over the last five years, the number of herds in Wales has decreased by 1% to approximately 11,955 herds (Table 1.2). The largest decrease in this five year period was from 2014 to 2015 with a decrease of over 3%. This is likely to be an artefact attributable to a cleansing exercise that was undertaken on the British Cattle Movement Service (BCMS) data during 2014, which resulted in the closing of inactive herds, therefore the true change is likely to be less. Since then the total number of herds has increased to similar levels seen in 2014. In the same five year period, the number of cattle in herds has increased by nearly 3% to just over 1.1 million cattle in 2018. The number of tests has also increased, and comparing 2014 to 2018, has increased by 9% from 2.1 million tests to 2.3 million tests. All herds in Wales have been tested annually since October 2008, but since 2010 around 300 herds in the Intensive Action Area of Pembrokeshire have been tested twice annually.

### Bovine tuberculosis incidence and prevalence in Wales

There were 744 new TB incidents in 2018, of which 665 (89%) were classified as OTF-W incidents and 78 (10.5%) were classified as OTF-S incidents; there was one unclassified incident (see Appendix 2 for definitions).

The number of new TB incidents in Wales has declined overall since 2008. Overall, 6% of Welsh herds incurred a new TB incident (OTF-W or OTF-S) in 2018 and 6% of herds were under movement restrictions in mid-December 2018 due to any TB incident starting at any time before this date (excluding herds restricted due to overdue tests) (Table 2.1). By TB Area in Wales, more herds were under movement restrictions (mid-December 2018) in the High TB West and East compared to other TB Areas, where a greater number of new incidents were located.

There were 7.5 new TB incidents per 100 herd years at risk in 2018, compared to nearly eight in 2017. This is equivalent to detecting 75 new incidents for every 1,000 herds that had been unrestricted for one year (Figure 2.3b). Incidence rate also varied by TB Area, being highest in the High TB West (12.7 new TB incidents per 100 herd years at risk) compared to the lowest in the Low TB Area (1.4 new TB incidents per 100 herd years at risk).

Between 2001 and 2009 there was a nearly 5-fold increase in the number of new incidents per 100 unrestricted herds. Since then there have been periods of sharp decline, punctuated by short-term increases, giving an overall long-term downward trend (60% decline since 2008) (Figure 2.1).

The largest clusters of new incidents were found in the High TB West and High TB East along the Welsh/ English border (Figure 2.4). The animal-level frequency of reactors and inconclusive reactors in 2018 followed similar geographical patterns to herd incidence with frequency being highest in the High TB West and East Areas (Table 2.3). As expected, the number of reactors per 1,000 animal tests was lowest in the Low TB Area in the North of Wales (0.25 reactors per 1,000 animal tests), and highest in the High TB West Area (3.73; Figure S1).

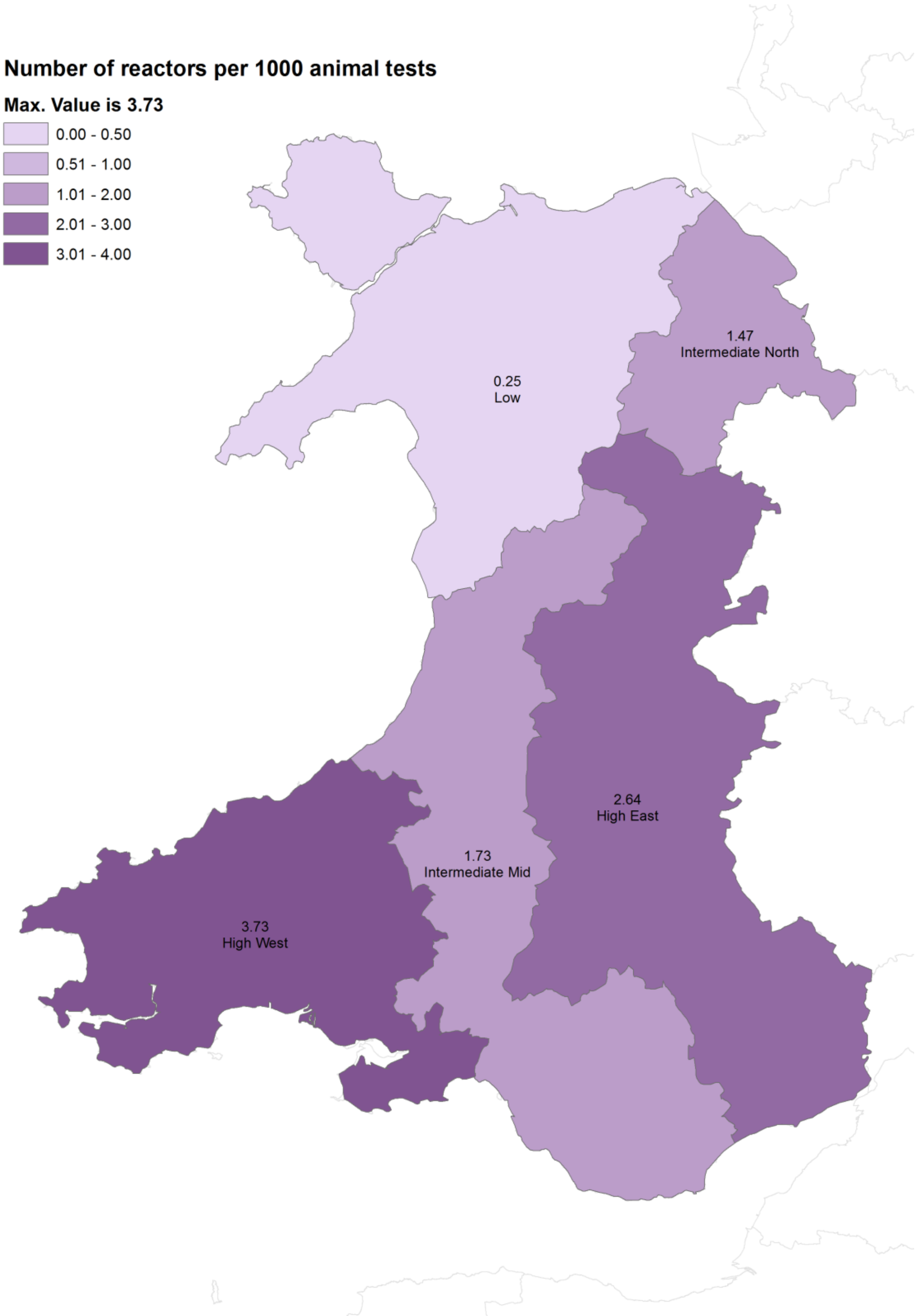



**Figure S1:** Reactors per 1,000 animal tests, 2018 (includes SICCT and gIFN tests)

The incidence of TB increased with herd size, with lower incidence rates observed in herds with fewer than 300 cattle relative to those with more than 300. This effect remains after adjusting for the effects of herd type and location. Similarly, the incidence rate remained significantly higher for dairy herds even after adjustment for herd size and location. Incidence of TB was significantly lower in the Intermediate and Low TB Areas compared to the High TB West, and the effect remained after adjusting for herd size and type (Table 2.4).

Trends in the number of new, closed and ongoing incidents in Wales are presented in Figure S2. The numbers of new incidents and closed incidents have decreased in the past five years (12% decrease in new incidents from 2014 to 2018 and 17% in closed incidents). However, there was an increase in new incidents in 2017 which subsequently dropped again in 2018. The number of ongoing incidents in Wales has doubled over the last five years, but is still much lower compared to the number of new or closed incidents (168 in 2018).

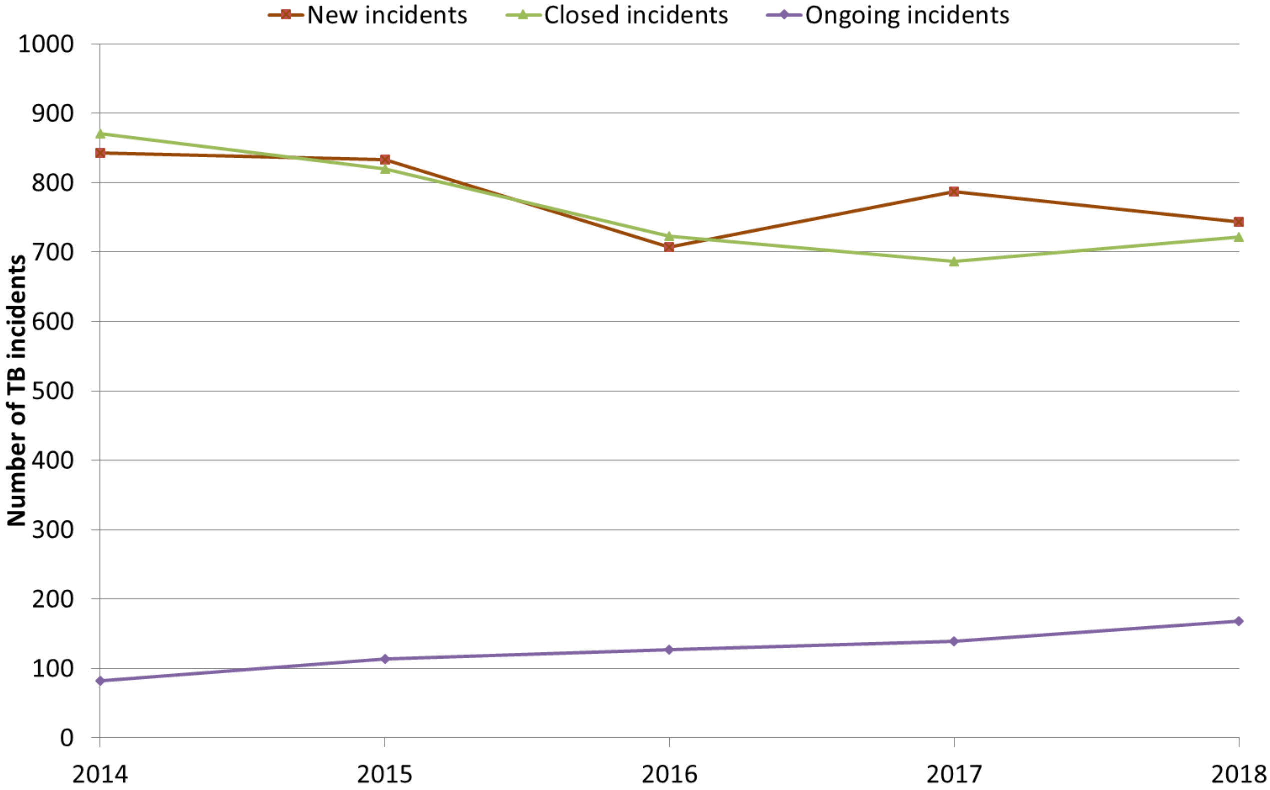



**Figure S2:** New, closed and ongoing TB incidents in Wales, 2014 – 2018

## Routine slaughterhouse surveillance

Of the 744 new TB incidents that started in 2018, 75 (10%) were disclosed in the slaughterhouse, all of which were OTF-W incidents. This equates to 11% of the 665 OTF-W incidents in 2018. Fifty-nine per cent of the samples submitted from slaughterhouses were *M. bovis* positive, similar to previous years in Wales and compared to 68% in GB (Table 3.1).

Where the disclosing test was slaughterhouse inspection, the median number of reactors taken at the first whole herd test was zero in the High East, Intermediate Mid and Low TB Areas, one in the Intermediate North and two in the High TB West (Table 3.4). For routine skin testing, the median number of reactors was one across all TB Areas and for risk-based skin testing, all TB Areas were one, apart from the High West TB Area, where the median was two.

When looking at the *total number of reactors taken in incidents that closed* in 2018, the median number of reactors taken (where the disclosing test was slaughterhouse inspection), was highest in the Low TB Area (median=6) and lowest in the Intermediate Mid TB Area (median=0; Table 3.4). Where the disclosing test was risk-based skin testing, the median was highest in the High TB West Area (median=5) and lowest in the Low TB Area median=1). For routine skin testing, the highest was the Intermediate North TB Area (median=2), and for all remaining TB Areas the median was one. Since 1990, the median number of reactors disclosed through skin testing has remained between one and three since 1990, and for slaughterhouse disclosure has been more variable, between zero and three since 1995 apart from a jump in 1996 and 1997 (median=5) (Figure 3.3).

There is more variation in the mean when looking at disclosure from both slaughterhouse and skin testing. Since 2004 the mean number of reactors identified per skin-test-disclosed incident has fluctuated between five and eight, although was higher in 2013, 2016 and 2017. For slaughterhouse-disclosed incidents the mean is more volatile, jumping between three and 12 since 1996. This is primarily due to the small number of slaughterhouse cases and the occasional high reactor number incident (Figure 3.4).

**Post mortem examination and culture of suspected TB cases**

In addition to the 75 slaughterhouse cases where retrospective evidence of TB was identified, a further 11,466 cattle were slaughtered in Wales in 2018 following detection of a new TB incident in their herd of origin. Of these, 68% were skin test or interferon-gamma reactors, 25% were inconclusive reactors (IR) and 7% were direct contacts (DC) (Figure 4.1).

In the High West, Intermediate North and Intermediate Mid TB Areas, the proportion with detected lesions (DLs) that were *M. bovis* positive was higher for reactors than for DCs and IRs; whereas the proportion was higher for DCs in the High East TB Area, and for IRs in the Low TB Area (Tables 4.1 a-e).

An increase in the number of animals that were slaughtered was observed since 1990 across all reasons for slaughter for TB control, reaching a peak of nearly 11,700 in 2009. The number reduced in subsequent years but has increased again since 2013, up to 11,466 in 2018 (Figure 4.2a).

The number of IRs slaughtered increased ten-fold between 2008 and 2009 and, following a decline between 2010 and 2014, has since increased and was highest in 2018 (2,815 IRs slaughtered). The increase between 2008 and 2009 can be explained by a change in policy, implemented in 2009, which reduced the number of times that an animal testing inconclusive could be re-tested from two to one. An IR that fails to give a negative result at this re-test is considered to be positive[1].

Since 2008, the overall number of reactors and DCs that were slaughtered for TB control reasons has been variable, increasing up to 2008 and 2009 with subsequent declines and then further increases in the last three years. The recent increase in reactors is primarily attributable to increases in gamma-testing (gIFN testing), which is more sensitive than the skin test. Gamma-testing is used to help clear infection in recurrent and persistent TB incidents and to prevent disease from becoming established in low incidence areas.

[1] Animals having two successive tests giving inconclusive reactor measurements are generally considered to be skin test reactors, but may be described as “IRs After 2 [or more] tests as IR” to distinguish them from other reactors in some parts of this report. IRs may be re-classified as reactors when interpreted severely.

There was a sharp apparent increase in the number of DCs slaughtered in 2016 and 2017, where the total nearly doubled compared to 2015. In 2018, the total decreased sharply, coinciding with a large increase in the number of IRs slaughtered in 2017 and 2018 (1,750 and 2,815 respectively). These changes primarily reflect an issue with how some IRs were recorded in the SAM database. During 2016, official veterinarians were directed to apply more sensitive testing procedures in certain circumstances, and this included removing IRs. Until April 2017, it was not possible to record these cases as IRs on SAM in such a way as to enable the intended removal and compensation processes to take place. Consequently, these animals were recorded as DCs.

Overall in 2018, lesions were detected in 12% of slaughtered animals, although this proportion varied depending on the method of disclosure: reactors (16%), IRs (2%) or DCs (4%) (Figure 4.1). This also varies according to whether the skin testing was standard (32%) or severe interpretation (7%), or if reactors were identified via gIFN testing (5%). There is also wider variation when comparing different TB Areas, with the highest proportion of standard and gIFN reactors with DLs in the High TB East Area (42% and 12% respectively), and in the Intermediate Mid TB Area for severe interpretation reactors (14%; Table 4.1).

Since 2002 there has been a gradual decline in the proportion that were *M. bovis* positive, although a slight increase was observed in 2014 (which coincided with an increase in the number of cattle slaughtered, and the number of reactors alongside an increase in gIFN testing, Figure 4.4).

**Duration of bovine TB incidents in Wales**

In each TB Area, all OTF-S incidents were closed within 240 days, compared to 40-57% of OTF-W incidents (Table 5.1). Incident duration was significantly longer in herds with over 300 animals and in dairy herds (Table 5.2).

In Wales overall, the median duration of OTF-W incidents has remained around 240 days since 2001 with a decrease of around 6% in 2018 compared to 2010. The overall decrease may be attributable to the change in definition of OTF-W and OTF-S incidents, where long-lasting OTF-S incidents were lost from the OTF-S cohort, yet these reclassified incidents were still shorter than existing OTF-W incidents, thus bringing down the median duration of OTF-W incidents (Figure 5.1a). OTF-W incidents of very long duration were more common in the High TB Areas (West and East) (Figure 5.2). The median duration of OTF-S incidents was 111 days in 2018 and has been declining slowly since 2003 (140 days).

**Recurrent incidents**

Of the 11,542 herds included in analyses, 82% had no incidents in either 2018 or the previous 36-months (Table 6.1).

The proportion of herds with a TB incident that had a history of TB was 3.5 times higher than the proportion with no TB history (Table 6.2). Herds with a history of TB, with herd sizes of 51-200 animals, beef herds and herds found in the High West and Intermediate Mid TB Areas were more likely to have a TB incident in 2018 compared to herds in these categories with no history of TB (Table 6.2).

Of the 265 recurrent incidents included in the analyses, the time elapsed between incidents ranged from 71 days to 36 months (median = 18 months). The median duration between incidents tended to be slightly longer where the 2018 incident type was OTF-S compared to OTF-W (Table 6.3).

### Inconclusive reactor herds that subsequently suffered an incident

Nineteen per cent of IR-only herds in Wales in 2018 were shown to be infected with TB at the first IR retest. More dairy herds which were clear at the IR retest went on to have a TB incident at a subsequent test, compared with beef herds (22% vs 14%) (Table 7.1).

There were 973 IR-only herds that had IR-retests in Wales in 2018, of which 158 (16%) had an OTF-W incident at the IR-retest and 28 (3%) had an OTF-S incident. The remaining 787 (81%) were clear at the IR-retest. Significantly more IR-only herds that were clear at a retest went on to have a TB incident compared with non-IR herds that tested clear at a routine whole herd test in the same period (19% vs. 5%, $p<0.001$ Fishers Exact test). The proportions observed in 2018 were similar to those observed in recent years.

The proportion of IR-only herds with a subsequent OTF-S incident has decreased considerably since 2009, to 3% in 2017 and 2018, related to the change in the way incidents were classified from 2011 (Figure 7.1). The proportion of IR-only herds that had a subsequent OTF-W incident at the IR retest was around 9% up to 2011 before increasing to 17% in 2013. This increase would be expected as more herds were classified as OTF-W from 2011 onwards. However despite this increase, the proportion itself has remained relatively stable since 2013, between 15% and 17%.

The characteristics of herds that are associated with high incidence of TB infection are also associated with increased likelihood of subsequent incidents following an IR-only test (Table 7.1). Demographic and geographical factors which are associated with higher rates of TB (Section 2) are also associated with higher levels of IR-only herds going on to have a subsequent incident.

Of the 2,940 IR-only animals that had an inconclusive reaction to the skin test, 78% tested clear at the first retest, and 1,183 (51%) of these remained clear during the follow up period. A further 523 were routinely slaughtered and screened negative in the slaughterhouse. Of the 1,183 animals that tested clear during the follow-up period, 41 (3%) went on to become a reactor within 3 months of that clear test and another 70 (6%) within 12 months (Figure 7.6).

### Genotypes identified in bovine and non-bovine species in Wales

There were 393 isolates with full genotypes originating from 363 separate bovine TB incidents in cattle in Wales commencing in 2018. The most common *M. bovis* genotypes (17:a, 9:b, 9:c and 22:a) make up nearly 90% of all Welsh incidents and have homeranges in Wales (Table 8.2, Figure S3).

Twenty five non-bovine isolates were genotyped in 2018. This included 18 badger samples, three deer (consisting of two incidents), one cat, one guanaco and two alpaca (one incident) samples.

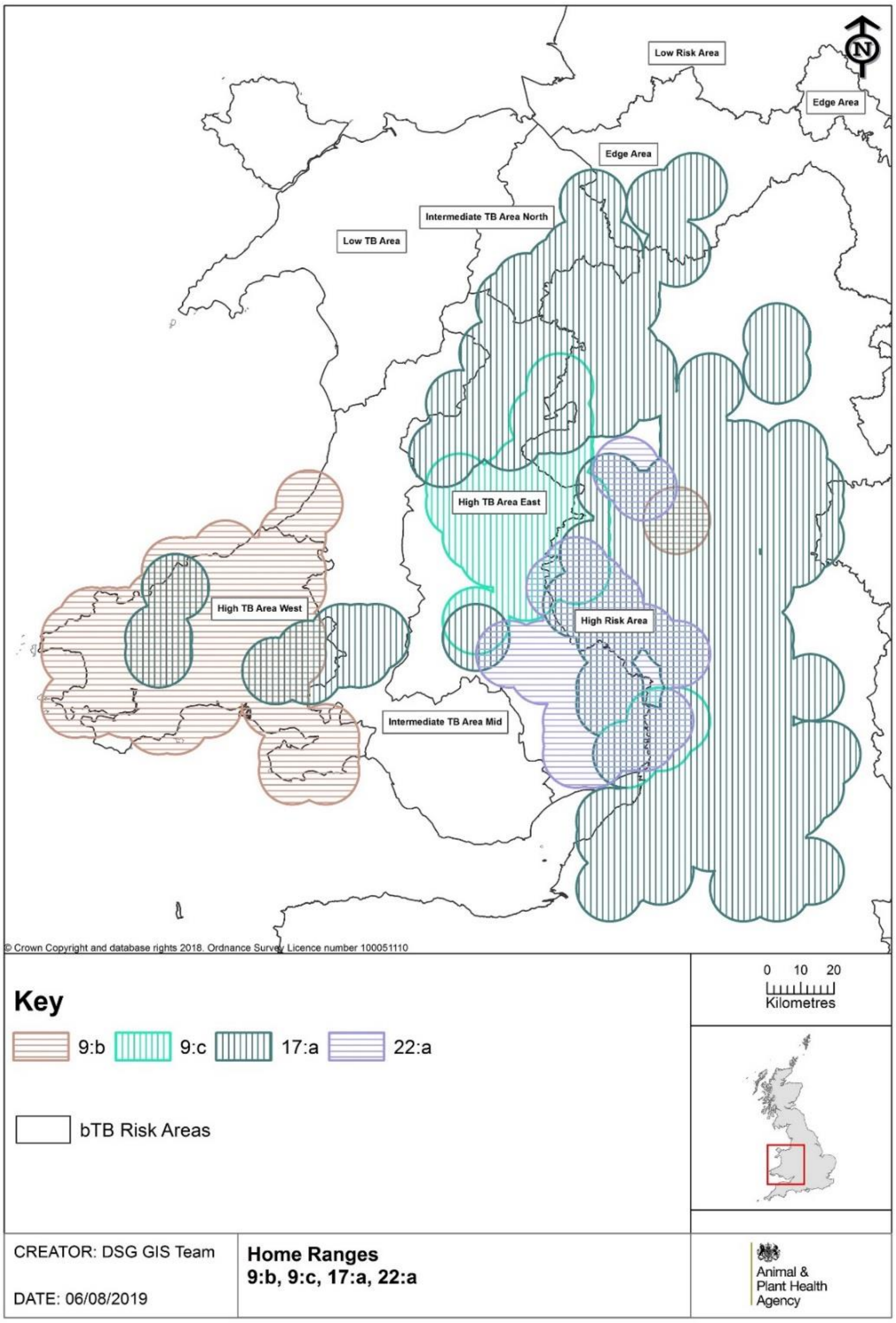



**Figure S3:** Homeranges for genotypes 9:b, 9:c, 17:a and 22:a using 2014-18 data

# Introduction

This report is the ninth iteration of a series of annual reports that commenced with the report for the period January to December 2010. The primary purpose of these reports is to provide important information about the bovine tuberculosis epidemic in Wales. This report focuses on the period January to December 2018 but, where it is useful to do so, the report includes historical data.

Like those before it, this report is designed to be a principal resource to those people directly involved in making policy decisions about the bovine tuberculosis eradication programme in Wales. The epidemiology of bovine tuberculosis is complex and in order to be fit for its primary purpose the report contains complex technical information that some may find inaccessible. Notwithstanding this it is published in the hope that others will find its content informative and useful. A summary is provided and much of the information contained here will form the basis for other publications aimed at different audiences.

It is inevitable and entirely appropriate that the format and content of the reports in this series will evolve over time. The challenge will be to do so while remaining true to the primary purpose and maintaining a consistent narrative of the bovine tuberculosis epidemic in Wales.

The considerable effort that colleagues in the APHA have put into producing this valuable and informative report is greatly appreciated.

Office of the Chief Veterinary Officer
Welsh Government
September 2019

# 1.0 Welsh cattle population characteristics and TB tests

**Key Points:**

- Herd density is greatest in the High TB West Area and in Anglesey in the Low TB Area.
- Although beef herds are more common, dairy herds make up a higher proportion of large (>300 animals) herds.
- The number of tests per animal is stable following an increase between 2014 and 2015.

This section describes population demographics of cattle in Wales. This includes factors which can affect TB infection risk such as herd type and size. A summary of the number of TB tests performed is provided. Skin testing is a key component of TB surveillance and includes both routine and predetermined interval testing. Additionally, enhanced testing occurs in response to specific risks, for example, herds that are contiguous to infected herds. Surveillance effort is related to the estimated risk of infection. It can be expressed as the number of tests in relation to the number of herds, animals or other subsets (e.g. herd types).

*1.1 Welsh cattle population characteristics*

The density of live cattle herds registered as active on SAM on 31st December 2018 in Wales and the bordering English counties is shown in Figure 1.1 (see Appendix 5 for description of areas).

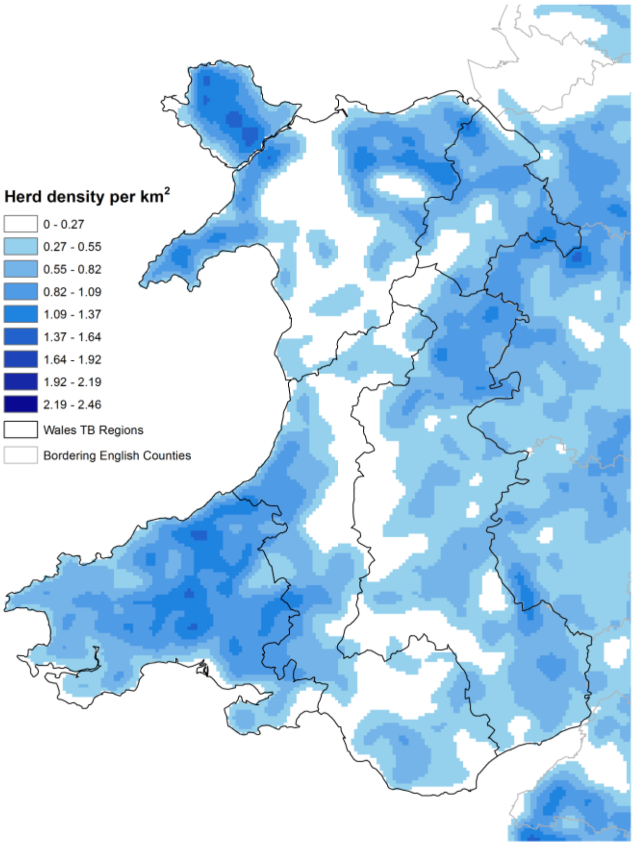



**Figure 1.1**: Density of cattle herds in Wales and English border counties, 2018

The geographical distribution remained consistent with previous years. The High West TB Area (comprising Pembrokeshire, West Carmarthenshire, South West Ceredigion and the Gower) had the largest number of herds (3,251; 27% of total). The High East TB Area (comprising North East, Mid and South Powys and Gwent) had a similar number of herds to the Low TB Area (2,862 and 2,841 respectively, both 24% of the total). Large areas of low herd density (<0.24 herds per km$^2$) exist across the central/western mountainous section of Wales; from mainland Gwynedd in the North to the Glamorgans in the South (Figure 1.1).

Beef herds formed the majority (77%) of cattle herds in Wales whilst dairy and mixed/ other herds accounted for 20% and 3%, respectively. Variation in these proportions exist between TB Areas with slightly higher proportions of dairy herds in the High TB West and Intermediate Mid Areas (33% and 28% respectively; Table 1.1a).

**Table 1.1a:** Herds in Wales (active on SAM) by herd type and geographical area, end-2018

| | Herds | Proportion of total herds in Wales (%) | Herd type [no. herds (%)] | | |
|---|---|---|---|---|---|
| | | | Beef | Dairy | Mixed / Other |
| **TB Area:** | | | | | |
| High East | 2,862 | 24 | 2,449 (86) | 324 (11) | 89 (3) |
| High West | 3,251 | 27 | 2,069 (64) | 1,082 (33) | 100 (3) |
| Intermediate Mid | 2,048 | 17 | 1,691 (83) | 290 (14) | 67 (3) |
| Intermediate North | 953 | 8 | 651 (68) | 264 (28) | 38 (4) |
| Low | 2,841 | 24 | 2,377 (84) | 342 (12) | 122 (4) |
| **Total** | **11,955** | **100 (%)** | **9,237 (77)** | **2,302 (20)** | **416 (3)** |

Approximately 71% of herds in Wales consisted of fewer than 100 cattle. Herds in the High West TB Area tended to be larger with 13% having a herd size greater than 300 cattle. Despite making up the majority of the total number of herds in Wales, beef herds are typically smaller than dairy cattle enterprises. Around 80% of beef herds had 100 animals or fewer compared with only 33% of dairy herds (Table 1.1b and c).

**Table 1.1b:** Herds in Wales (active on SAM) by size category, geographic location and herd type, end-2018

| | Herd size | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Undeter-mined[1] | 1-10 | 11-50 | 51-100 | 101-200 | 201-300 | >300 | Total |
| **TB Area** | | | | | | | | |
| High East | 17 | 490 | 959 | 682 | 427 | 147 | 140 | 2,862 |
| High West | 14 | 548 | 935 | 588 | 548 | 239 | 379 | 3,251 |
| Intermediate Mid | 6 | 471 | 764 | 397 | 259 | 88 | 63 | 2,048 |
| Intermediate North | 2 | 190 | 265 | 173 | 159 | 78 | 86 | 953 |
| Low | 19 | 546 | 1,022 | 514 | 413 | 164 | 163 | 2,841 |
| **Herd Type** | | | | | | | | |
| Beef | 14 | 1,925 | 3,537 | 1,966 | 1,242 | 327 | 226 | 9,237 |
| Dairy | 2 | 114 | 290 | 363 | 545 | 385 | 603 | 2,302 |
| Other | 42 | 206 | 118 | 25 | 19 | 4 | 2 | 416 |
| **Total** | **58** | **2,245** | **3,945** | **2,354** | **1,806** | **716** | **831** | **11,955** |
| **Proportion of total herds (%)** | **0.49** | **18.8** | **33.0** | **19.7** | **15.1** | **6.0** | **7.0** | |

[1] Undetermined herd sizes arise due to no testing taking place or no cattle showing on BCMS. They are mainly herds that do not have cattle shown on CTS or no link on the CPH, hence are not tested. Many of these are listed as 'temporary gatherings' on SAM and therefore not typical cattle farms.

**Table 1.1c:** Percentage of herds (active on SAM) by size category, geographic location and herd type, end-2018

| | Herd size [%] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Undeter-mined | 1-10 | 11-50 | 51-100 | 101-200 | 201-300 | >300 | Median herd size |
| **TB Area** | | | | | | | | |
| High East | 1 | 17 | 34 | 24 | 15 | 5 | 5 | 51 |
| High West | 0 | 17 | 29 | 18 | 17 | 7 | 12 | 63 |
| Intermediate Mid | 0 | 23 | 37 | 19 | 13 | 4 | 3 | 59 |
| Intermediate North | 0 | 20 | 28 | 18 | 17 | 8 | 9 | 39 |
| Low | 1 | 19 | 36 | 18 | 15 | 6 | 6 | 45 |
| **Herd Type** | | | | | | | | |
| Beef | 0 | 21 | 38 | 21 | 13 | 4 | 2 | 38 |
| Dairy | 0 | 5 | 13 | 16 | 24 | 17 | 26 | 186 |
| Other | 10 | 50 | 28 | 6 | 5 | 1 | 0 | 10 |
| **Total (%)** | **0** | **19** | **33** | **20** | **15** | **6** | **7** | |

The number of herds in 2018 was similar to the previous year (only a 0.2% decline, Table 1.2) and when looking over a period of five years, has decreased by only 0.9%. In the same period, total cattle increased by 2.8%. Much of the apparent change in herd numbers was concentrated in 2014-2015 and likely to be an artefact of a cleansing exercise performed on the British Cattle Movement Service (BCMS) data during 2014, which resulted in the closing of inactive herds. The total number of herds has since increased to similar levels seen in 2014, and could be as a result of policy changes, for example where TB Isolation units require a separate and unique CPH, thus lifting the number of herds.

**Table 1.2:** Herds (active on SAM), cattle and animal-level tests, 2014-2018

| Year | Total herds | % change in herds[1] | Total cattle[2] | % change in cattle[1] | Total tests (animal level)[3] | % change in tests[1] |
|---|---|---|---|---|---|---|
| 2014 | 12,067 | ↓ 4.8 | 1,102,768 | ↑ 0.7 | 2,146,122 | ↓ 1.5 |
| 2015 | 11,675 | ↓ 3.2 | 1,118,979 | ↑ 1.5 | 2,243,768 | ↑ 4.6 |
| 2016 | 11,651 | ↓ 0.2 | 1,134,341 | ↑ 1.4 | 2,267,229 | ↑ 1.0 |
| 2017 | 11,978 | ↑ 2.8 | 1,137,399 | ↑ 0.3 | 2,275,730 | ↑ 0.4 |
| 2018 | 11,955 | ↓ 0.2 | 1,134,137 | ↓ 0.3 | 2,343,960 | ↑ 3.0 |

1 Arrows indicate the direction of the percentage change: ↓ = reduction in number, ↑ = increase in number
2 Sourced from official Defra statistics
3 Tests for both surveillance and for disease control purposes are included. Numbers of routinely slaughtered cattle (derived from CTS) are included because every carcase undergoes inspection for macroscopic lesions that could indicate TB.

## *1.2 Bovine tuberculosis testing applied to the Welsh cattle population*

The total number of tests conducted on cattle in Wales increased by 3.0% (68,230 tests) between 2017 and 2018 (Table 1.2). In 2018, the total number of annual tests conducted on cattle in Wales included approximately 235,000 cattle that were slaughtered by the meat industry and underwent routine inspection for the presence of lesions indicative of *M. bovis* infection. The ratio of animal-level tests to the number of cattle has remained fairly static, 2:1 between 2014 and 2018 (Table 1.2). Since 2008, all herds in Wales have been tested annually. However, herds in the Intensive Action Area (IAA) of Pembrokeshire (approximately 300 herds) have been tested biannually since May 2010. This regime has continued since the refreshed TB eradication programme launched on 1 October 2017.

# 2.0 Bovine tuberculosis incidence and prevalence in Wales

**Key points**

- There was a 4% decrease in the number of new TB incidents per 100 herd years at risk between 2017 and 2018.
- Dairy herds had a substantially higher incidence rate than beef herds (15.9 vs. 4.8 per 100 years at risk). TB incidence also increases with herd size.
- Overall, prevalence of herds under restrictions has remained stable in Wales since 2014, at around 6% however this varies by TB Area.

In this section, the scale of TB infection in Welsh herds in 2018 is compared with previous years. The variation in TB incidence and prevalence between different geographical areas, herd sizes and herd types is described to facilitate the development of targeted surveillance strategies.

Three methods are used in this section to determine the incidence or prevalence of TB in Welsh cattle herds. These are described in detail in Appendix 1, and summarised here:

- **Incidence of TB** – this is expressed as the number of newly detected infected herds during 2018, per 100 active herds tested by whole herd test when not under movement restrictions and therefore at risk of having a new incident.
- **Incidence rate** – this is calculated by dividing the number of new incidents by the total amount of time the herds tested during the period in question were unrestricted and at risk of infection since the end of their last TB incident or negative herd test (described as 'herd-years at risk'). This is an established method for disease incidence estimation, and provides a more reliable time series as it accounts for changes in regional testing frequency over time.
- **Prevalence of TB** – this is calculated as the proportion of herds that are under movement restriction at a single point in time (mid-December), per 100 live herds.

### *2.1 Bovine tuberculosis incidence and prevalence in 2018*

Six per cent of Welsh herds incurred a new TB incident in 2018 and 5.7% of herds were under movement restrictions in mid-December 2018 (excluding herds under restriction due to an overdue test) (Table 2.1). There were 7.5 new TB incidents per 100 herd years at risk. This is equivalent to detecting 75 new incidents for every 1,000 herds that had been unrestricted for one year and is a 4% decrease compared to 2017 (7.8 per 100 herd years at risk). As expected, incidence rates were highest in the High TB Areas (East and West).

**Table 2.1:** Incidence and prevalence of TB in Wales, 2018

| TB Area | Total incidents | OTF-W | OTF-S | Denominator |
|---|---|---|---|---|
| **New TB incidents** | | | | |
| High East | 251 | 231 | 20 | NA |
| High West | 332 | 305 | 27 | NA |
| Intermediate Mid | 60 | 49 | 11 | NA |
| Intermediate North | 67 | 58 | 9 | NA |
| Low | 34 | 22 | 11 | NA |
| **New TB incidents per 100 live herds** | | | | |
| High East | 8.8 | 8.1 | 0.7 | 2,862 |
| High West | 10.2 | 9.4 | 0.8 | 3,251 |
| Intermediate Mid | 2.9 | 2.4 | 0.5 | 2,048 |
| Intermediate North | 7.0 | 6.1 | 0.9 | 953 |
| Low | 1.2 | 0.8 | 0.4 | 2,841 |
| **New TB incidents per 100 unrestricted herds tested** | | | | |
| High East | 9.9 | 9.1 | 0.8 | 2,530 |
| High West | 11.8 | 10.8 | 1.0 | 2,820 |
| Intermediate Mid | 3.3 | 2.7 | 0.6 | 1,844 |
| Intermediate North | 8.0 | 7.0 | 1.1 | 833 |
| Low | 1.4 | 0.9 | 0.4 | 2,449 |
| **New TB incidents per 100 herd years at risk** | | | | |
| High East | 10.8 | 10.0 | 0.9 | 2,316[1] |
| High West | 12.7 | 11.6 | 1.0 | 2,619[1] |
| Intermediate Mid | 3.4 | 2.7 | 0.6 | 1,789[1] |
| Intermediate North | 8.5 | 7.4 | 1.1 | 789[1] |
| Low | 1.4 | 0.9 | 0.5 | 2,415[1] |
| **Herds under restriction (mid-December )** | | | | |
| High East | 207 | 203 | 4 | NA |
| High West | 358 | 344 | 14 | NA |
| Intermediate Mid | 44 | 43 | 1 | NA |
| Intermediate North | 49 | 46 | 3 | NA |
| Low | 21 | 19 | 2 | NA |
| **Herds under restriction per 100 live herds** | | | | |
| High East | 7.2 | 7.1 | 0.1 | 2,860[2] |
| High West | 11.0 | 10.6 | 0.4 | 3,252[2] |
| Intermediate Mid | 2.1 | 2.1 | 0.0 | 2,049[2] |
| Intermediate North | 5.1 | 4.8 | 0.3 | 954[2] |
| Low | 0.7 | 0.7 | 0.1 | 2,841[2] |

[1] This is the number of 'herd-years at risk'
[2] This is the number of 'live' herds in *mid-December* 2018 so differs from the herd number given in Section 1.

### *2.2 Temporal trends in TB incidence and prevalence in Wales*

An overall decrease in the total number of new incidents per 100 unrestricted herds has been observed since the end of 2008, despite increases in 2011, 2014 and 2017, and this declining trend continued in 2018 (Figure 2.1). However, an increase of 10% was observed between the beginning of 2016 and the end of 2017. The difference in incidence between OTF-W and total incidents has continually narrowed since 2011 due to the change in classification of OTF-W[1] incidents and the subsequent increase in the proportion of all incidents classified as OTF-W.

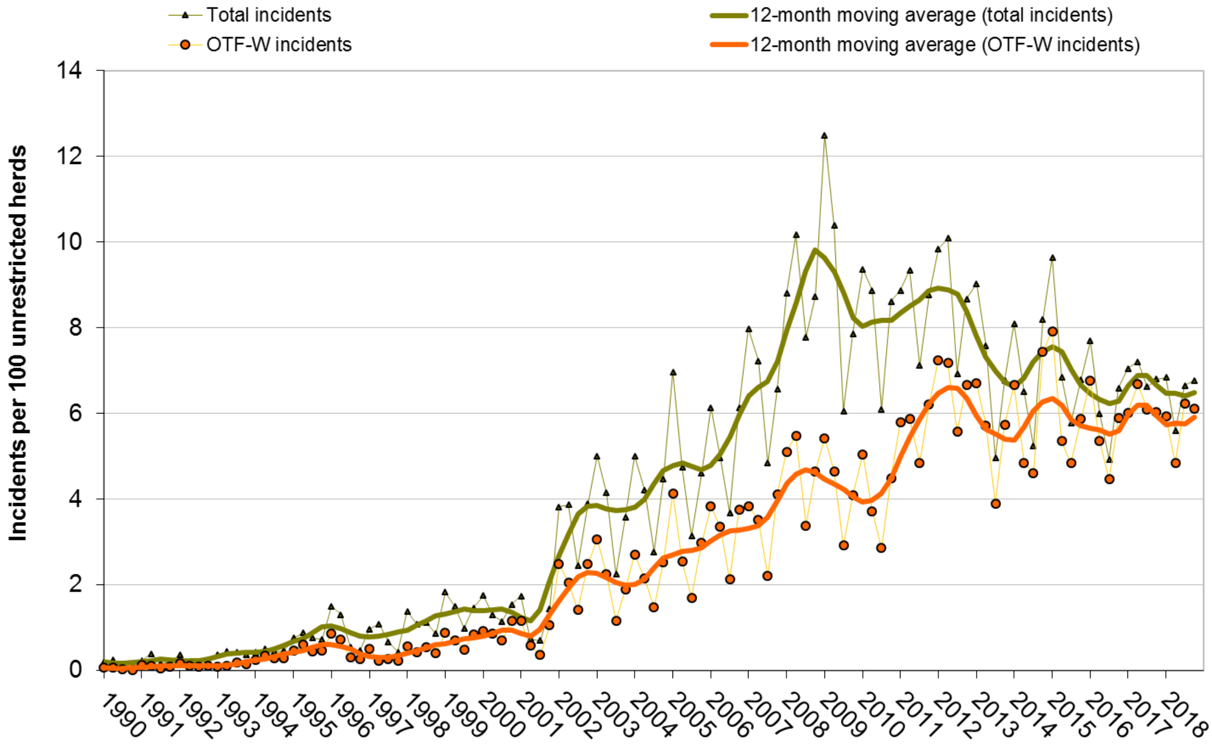



**Figure 2.1:** Quarterly number of total and OTF-W incidents per 100 unrestricted herds between January 1990 and December 2018

A similar trend was observed for prevalence (defined as the proportion of herds under movement restrictions; Figure 2.2). In recent years, prevalence has peaked on an approximate three-yearly basis, for example, in May 2009 (7.7%), July 2012 (7.0%), and May 2015 (5.8%). The explanation for this oscillation in prevalence is unclear but could be associated with the high risk of recurrence of infection in herds and the sequence by which herds were tested in relation to TB risk before annual testing was introduced (where herds from low incidence areas would be tested on a less frequent basis). Following a peak in July 2012, the proportion of herds under restriction declined to around 5%, and has since remained relatively stable.

[1] Throughout this report the OTF-W cohort contains incidents without post mortem evidence of infection that have been determined to have sufficient epidemiological evidence to withdraw OTF status (OTF-W-2; see Materials and Methods section for more information).

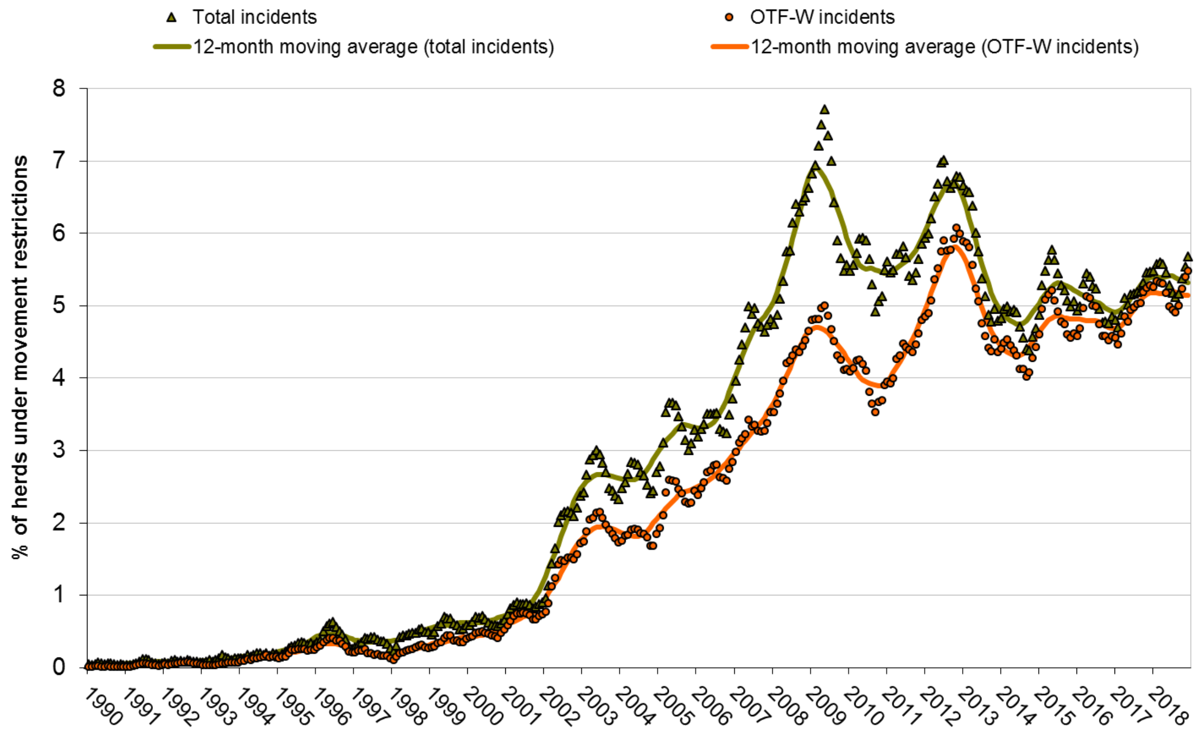



**Figure 2.2:** Proportion of herds that were under movement restrictions between January 1990 and December 2018

The temporal changes in the three measures used to assess the scale of the TB epidemic in Wales are compared in Figure 2.3. Generally, the temporal trends in incidence per 100 live herds and incidence rate per 100 herd-years at risk are similar, with a general decline since 2013. Prevalence (number of herds restricted per 100 live herds) shows a slightly different trend, and since an initial decrease in 2013, has been rising steadily since 2016 (for total and OTF-W incidents). OTF-W incidents are under movement restrictions for longer periods compared to OTF-S incidents as they require a second clear short-interval test (SIT) before movement restrictions can be lifted. Also, as new OTF-W incidents in the Low and Intermediate North TB Areas have subject to mandatory herd gIFN tests, this could lead to prolonged movement restrictions if additional reactors are disclosed.

As expected, OTF-S incidence and prevalence has declined over time, particularly since 2011, as an artefact of OTF-S incidents being reclassified as OTF-W.

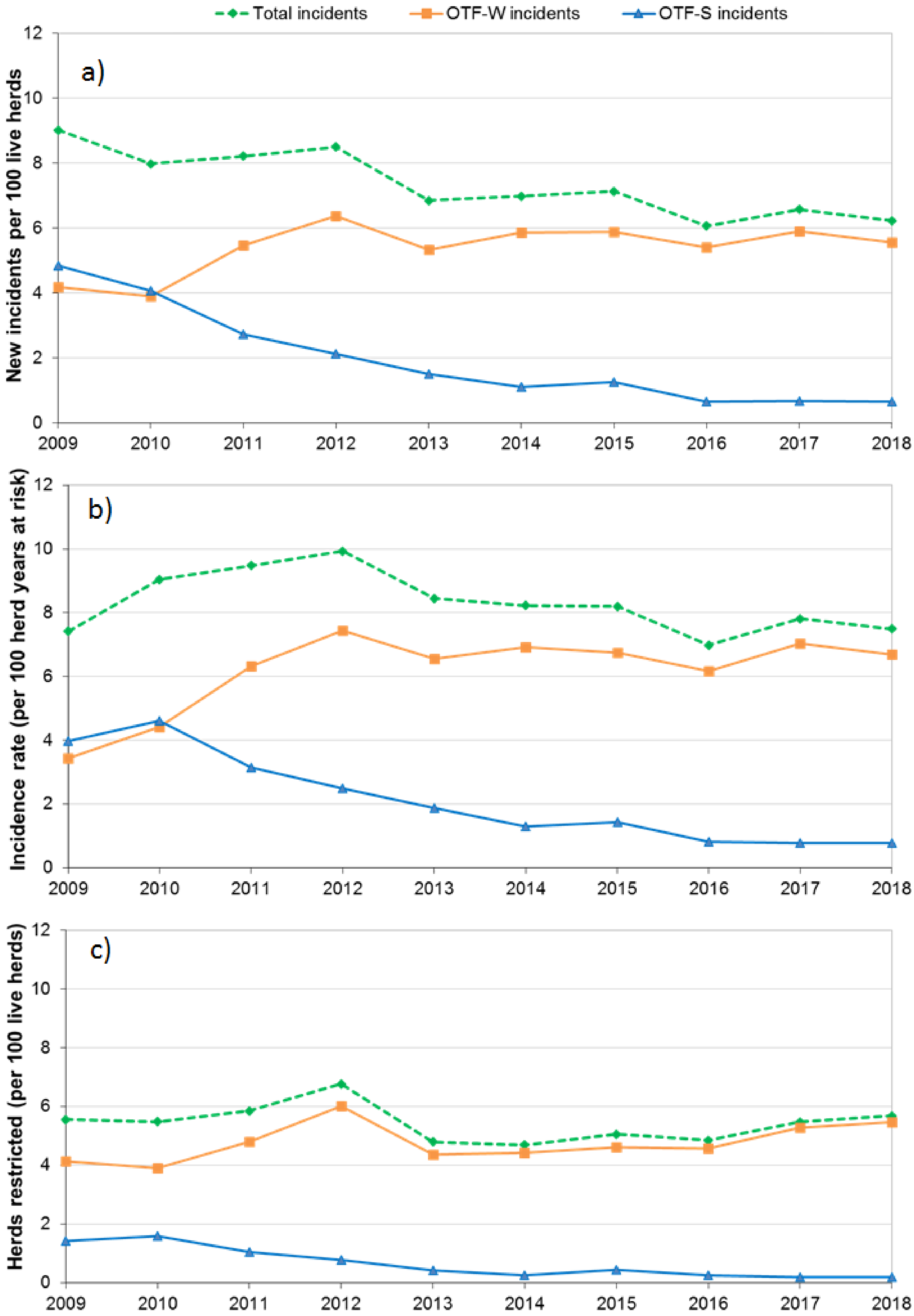



**Figure 2.3 A to C:** Ten year trends in the total number of (a) new incidents per 100 herds, (b) new incidents per 100 herd years at risk, and (c) point prevalence of herds under movement restrictions in each TB Area of Wales, December of each year

*2.3 Incidence and prevalence of TB across Wales*

Figure 2.4 shows the geographical distribution of OTF-W and OTF-S incidents annually between 2014 and 2018. There has been little change in the geographical distribution of new TB incidents during this period.

New TB incidents were detected in every TB Area in Wales during 2018, however, as observed historically, the majority of incidents were found in the south west and along the English/Welsh border. Larger numbers of new incidents are typically detected in areas with higher cattle herd density, however, the cattle population distribution does not entirely account for variation in the number of new incidents detected in each TB Area (Figure 1.1). This becomes evident when the number of herds is adjusted for, as areas including Anglesey, Gwynedd and Clwyd (within the Low TB Area) continued to have fewer new incidents per 100 unrestricted herds in 2018 compared to areas in the High West and High East TB Areas (along the English/Welsh border areas; Figure 2.5).

The temporal trends in the number of new incidents per 100 unrestricted herds (Figure 2.5) and the incidence rates of TB per 100 herd years at risk (Figure 2.6) vary by TB Area in Wales.

In Wales overall, incidence (per 100 unrestricted herds) has declined since 2009 as well as in the High TB Areas (both East and West) and the Intermediate Mid TB Area. Declines in incidence were observed for the High East, Intermediate Mid and Low TB Areas in 2018 and increases in the High West TB Area. Incidence rates in the High TB Areas are, as expected, higher than for Wales overall. In 2017/18, the incidence rate in the Intermediate North TB Area was higher than the average for Wales, and has increased since 2016.

Overall, prevalence (the proportion of herds under restriction) has remained stable in Wales since 2014 (Figure 2.7). Though prevalence was greatest in the High West TB Area West, a small decrease was observed between 2016 and 2017. Within the High East and Intermediate North TB Areas, prevalence slightly increased, whilst remaining relatively consistent within the Intermediate Mid and Low TB Areas between these two years. The proportion of herds under restriction has remained between 6-8% for the last four years in the High East TB Area. The highest prevalence was observed in the High West TB Area, remaining around 10% throughout 2018. Prevalence in the Intermediate North TB Area increased from 2016 but then remained relatively stable in 2018. For over five years, prevalence in the Intermediate Mid TB Area has been around 2% and less than 1% for the Low TB Area.

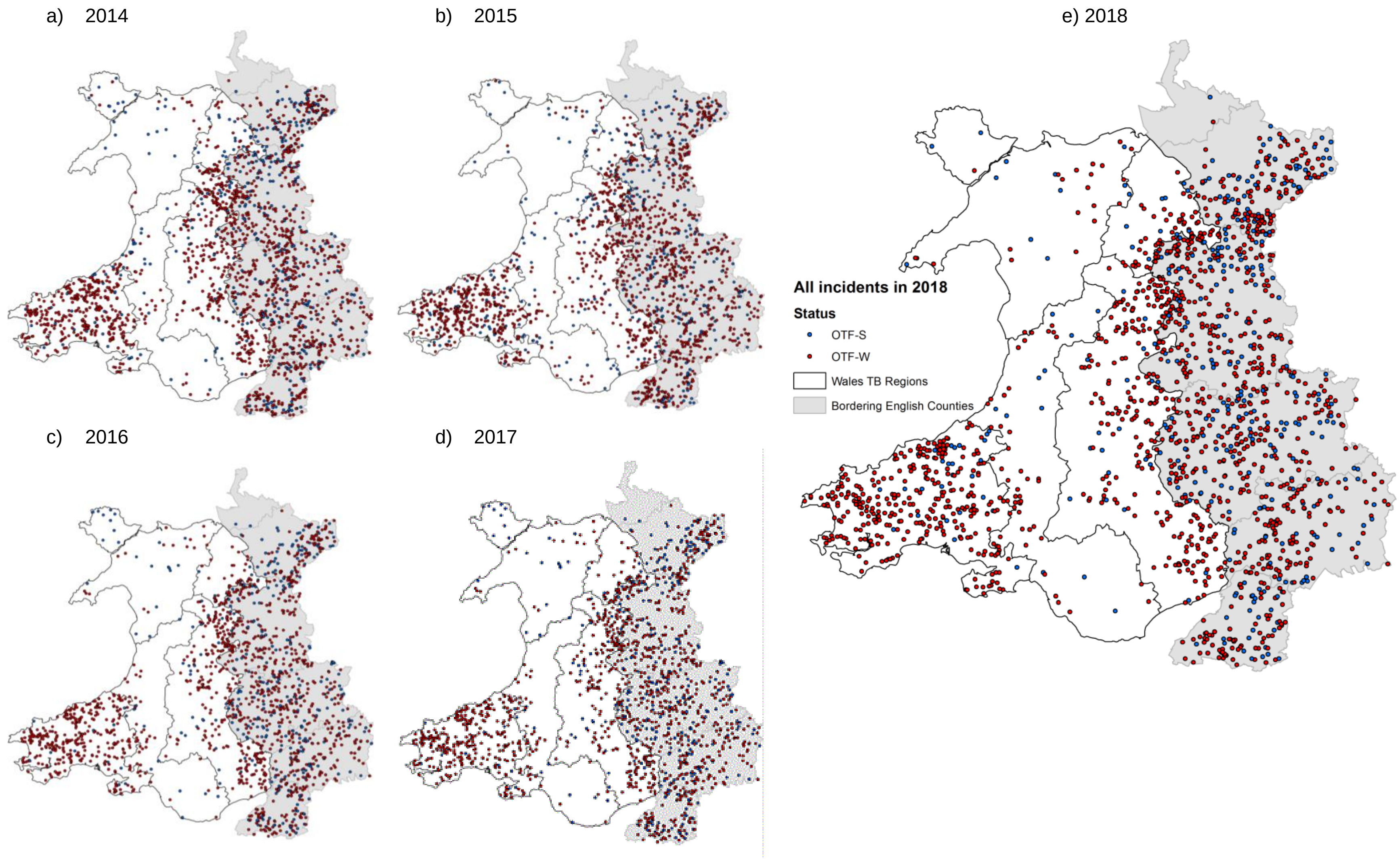



**Figure 2.4:** Geographical distribution of new OTF-W and OTF-S incidents occurring in Wales and bordering English counties in 2014 - 2018

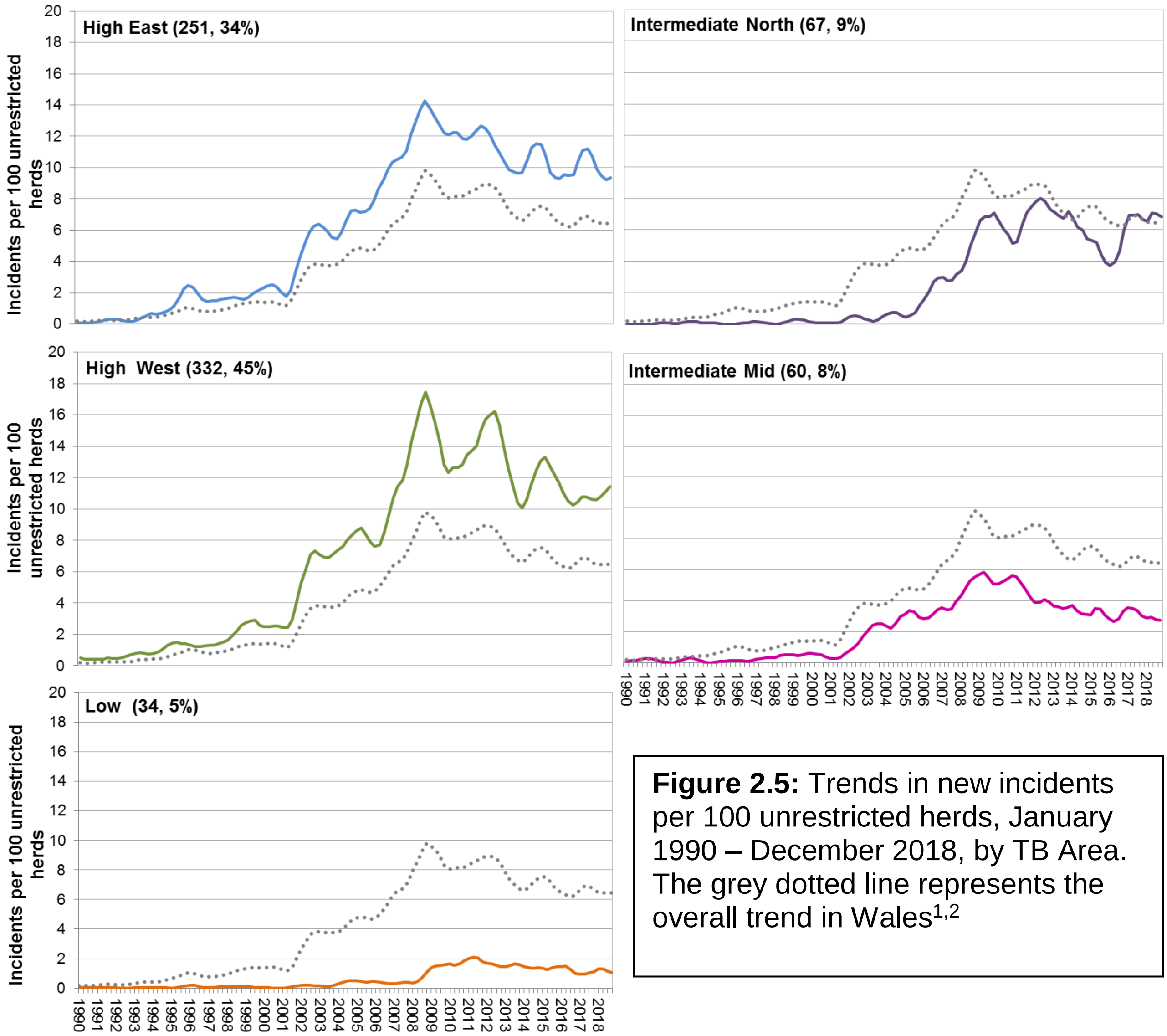



**Figure 2.5:** Trends in new incidents per 100 unrestricted herds, January 1990 – December 2018, by TB Area. The grey dotted line represents the overall trend in Wales[1,2]

[1] Quarterly (annualised), smoothed 12-month moving average
[2] The raw number of herds and the percentage this makes up for Wales overall in 2018 is given for each count

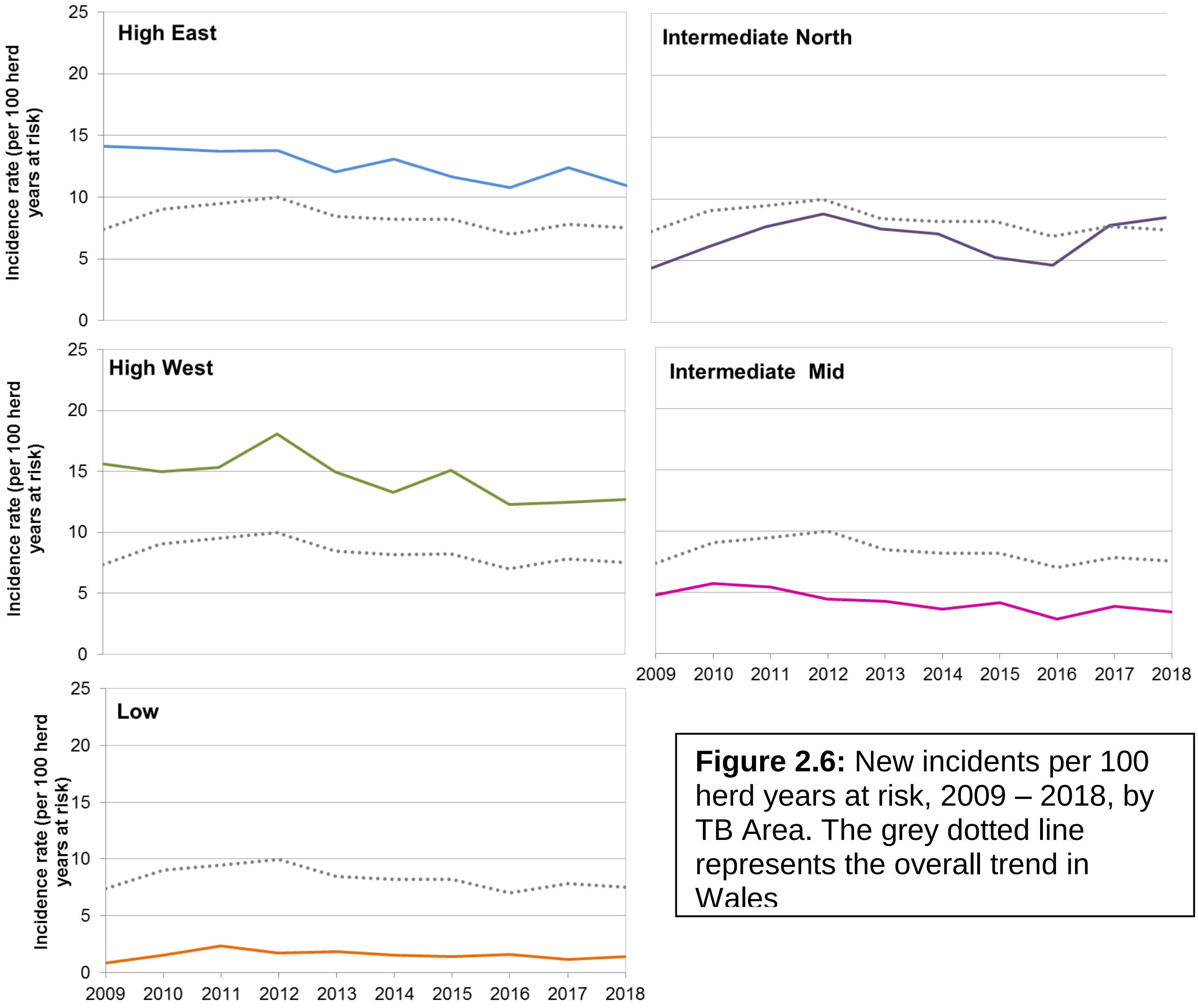



**Figure 2.6:** New incidents per 100 herd years at risk, 2009 – 2018, by TB Area. The grey dotted line represents the overall trend in Wales

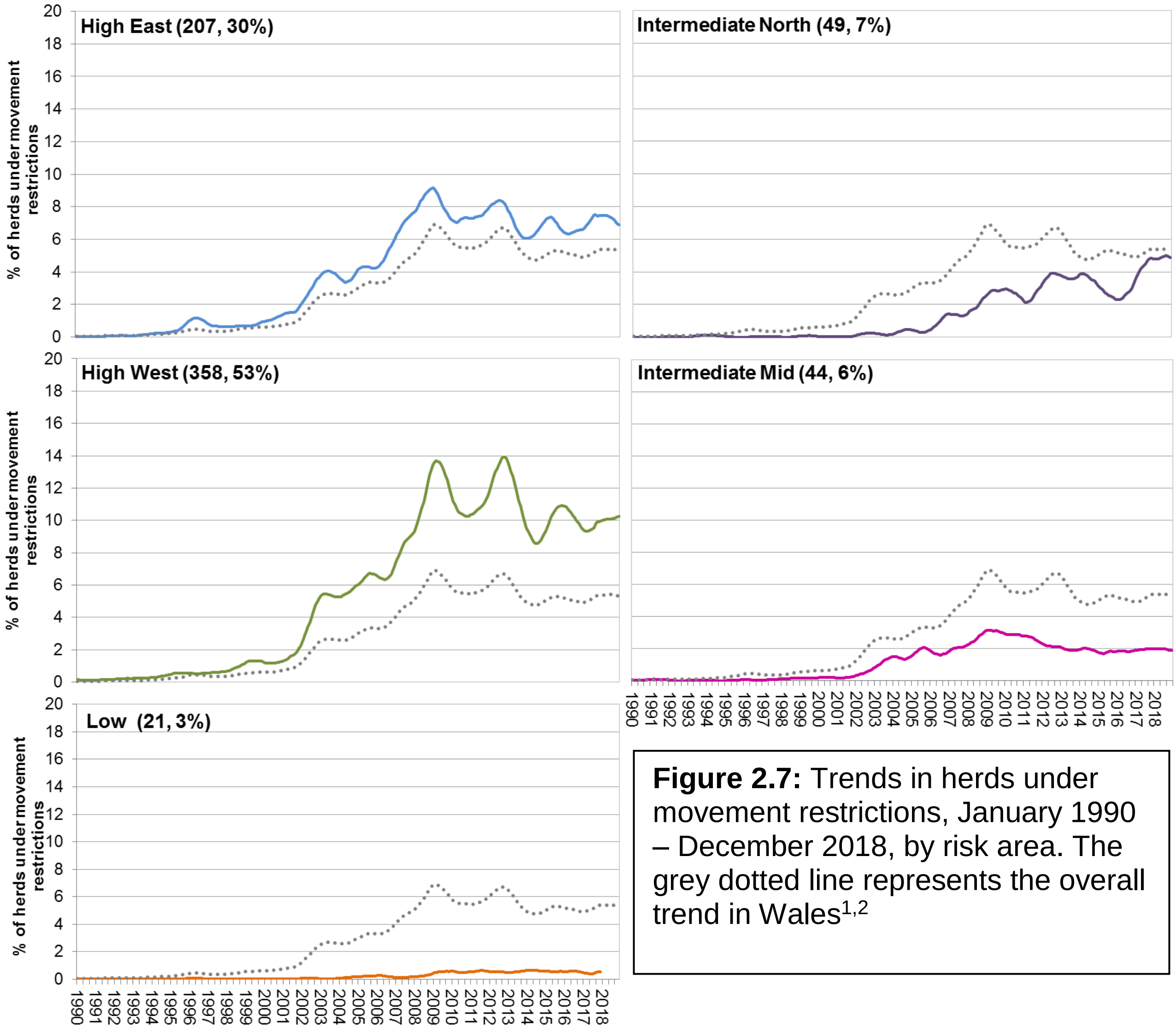



**Figure 2.7:** Trends in herds under movement restrictions, January 1990 – December 2018, by risk area. The grey dotted line represents the overall trend in Wales[1,2]

[1] Quarterly (annualised), smoothed 12-month moving average
[2] The raw number of herds and the percentage this makes up for Wales overall in 2018 is given for each count

*2.4 New TB incidents identified by different test types*

In 2018, there were 744 new TB incidents, of which 665 (89%) were classified as OTF-W incidents and 79 (11%) were classified as OTF-S incidents (see Appendix 2 for definitions). Similar numbers of OTF-W incidents were detected by ‘Routine’ and ‘Herd Risk’ test types (Table 2.2), whilst more than double were detected by ‘Area Risk’ tests (see Appendix 3 for test type category details). However, when considered as a proportion of all tests, more than six times as many incidents were detected per 100 ‘Herd Risk’ tests and almost four times as many incidents per 100 ‘Area Risk’ tests than through ‘Routine’ herd tests.

Most TB incidents were detected through area risk surveillance, which equated to 7% of area risk tests. As a proportion of herd tests by test type, herd risk tests detected a higher proportion of TB incidents (11%) which is to be expected given that these tests are conducted in area, herds and cattle perceived to be at increased risk of infection.

**Table 2.2:** Tests taken from animals in herds not under restriction (surveillance tests), resulting incidents and incidents per 100 herd surveillance tests, 2018

| **Surveillance test type [1]** | **Total herd (surveillance) tests** | **TB incidents** | | **TB incidents per 100 herd tests** | | **Number restricted following inconclusive reactor test[2]** | |
|---|---|---|---|---|---|---|---|
| | | **Total** | **OTFW** | **Total** | **OTFW** | **Total** | **OTFW** |
| Routine | 7,303 | 161 | 112 | 2.20 | 1.53 | 46 | 31 |
| Area Risk | 3,973 | 287 | 274 | 7.22 | 6.90 | 66 | 61 |
| Herd Risk | 1,104 | 119 | 117 | 10.78 | 10.60 | 37 | 36 |
| Movement Risk 2 | 11,693 | 70 | 55 | 0.60 | 0.47 | 17 | 10 |
| Movement Risk 1 | 2,553 | 16 | 16 | 0.63 | 0.63 | 2 | 2 |
| SLH | 190,182 | 75 | 75 | 0.04 | 0.04 | 0 | 0 |
| Control | 187 | 13 | 13 | 6.95 | 6.95 | 0 | 0 |
| New Herds | 429 | 3 | 3 | 0.70 | 0.70 | 0 | 0 |
| **Total** | **217,424** | **744** | **665** | **0.34** | **0.31** | **168** | **140** |

[1] See Appendix 3 for test type category details
[2] Incidents in which movement restrictions did not commence (in 2018) until an inconclusive reactor test was performed
[3] Number of animals slaughtered from herds that were not under restriction; this is at the animal-level and not the herd-level and therefore not directly comparable with other surveillance test types within this table

Historically, approximately 30% of new TB incidents were detected by 'Routine' testing but over the last five years has reduced to 20%. This has largely been due to a gradual increase in the proportion of TB incidents detected through area risk tests, where between 34% and 42% of annual TB detections have originated since 2011.

The Wales TB eradication programme launched on 1 October 2017 with a regionalised approach to eradicating TB in Wales, where enhanced measures have been applied in each TB Area tailored to protect the Low TB Area from disease and reduce the level of disease in the Intermediate and High TB Areas.

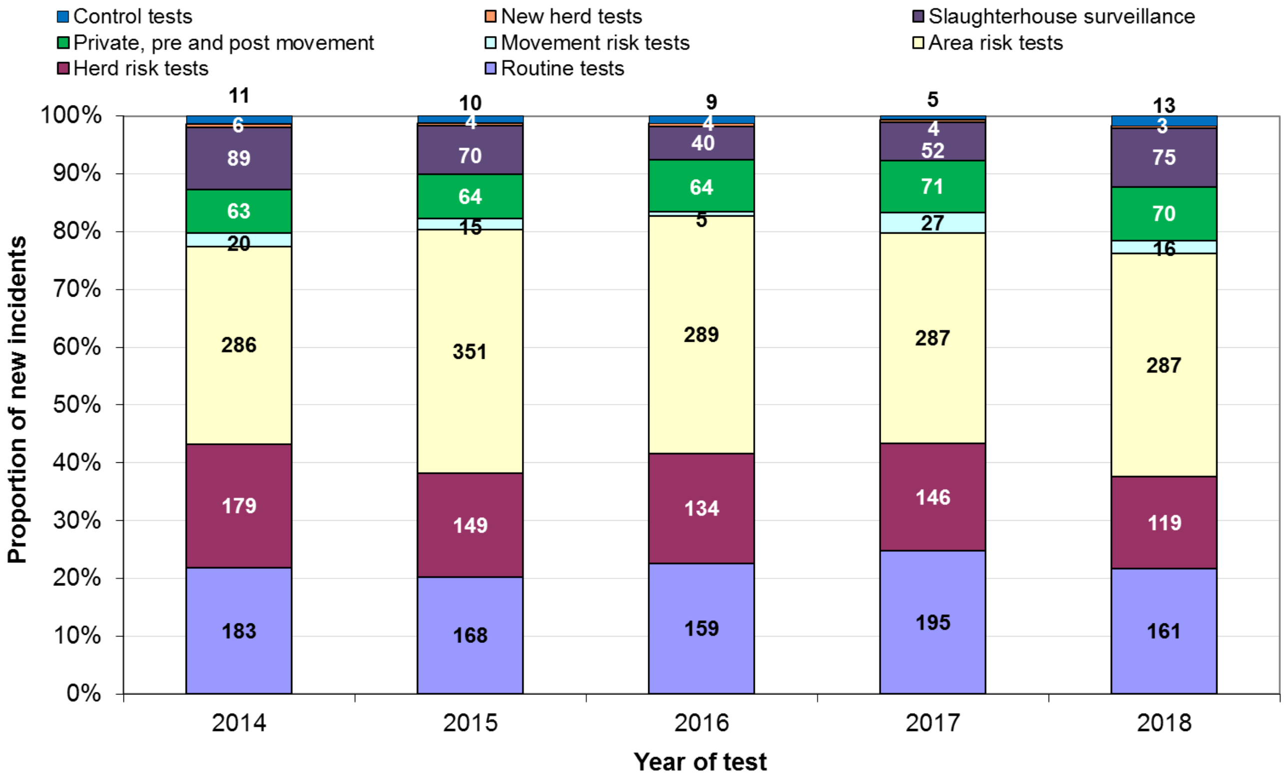



**Figure 2.8:** New TB incidents detected by different surveillance testing methods

* Incidents were detected in "other" test type category in 2014 (n=1), 2016 (n=1) and 2018 (n=2) – not presented here.

## *2.5 Animal level frequency of TB*

In High TB Areas in the East and West, the number of tests performed is approximately double that of animals tested. The application of short interval tests during incidents means that animals were tested more frequently in these areas. In addition, parts of Pembrokeshire, Carmarthenshire and Ceredigion (all in High West TB Area) were subject to six monthly testing as part of the Intensive Action Area strategy. Reactor and IR frequencies were greatest in the High TB Areas, reflecting the geographical distribution of TB incidents in Wales.

**Table 2.3:** Animal level frequency of reactors and inconclusive reactors in 2018

| | Animals tested | Skin Tests Performed on Animals | Animals slaughtered as reactors | Reactor frequency % | Animals slaughtered as IRs[1] | IR frequency % |
|---|---|---|---|---|---|---|
| **TB Area:** | | | | | | |
| High East | 267,408 | 456,258 | 1,204 | 0.45 | 105 | 0.04 |
| High West | 464,978 | 937,079 | 3,496 | 0.75 | 297 | 0.06 |
| Intermediate Mid | 147,023 | 203,993 | 299 | 0.20 | 29 | 0.02 |
| Intermediate North | 113,829 | 186,895 | 323 | 0.28 | 37 | 0.03 |
| Low | 229,891 | 270,708 | 67 | 0.03 | 10 | 0.00 |

[1]Includes 2 and 3 x IRs

### *2.6 Variation in TB incidence by herd type, herd size and geographical area*

Table 2.4 shows TB incidence rates by TB Area, herd type and herd size. The rate ratios in the table indicate the size of the difference between the different categories of herd size, type and TB Area, relative to the reference category (see Materials and Methods for explanation of the choice of reference category). For example, if a category had an incidence rate ratio of 2.0, this means that the incidence rate in herds within that category was twice as high as that of the reference category. A ratio of less than 1 represents categories where the incidence rate is lower than that of the reference category.

The results from the analysis of incidence rates indicate that TB incidence increases with herd size. This effect remains after adjusting for the influence of herd type and location, and has been observed consistently for the past five years. Dairy herds had a substantially higher incidence rate than beef herds (15.9 vs. 4.8 per 100 years at risk). However, some of this effect is attributable to differences in herd size and location. Nevertheless, even after adjusting for these factors, there remains a statistically significant difference between beef and dairy herds; this is consistent with recent years, with the exception of 2014. As expected the lowest incidence rates were observed in the Intermediate Mid, North and Low TB Areas, whilst the highest was in the High West and East TB Areas.

**Table 2.4:** Analysis of incidence rates by herd size, type and location and results of Poisson Regression analyses of the associations between these factors and the incidence rate of all new TB incidents that started in 2018

| | Time at risk (years) | Number new TB incidents | TB incidence rate (per 100 herd years) | Unadjusted[1] incidence rate ratio[3] | Adjusted[2] incidence rate ratio[3] |
|---|---|---|---|---|---|
| **Herd size** | | | | | |
| 1 – 10 | 1,482 | 11 | 0.74 | 0.02*** | 0.03*** |
| 11 – 50 | 3,329 | 107 | 3.21 | 0.11*** | 0.14*** |
| 50 – 100 | 2,387 | 153 | 6.41 | 0.21*** | 0.26*** |
| 100 – 200 | 1,522 | 174 | 11.44 | 0.38*** | 0.43*** |
| 200 – 300 | 569 | 97 | 17.04 | 0.57*** | 0.63*** |
| >300 | 676 | 202 | 29.87 | *Ref* | *Ref* |
| **Herd type** | | | | | |
| Beef | 8,882 | 427 | 4.81 | *Ref* | *Ref* |
| Dairy | 1,970 | 314 | 15.94 | 3.32*** | 1.25* |
| Other/mixed | 234 | 3 | 1.28 | 0.27* | 0.41$^{ns}$ |
| **TB Area** | | | | | |
| High East | 2,532 | 251 | 9.91 | 0.87$^{ns}$ | 1.15$^{ns}$ |
| High West | 2,908 | 332 | 11.42 | *Ref* | *Ref* |
| Intermediate Mid | 1,982 | 60 | 3.03 | 0.27*** | 0.39*** |
| Intermediate North | 897 | 67 | 7.47 | 0.65** | 0.70** |
| Low | 2,768 | 34 | 1.23 | 0.11*** | 0.14*** |

*, **, *** and $^{ns}$ denote probability values of p≤0.05, p≤0.01, p≤0.001 and p>0.05 respectively with p>0.05 interpreted as not statistically significant.

[1] Results of univariable Poisson regression analysis of the associations between herd size, herd type or geographical area and the incidence rate of new TB incidents.

[2] Results from Poisson regression analysis where the associations between herd size, herd type or geographical area and the TB incidence rate were simultaneously adjusted for.

[3] The rate ratio is the incidence rate in each category / incidence rate in the reference category ['*Ref*'])

### *2.7 Summary of new, closed and ongoing incidents in Wales*

There were 744 new TB incidents in Wales in 2018, which represents a 5.5% decrease compared to 2017. The High West and East TB Areas had the highest number of new incidents (332 and 251 respectively) which equates to nearly 80% of the total for Wales (Table 2.5).

A total of 493 incidents in Wales closed during 2018, having begun prior to 2018. Again, most (83%) were located in the High TB Areas in the West and East.

There were a total of 168 ongoing (started prior to 2018) TB incidents in Wales, 167 (99%) of which were OTF-W incidents. The number of ongoing incidents has doubled in the past five years (Figure S2 in Summary). The majority of total ongoing TB incidents were located in the High West TB Area (108, 90%), with 43 in the High East, with only one in the Low TB Area.

**Table 2.5:** The number of new, closed and ongoing TB incidents by TB Area in Wales, 2018

| TB Area | | Total incidents | OTF-W | OTF-S |
|---|---|---|---|---|
| **High East** | New incidents in 2018 | 251 | 231 | 20 |
| | Closed[1] incidents in 2018 | 194 | 188 | 6 |
| | Ongoing[2] incidents in 2018 | 43 | 43 | 0 |
| **High West** | New incidents in 2018 | 332 | 305 | 27 |
| | Closed[1] incidents in 2018 | 217 | 210 | 7 |
| | Ongoing[2] incidents in 2018 | 108 | 107 | 1 |
| **Intermediate Mid** | New incidents in 2018 | 60 | 49 | 11 |
| | Closed[1] incidents in 2018 | 37 | 32 | 5 |
| | Ongoing[2] incidents in 2018 | 4 | 4 | 0 |
| **Intermediate North** | New incidents in 2018 | 67 | 58 | 9 |
| | Closed[1] incidents in 2018 | 30 | 27 | 3 |
| | Ongoing[2] incidents in 2018 | 12 | 12 | 0 |
| **Low** | New incidents in 2018 | 34 | 22 | 12 |
| | Closed[1] incidents in 2018 | 15 | 12 | 3 |
| | Ongoing[2] incidents in 2018 | 1 | 1 | 0 |
| **Wales overall** | **New incidents in 2018** | **744** | **665** | **79** |
| | **Closed[1] incidents in 2018** | **493** | **469** | **24** |
| | **Ongoing[2] incidents in 2018** | **168** | **167** | **1** |

[1] Closed incidents begun prior to 2018 but ended during 2018
[2] Ongoing incidents began prior to 2018 and were still ongoing at the end of 2018

The geographical location of all new, closed and ongoing incidents stratified by OTF-W and OTF-S status can be seen in Figure 2.9. Most of the OTF-W incidents (encompassing new, closed and ongoing) appear to be clustered in the High West and East TB Areas, while OTF-S incidents seem to be more evenly spread across Wales.

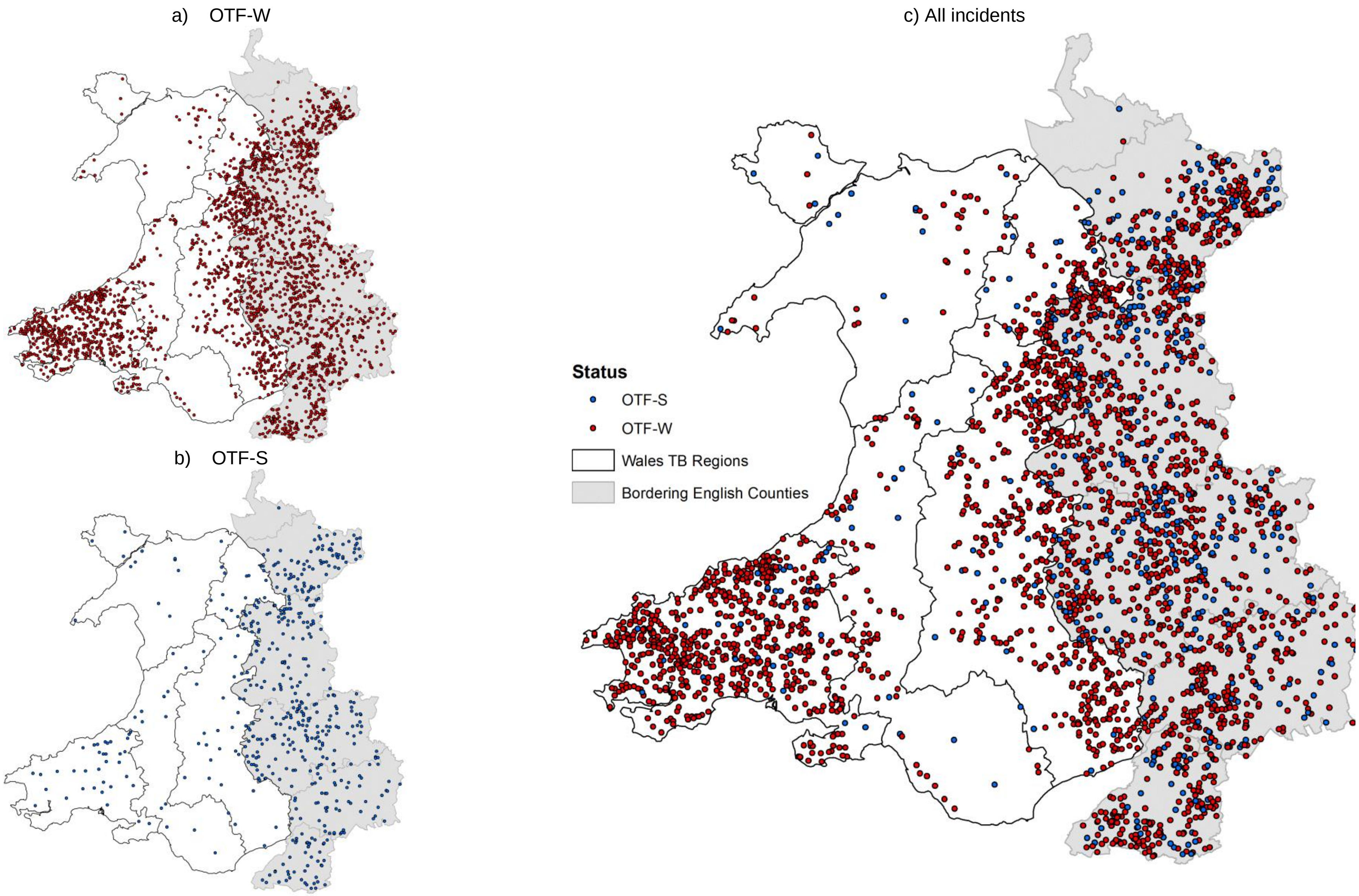



**Figure 2.9:** Incidents (new, closed and ongoing) occurring in Wales and bordering English counties, 2018

# 3.0 Routine slaughterhouse surveillance

**Key Points:**

- 59% of the samples submitted from slaughterhouses were *M. bovis* positive, lower than the proportion for Great Britain as a whole (68%) (Table 3.1)
- 11% of OTF-W incidents in Wales overall were disclosed at slaughter in 2018 (50% increase compared to 2017) but the proportion varies by TB Area and is higher in the High West, Intermediate North and Low TB Areas (Figure 3.1)

Slaughterhouse surveillance is the *post-mortem* inspection of all cattle slaughtered commercially in abattoir. This type of surveillance may detect some infected cattle that may have been missed by active live animal surveillance. Slaughterhouse surveillance acts as an indicator for the efficacy of the live animal testing component of the surveillance system. Monitoring trends in the proportion of TB incidents disclosed at the slaughterhouse can therefore identify changes which may warrant further investigation.

Routine slaughterhouse surveillance identifies animals with TB-like lesions from a population that are not being sent to slaughter as reactors on the basis of:

- A positive field test result (i.e. Single Intradermal Comparative Cervical Test (SICCT; skin test) or interferon-gamma (gIFN) test.

As such, to increase the specificity of routine slaughterhouse surveillance, *M. bovis* must be isolated from suspect lesions by laboratory culture before TB infection can be confirmed.
The following section compares detection of TB by slaughterhouse inspection to skin testing. Observable changes in trends may be due to real changes in the epidemiology of the disease, or due to changes in testing protocol. The number of cattle culled as a result of suspicion of TB infection, for example skin test reactors and 'direct contacts' are discussed in Section 4.

### *3.1 Submission of samples from animals with lesions suspicious of TB*

The number of slaughterhouse samples submitted between 2014 and 2018 from cattle originating from Welsh herds and their culture results are presented in Table 3.1. There was a sharp decline in the number of submissions made in 2016 and 2017 but in 2018 these returned to levels seen in 2015 and 2014. Fluctuations in the number of slaughterhouse submissions has occurred over a long period, and declines in slaughterhouse testing could be due to infected cattle being detected earlier by more frequent TB field testing and more sensitive testing regimes for herds sustaining TB incidents. The proportion of samples submitted from slaughterhouses which were positive for *M. bovis* was 59% in 2018, which is consistent with 2017 despite some variation over the past five years. The proportion in 2016 was the lowest in the last five years (52%). The proportion for Great Britain as a whole in 2018 was 68% (Bovine tuberculosis in Great Britain. Surveillance data for 2018 and historical trends).

**Table 3.1:** Culture results from cattle with TB-like lesions detected during slaughterhouse surveillance in Wales, 2014-2018

| Year | Number of samples submitted | Authorised culture result[1] | | | | | | Proportion *M. bovis* (%) |
|---|---|---|---|---|---|---|---|---|
| | | ***M. bovis*** | ***M. avium*** | ***Actinobacillus spp.*** | **Unclassified mycobacterium** | **Contaminated** | **Negative** | |
| 2014 | 143 | 98 | 0 | 11 | 0 | 0 | 34 | 68.53 |
| 2015 | 138 | 94 | 0 | 4 | 0 | 0 | 40 | 68.12 |
| 2016 | 95 | 49 | 0 | 11 | 0 | 0 | 35 | 51.58 |
| 2017 | 97 | 59 | 0 | 9 | 0 | 0 | 29 | 60.82 |
| 2018 | 138 | 81 | 0 | 9 | 0 | 0 | 47 | 58.70 |

[1] 'Other' Mycobacterium samples are not included in the authorised culture results. In 2018, there was one 'Other' sample submitted.

The culture results of samples processed in 2018, split by TB Area are shown in Table 3.2. The largest percentages of *M. bovis* positive submissions came from animals originating from herds in the High TB West and East Areas (67% and 63% respectively). This is similar to 2017 when these TB Areas also had the largest proportion of *M. bovis* positive samples (76% and 61%, respectively).

**Table 3.2:** Culture results from cattle with TB-like lesions detected during slaughterhouse surveillance, by TB Area, 2018

| TB Area | No. samples submitted | *M. bovis* positive | *M. bovis* negative | Contaminated | Proportion *M. bovis* (%) |
|---|---|---|---|---|---|
| High East | 30 | 19 | 11 | 0 | 63.33 |
| High West | 66 | 44 | 22 | 0 | 66.67 |
| Intermediate Mid | 22 | 11 | 11 | 0 | 50.00 |
| Intermediate North | 8 | 2 | 6 | 0 | 25.00 |
| Low | 12 | 5 | 7 | 0 | 41.67 |
| Total Wales | 138 | 81 | 57* | 0 | 58.70 |

**M*. Other and *Actinobacillus* spp. are included in the total for *M*. *bovis* negative, hence the total negative in Table 3.1 is different.

### *3.2 Incidents disclosed at slaughterhouse inspection*

Of the 665 OTF-W incidents in Wales in 2018, (11.3%) were disclosed in the slaughterhouse). This is a 50% increase compared to 2017 and matched a similar proportion to 2015 figures (10%, both 2016 and 2017 were lower at 7% of OTF-W incidents). The proportion varies widely by TB Area in Wales, being highest in the Intermediate Mid TB Area (24%) and lowest in the Intermediate North Area (3%) (Figure 3.1). In the High TB Areas (both East and West), the proportion has remained fairly stable over time at around 10%, but there is considerably more variation in the Intermediate and Low TB Areas.

The number of incidents is partly linked to the surveillance effort at the slaughterhouse. This surveillance underwent major changes in the period following a training exercise in 2010 which resulted in more submissions being made. The lower proportions in 2003 and 2009 may be due to the resumption of testing following the 2001 FMD outbreak, and the increase in testing for Health Check Wales in 2008 respectively, both of which resulted in increases in the number of incidents disclosed through live animal testing. This is more evident in the Intermediate North, Mid and Low TB Areas.

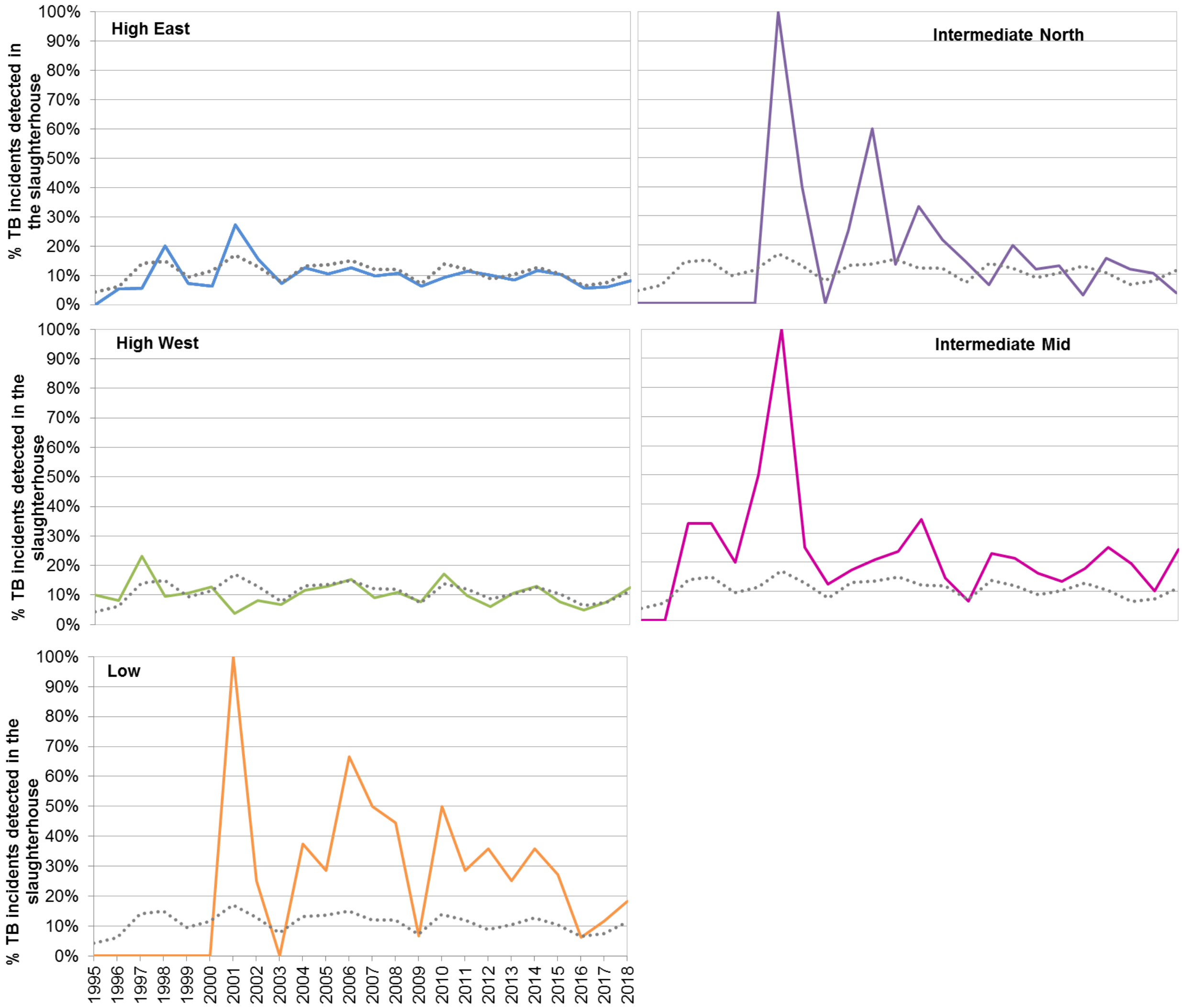



**Figure 3.1:** Proportion of OTF-W incidents disclosed in the slaughterhouse by TB Area, 1995-2018[1]

[1] Slaughterhouse data not available prior to 1995

The geographical distribution of new slaughterhouse incidents between 2014 and 2018 is shown in Figure 3.2 and reflects the distribution of total TB incidents (i.e. those detected by live animal testing or slaughterhouse inspection) (Section 2, Figure 2.4). Slaughterhouse-detected incidents occur consistently in the High West and East TB Areas where the burden of disease is highest. Sporadic incidents also occur in other parts of Wales.

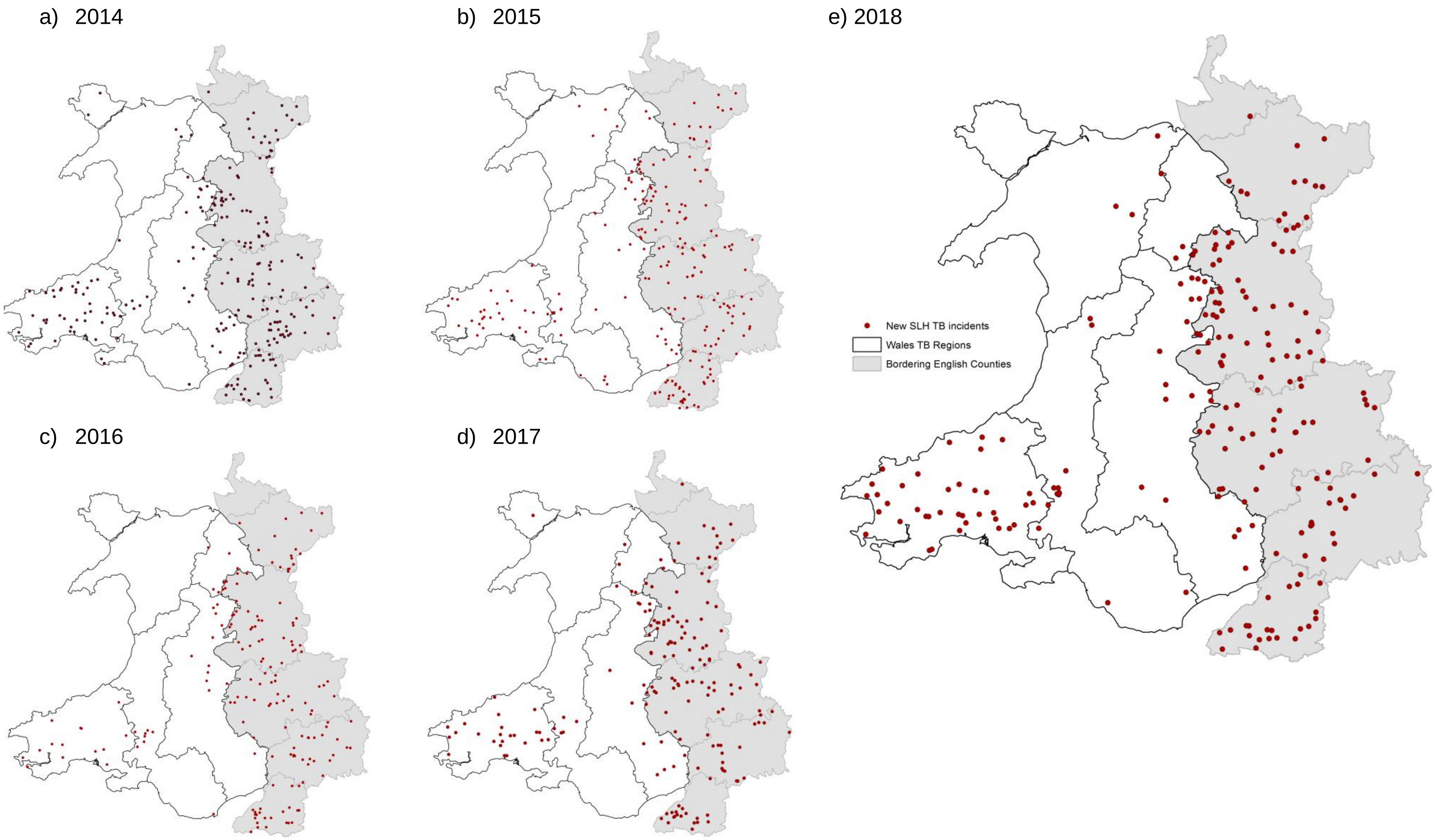



**Figure 3.2:** New incidents disclosed in the slaughterhouse, 2014 – 2018

The sensitivity of slaughterhouse surveillance, i.e. the ability of the surveillance to identify truly infected animals, can be affected by multiple factors such as:

- disease intrinsic factors,
- herd characteristics, (e.g. size, type, or location) or,
- intrinsic slaughterhouse processes.

These factors should be taken into account when assessing the odds of an incident being detected to control for any effects they might have on the direction or magnitude of the outcome.

The results of a logistic regression analysis of the associations between herd type, herd size and geographical area on the odds of an OTF-W incident being disclosed in the slaughterhouse in 2018 are presented in Table 3.3. The odds ratios[1] indicate the size of the difference in the odds of an incident being detected in the slaughterhouse between the different categories of each variable, relative to a reference category (see Materials and Methods for explanation of the choice of reference category).

Herd type was not associated with an OTF-W incident being disclosed in the slaughterhouse, even after controlling for the effects of herd size and location.

After controlling for the effects of herd type and location, herd sizes of 11-50, 51-100 and 101-200 animals were associated with a reduction in the odds of an OTF-W incident being disclosed in the slaughterhouse, relative to herds of more than 300 animals.

After controlling for the effects of herd size and type, the odds of an OTF-W incident being disclosed in the slaughterhouse was nearly three times as high in the Intermediate Mid TB Area, relative to the High West TB Area.

The High East, Intermediate North and Low TB Areas were not significantly associated with increased or decreased odds of disclosing an OTF-W slaughterhouse incident, indicating that, with the exception of the Intermediate Mid TB Area, slaughterhouse surveillance sensitivity does not vary across Wales as all TB Areas are subject to a similar intensity of live animal testing, despite differences in disease incidence.

[1] The ‘odds ratio’ in this case is the odds (probability) of an incident being detected in the slaughterhouse divided by the odds of an incident being detected via routine skin testing.

**Table 3.3:** Results of Logistic regression analyses of the associations between herd type, herd size and TB Area and the odds of an OTF-W incident being disclosed in the slaughterhouse in 2018

| | Total OTF-W incidents | No. SLH cases (%) | No. non-SLH cases (%) | Unadjusted[1] | | | Adjusted[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | odds ratio[3] | 95% confidence interval | | odds ratio[3] | 95% confidence interval | |
| **Herd size** | | | | | | | | | |
| 1 - 10 | 4 | 0 (0) | 4 (100) | - | - | - | - | - | - |
| 11 - 50 | 101 | 4 (3.96) | 97 (96.04) | 0.16*** | 0.06 | 0.48 | 0.11*** | 0.03 | 0.37 |
| 51 - 100 | 141 | 7 (4.96) | 134 (95.04) | 0.21*** | 0.09 | 0.49 | 0.17*** | 0.07 | 0.45 |
| 101 - 200 | 147 | 16 (10.88) | 131 (89.12) | 0.49* | 0.26 | 0.92 | 0.38** | 0.18 | 0.79 |
| 201 - 300 | 97 | 13 (13.4) | 84 (86.6) | 0.62ns | 0.31 | 1.24 | 0.55ns | 0.26 | 1.14 |
| >300 | 175 | 35 (20) | 140 (80) | *Ref* | | | *Ref* | | |
| **Herd type** | | | | | | | | | |
| Beef | 365 | 35 (9.59) | 330 (90.41) | *Ref* | | | *Ref* | | |
| Dairy | 297 | 40 (13.47) | 257 (86.53) | 1.47ns | 0.91 | 2.38 | 0.66ns | 0.35 | 1.24 |
| Other/mixed | 3 | 0 (0) | 3 (100) | - | - | - | - | - | - |
| **TB Area** | | | | | | | | | |
| High East | 231 | 19 (8.23) | 212 (212) | 0.63 ns | 0.35 | 1.12 | 0.74 ns | 0.40 | 1.39 |
| High West | 305 | 38 (12.46) | 267 (87.54) | *Ref* | | | *Ref* | | |
| Intermediate Mid | 49 | 12 (24.49) | 37 (75.51) | 2.28* | 1.09 | 4.75 | 2.71 ** | 1.24 | 5.92 |
| Intermediate North | 58 | 2 (3.45) | 56 (96.55) | 0.25 ns | 0.06 | 1.07 | 0.26 ns | 0.06 | 1.14 |
| Low | 22 | 4 (18.18) | 18 (81.82) | 1.56 ns | 0.50 | 4.86 | 1.16 ns | 0.36 | 3.81 |
| **Total** | **665** | **75 (11.28)** | **590 (88.72)** | **-** | | | **-** | | |

*, **, *** and ns denote levels of statistical significance of p≤0.05, p≤0.01, p≤0.001, p>0.05 and not significant respectively.

[1] Results of univariable logistic regression analyses of the associations between herd size, herd type or TB risk area and the odds of an incident being detected in the slaughterhouse.

[2] Results of multivariable logistic regression analyses where the associations between herd size, herd type or TB risk area and the odds of an incident being detected in the slaughterhouse were adjusted for the effects of each other.

[3] The odds ratio is the odds of disease in the exposed categories relative to the odds of disease in the unexposed (reference ['*Ref*']) category.

*3.3 Reactors in herd tests following detection of slaughterhouse cases*

Following the detection of new TB incidents via slaughterhouse testing, whole herd tests are administered. Tables 3.4 a-e show the median and mean number of reactors identified at the first whole herd test for incidents identified at slaughterhouse and via skin testing (routine and risk-based) in 2018, split by TB Area.

The merit in considering the first whole herd test, rather than the entire incident, is that some incidents detected in 2018 may still have been open at the end of the year. This can give an indication of the severity of the incidents which began in 2018. The mean (average) number of reactors is higher than the median (mid-point) which reflects the positively skewed distribution of reactors. Most incidents result in only one or two reactors, so the median is low, but there are a minority of incidents with much larger numbers of reactors, thus pulling the mean upwards. An increase in the median number of reactors from a slaughterhouse incident could be an indicator of built-up infection.

The median number of reactors was mostly zero or one across all TB Areas for both slaughterhouse inspection and skin testing (risk and routine), but was two for risk-based skin testing and slaughterhouse inspection in the High West TB Area. The mean is more skewed as may be based on a very small number of incidents having a particularly large number of reactors. Where the disclosing test was slaughterhouse inspection, the mean number of reactors was highest in the Intermediate Mid TB Area (n=9; Total TB and OTF-W incidents; based on 12 OTF-W incidents), whereas for routine and risk-based skin testing, the mean was highest in the High West TB Area (for both total and OTF-W incidents), based on two slaughterhouse disclosed incidents with a large number of reactors (53 and 48 respectively). For risk-based and routine skin testing, the mean number of reactors identified in incidents was also highest in the High West TB Area.

**Table 3.4 (a-e):** Reactors identified at the first whole herd test following an incident, by TB Area (2018)

| **(a) High TB East: Disclosing test** | **Number new incidents** | | **Number of reactors taken at first WHT per incident[1]** | | | | **Number of reactors taken at first WHT per OTF-W incident[1]** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 19 | 19 | 3.3 | 0 | 0 | 5 | 3.3 | 0 | 0 | 5 |
| Skin testing - Risk | 180 | 172 | 2.2 | 1 | 1 | 2 | 2.3 | 1 | 1 | 3 |
| Skin testing - Routine | 52 | 40 | 2.1 | 1 | 1 | 2 | 2.5 | 1 | 1 | 3 |
| **Total** | **251** | **231** | **2.3** | **1** | **1** | **2** | **2.4** | **1** | **1** | **3** |

[1]Inter-quartile range

| (b) High TB West: Disclosing test | Number new incidents | | Number of reactors taken at first WHT per incident[1] | | | | Number of reactors taken at first WHT per OTF-W incident[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 38 | 38 | 5.1 | 2 | 0 | 4 | 5.1 | 2 | 0 | 4 |
| Skin testing - Risk | 237 | 224 | 3.2 | 2 | 1 | 4 | 3.4 | 2 | 1 | 4 |
| Skin testing - Routine | 57 | 43 | 2.8 | 1 | 1 | 2 | 3.5 | 2 | 1 | 3 |
| **Total** | **332** | **305** | **3.4** | **2** | **1** | **4** | **3.6** | **2** | **1** | **4** |

[1]Inter-quartile range

| (c) Intermediate TB Mid: Disclosing test | Number new incidents | | Number of reactors taken at first WHT per incident[1] | | | | Number of reactors taken at first WHT per OTF-W incident[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 12 | 12 | 9.0 | 0 | 0 | 0 | 9.0 | 0 | 0 | 0 |
| Skin testing - Risk | 29 | 24 | 2.3 | 1 | 1 | 3 | 2.7 | 2 | 1 | 4 |
| Skin testing - Routine | 19 | 13 | 1.1 | 1 | 1 | 1 | 1.3 | 1 | 1 | 1 |
| **Total** | **60** | **49** | **3.3** | **1** | **0** | **2** | **3.9** | **1** | **1** | **2** |

[1]Inter-quartile range

| (d) Intermediate TB North: Disclosing test | Number new incidents | | Number of reactors taken at first WHT per incident[1] | | | | Number of reactors taken at first WHT per OTF-W incident[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 2 | 2 | 0.5 | 1 | 0 | 1 | 0.5 | 1 | 0 | 1 |
| Skin testing - Risk | 54 | 50 | 2.6 | 1 | 1 | 2 | 2.8 | 1 | 1 | 3 |
| Skin testing - Routine | 11 | 6 | 1.0 | 1 | 1 | 1 | 1.0 | 1 | 1 | 1 |
| **Total** | **67** | **58** | **2.3** | **1** | **1** | **2** | **2.5** | **1** | **1** | **2** |

[1]Inter-quartile range

| (e) Low TB: Disclosing test | Number new incidents | | Number of reactors taken at first WHT per incident[1] | | | | Number of reactors taken at first WHT per OTF-W incident[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 4 | 4 | 0.0 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0 |
| Skin testing - Risk | 9 | 9 | 0.9 | 1 | 0 | 1 | 0.9 | 1 | 0 | 1 |
| Skin testing - Routine | 20 | 9 | 1.4 | 1 | 1 | 1 | 2.2 | 2 | 1 | 3 |
| **Total** | **33** | **22** | **1.1** | **1** | **0** | **1** | **1.3** | **1** | **0** | **1** |

[1]Inter-quartile range

Tables 3.5 a - e show the **total number of reactors** identified in incidents that **closed** in 2018 by TB Area, comparing those that were first detected at slaughterhouse inspection with those detected by skin testing. This includes incidents which began prior to 2018. The mean and median number of reactors was higher in TB incidents that closed in 2018 compared to the number identified at the first whole herd test (Tables 3.4 a - e). The mean number of reactors identified in incidents was highest in the Intermediate Mid Area (n=21.4 total and OTF-W), however this was driven by a single TB incident starting in 2016 with 104 reactors.

The median number of reactors was around one or two for routine skin testing, being slightly higher for risk-based skin testing (four in the Intermediate North and five in the High West TB Area. The Low TB Area had the highest median number of reactors disclosed in the slaughterhouse in 2018 (median=6).

**Table 3.5 (a-e):** Total number of reactors identified in incidents that closed in 2018, by TB Area

| **(a) High East: Disclosing test** | **Number closed incidents** | | **Total number of reactors taken per incident[1]** | | | | **Total number of reactors taken per OTFW incident[1]** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 16 | 16 | 8.7 | 3 | 1 | 5 | 8.7 | 3 | 1 | 5 |
| Skin testing - Risk | 200 | 192 | 6.8 | 3 | 1 | 7 | 7.1 | 3 | 1 | 8 |
| Skin testing - Routine | 62 | 50 | 3.4 | 1 | 1 | 3 | 4.0 | 2 | 1 | 3 |
| **Total** | **278** | **258** | **6.1** | **2** | **1** | **6** | **6.6** | **3** | **1** | **7** |

[1]Inter-quartile range

| **(b) High West: Disclosing test** | **Number closed incidents** | | **Total number of reactors taken per incident[1]** | | | | **Total number of reactors taken per OTFW incident[1]** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 23 | 23 | 9.1 | 2 | 0 | 7 | 9.1 | 2 | 0 | 7 |
| Skin testing - Risk | 47 | 222 | 10.0 | 5 | 2 | 11 | 10.4 | 5 | 2 | 12 |
| Skin testing - Routine | 7 | 35 | 6.6 | 1 | 1 | 4 | 8.7 | 3 | 1 | 6 |
| **Total** | **77** | **280** | **9.4** | **4** | **1** | **10** | **10.1** | **4** | **2** | **11** |

[1]Inter-quartile range

| (c) Intermediate North: Disclosing test | Number closed incidents | | Total number of reactors taken per incident[1] | | | | Total number of reactors taken per OTFW incident[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 3 | 3 | 7.7 | 3 | 1 | 3 | 7.7 | 3 | 1 | 3 |
| Skin testing - Risk | 34 | 30 | 7.2 | 4 | 1 | 10 | 8.0 | 5 | 2 | 10 |
| Skin testing - Routine | 18 | 13 | 6.4 | 2 | 1 | 7 | 8.5 | 4 | 1 | 10 |
| **Total** | **55** | **46** | **6.9** | **3** | **1** | **7** | **8.1** | **4** | **2** | **10** |

[1]Inter-quartile range

| (d) Intermediate Mid: Disclosing test | Number closed incidents | | Total number of reactors taken per incident[1] | | | | Total number of reactors taken per OTFW incident[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 7 | 7 | 21.4 | 0 | 0 | 0 | 21.4 | 0 | 0 | 0 |
| Skin testing - Risk | 20 | 16 | 3.7 | 2 | 1 | 5 | 4.6 | 3 | 1 | 6 |
| Skin testing - Routine | 29 | 19 | 2.9 | 1 | 1 | 4 | 4.1 | 3 | 1 | 4 |
| **Total** | **56** | **42** | **5.5** | **1** | **1** | **4** | **7.1** | **2** | **1** | **5** |

[1]Inter-quartile range

| (e) Low: Disclosing test | Number closed incidents | | Total number of reactors taken per incident[1] | | | | Total number of reactors taken per OTFW incident[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | OTF-W | Mean | Median | IQR 25% | IQR 75% | Mean | Median | IQR 25% | IQR 75% |
| Slaughterhouse inspection | 2 | 2 | 6.0 | 6 | 2 | 10 | 6.0 | 6 | 2 | 10 |
| Skin testing - Risk | 4 | 3 | 0.5 | 1 | 0 | 1 | 0.7 | 1 | 0 | 1 |
| Skin testing - Routine | 23 | 10 | 3.4 | 1 | 1 | 5 | 7.1 | 5 | 1 | 10 |
| **Total** | **29** | **15** | **3.2** | **1** | **0** | **5** | **5.7** | **5** | **1** | **8** |

[1]Inter-quartile range

Temporal trends in the mean and median number of reactors identified at the ***first whole herd test*** by method of disclosure are presented in Figure 3.3 for Wales overall. Generally the trends in the median number of reactors mirror the trends in the mean, albeit at a lower level. The median is less affected by extreme values and more appropriate for skewed data, such as this, where the frequency of observations is generally low but there may be a handful of extreme values. In 2018, the median number of reactors identified per incident at the first herd test after slaughterhouse inspection was zero, fluctuating between zero and one since 2003. The median number of reactors for incidents disclosed by routine skin testing had fluctuated between one and two since 1990 but increased to three in 2017 and 2018. Increased use of severe interpretation may have led to this increase in the median number of reactors.

The mean number of reactors identified at the first whole herd test through routine skin testing peaked around the time of the Foot and Mouth Disease outbreak in 2001 which caused considerable disruption to TB surveillance. The peak observed in 1996 reflects two slaughterhouse disclosed incidents in West Wales which together produced 89 reactors. Aside from this anomaly, the temporal trends indicate that there has been little difference in the mean number of reactors found in incidents disclosed through slaughterhouse cases and the mean number found in incidents detected through skin testing. This applies when looking at Wales overall but as Tables 3.4 (a - e) demonstrate, there is more variation when looking at the data by TB Area.

The temporal trends in the mean and median ***total*** number of reactors identified per closed TB incident by method of disclosure are presented in Figure 3.4. The median number of reactors identified per skin-test-disclosed incident remained relatively constant between 2005 and 2015, typically around two, although this increased to three from 2016 to 2018. The median number disclosed in the slaughterhouse has fluctuated between one and two reactors over the same time period (two in 2018). The mean number of reactors identified per skin-test-disclosed incident has increased over time from around two reactors per incident in 1990-1994 to seven in 2018, with peaks in 2013 (nearly ten per incident), 2016 and 2017 (nine per incident, respectively). A similar increasing trend can also be seen for slaughterhouse disclosed incidents, although there is more fluctuation due in part to the relatively small number of slaughterhouse cases.

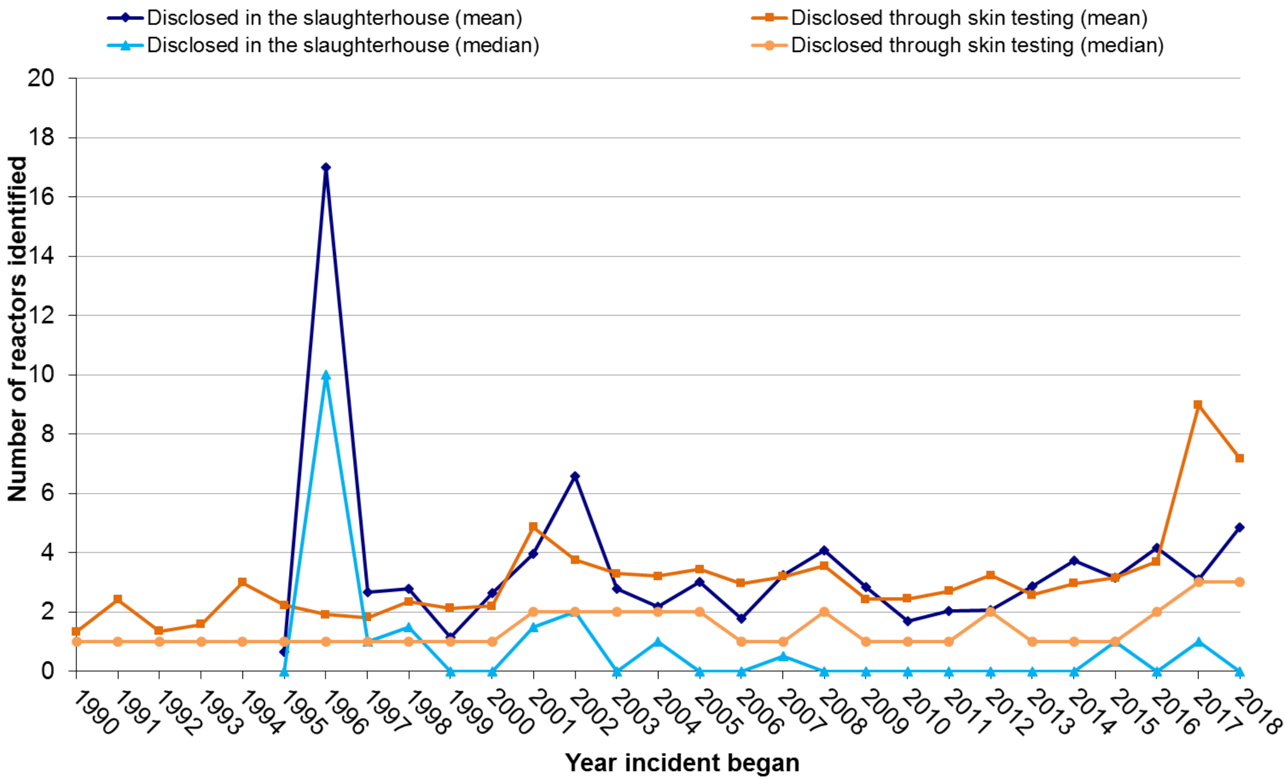



**Figure 3.3:** Reactors identified at the first whole herd test following disclosure of the incident, 1990 – 2018[1]

[1]Slaughterhouse data not available prior to 1995

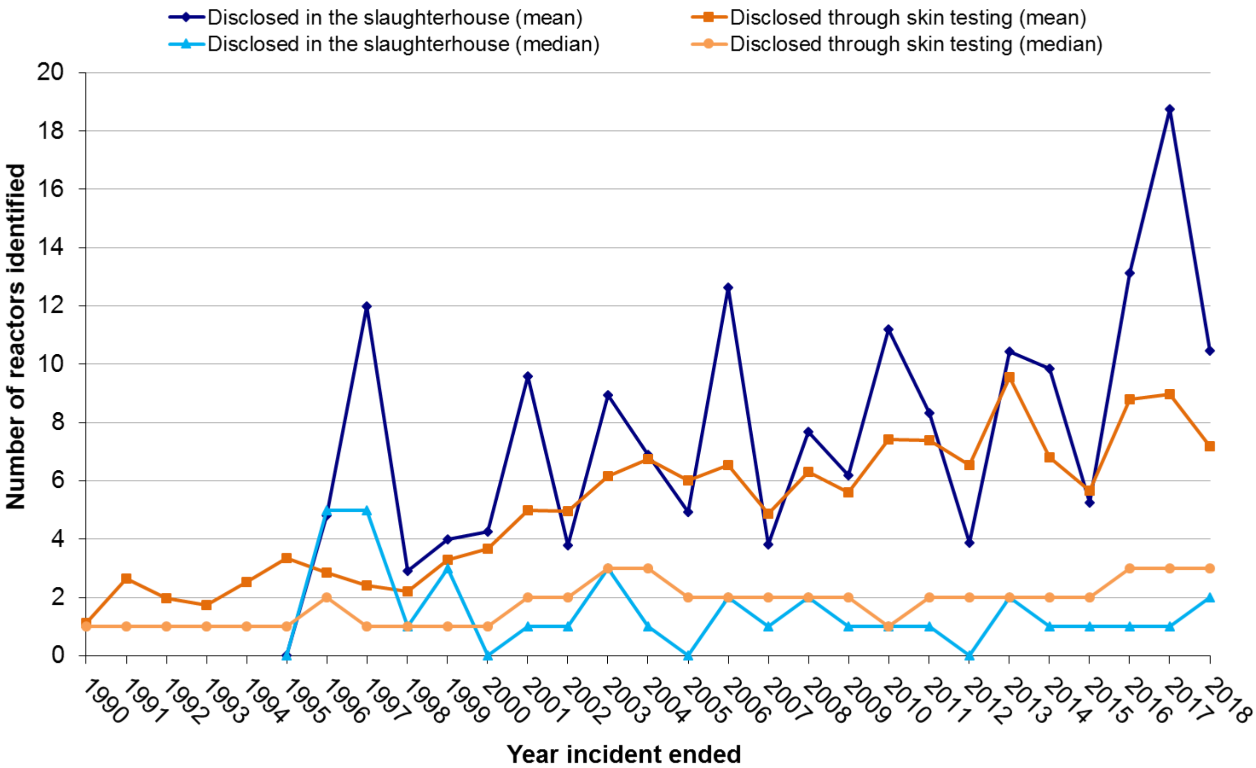



**Figure 3.4:** Reactors identified per incident that closed, 1990 – 2018[1]

[1]Slaughterhouse data not available prior to 1995

# 4.0 Post mortem examination and culture of suspected TB cases

**Key Points:**

- In the High West, Intermediate North and Intermediate Mid TB Areas, the proportion with detected lesions that were *M. bovis* positive was higher for reactors than for direct contacts and inconclusive reactors; whereas the proportion was higher for direct contacts in the High East TB Area, and for inconclusive reactors in the Low TB Area (Tables 4.1 a-e).
- In Wales overall, 31% of the total reactors taken in 2018 were gIFN positive.
- Of the 11,466 cattle slaughtered with evidence of TB in 2018, 68% were reactors, 25% inconclusive reactors and 7% direct contacts.
- Of the total 563 detected lesion samples with culture results in 2018, 91% were *M. bovis* positive (Figure 4.4).
- Of the 2,127 samples from animals with no detectable lesions and for which culture results were available in 2018, only 2% were *M. bovis* positive (Figure 4.4).

The tuberculin skin test is more sensitive than slaughterhouse inspection for detecting cattle at an early stage of infection with *M. bovis.* Lesion and culture results for animals slaughtered according to various TB risks (reactors, inconclusive reactors (IR) or direct contacts (DC)) are illustrated in this section which reports on the total number of TB suspect cattle slaughtered per year, regardless of when the incident started. Further information about inconclusive reactors is provided in Section 7.

Overall in Wales, lesions were detected in 16%[1] (1,290) of reactors to the tuberculin skin test and of this subset, 40% (514) were *M. bovis* positive (Figure 4.1). Severe interpretation of the skin test is a more sensitive reading which leads to additional animals with a smaller response to the test being classified and slaughtered as reactors. This decreases the likelihood of truly infected animals testing negative to the skin test and therefore increases the likelihood of detecting all infected animals within the herd. A smaller proportion of these animals yield carcases with detectable lesions (DLs) from which *M. bovis* can be isolated and cultured compared with animals classed as reactors via standard interpretation (see Appendix 2 for definitions of standard and severe interpretation.

[1] Samples are not sent for culture from the majority of reactors, IRs, and DCs, irrespective of whether they have detected lesions or not (Figure 4.1). Consequently, this data should not be used to estimate the true proportion of animals slaughtered for TB that would have been confirmed as TB positive via culture. However, since so few animals without detected lesions are found to be positive via culture test, we would not expect the true proportion to differ by much.

*4.1 Number of suspected TB cases that were slaughtered*[1]

A summary of cattle slaughtered as suspected TB cases in Wales in 2018, along with the outcome of carcase inspection, is presented in Figure 4.1.

In addition to the 75 slaughterhouse cases where retrospective evidence of TB was identified (see Section 3), a further 11,466 cattle were slaughtered in 2018 for TB control. Of these, 68% were reactors to either the skin test or interferon-gamma (gIFN), 25% were IRs and 7% were DCs. This distribution differs slightly from England[2] where 94% of compulsorily slaughtered animals were reactors, 4% were IRs and 2% were DCs. The higher proportion of IRs in Wales could be in part due to all IRs in chronic herd breakdowns being slaughtered (as part of the ongoing Action Plan process).

There was a 10% increase in the number of cattle slaughtered for TB control in 2018 compared with 2017, following a general increasing trend over the past five years.

Overall in 2018, lesions were detected in 12% of slaughtered animals, although this proportion varied depending on the method of disclosure: reactors (16%), IRs (2%) or DCs (4%) (Figure 4.1). This also varies according to whether the skin testing was standard (32%) or severe interpretation (7%), or if reactors were identified via gIFN testing (5%). There is also wider variation when comparing different TB Areas, with the highest proportion of standard and gIFN reactors with DLs in the High TB East Area (42% and 12% respectively), and in the Intermediate Mid TB Area for severe interpretation reactors (14%; Table 4.1).

The lower proportion of animals which were gIFN-positive with DLs is expected due to the greater sensitivity of the gIFN test which allows the detection of disease at any earlier stage of infection before lesions are likely to be detectable, and the lower specificity which means that the test is more likely to generate false positive results.

[1] Defra statistics report true reactors, IRx2 and IRx3 as “reactors” (which are compulsorily slaughtered), whereas in this report “reactors” includes only true reactors (including severe interpretation), and not IRx2 or IRx3. Defra statistics report only IRx1 as IRs whereas this report includes IRx1, IRx2 and IRx3 as IRs.

[2] https://www.gov.uk/government/collections/bovine-tb-surveillance-in-great-britain#2018

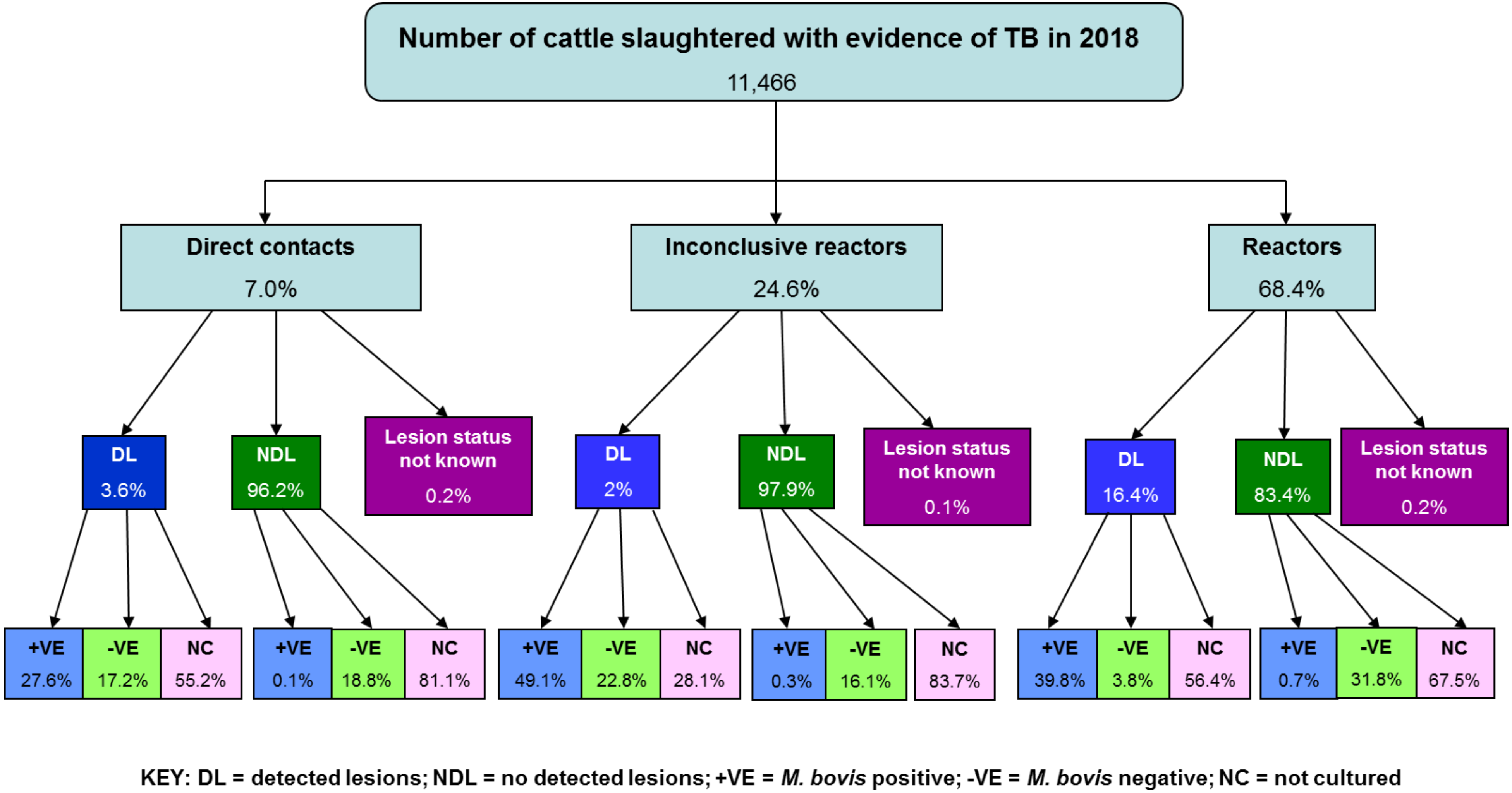



**Figure 4.1:** Testing pathways of animals slaughtered for TB control in Wales, 2018

Trends in the number of cattle slaughtered for different TB control reasons are shown in Figure 4.2a and Appendix 6. The 5-year trend in the number of one-, two- and three-times IR animals and DCs slaughtered is shown in Figure 4.2b.

An increase in the number of animals that were slaughtered was observed since 1990 across all reasons for slaughter for TB control, reaching a peak of nearly 11,700 in 2009. The number reduced in subsequent years but has increased again since 2013, up to 11,466 in 2018.

The number of IRs slaughtered increased ten-fold between 2008 and 2009 and, following a decline between 2010 and 2014, has since increased and was highest in 2018 (2,815 IRs slaughtered). The increase between 2008 and 2009 can be explained by a change in policy, implemented in 2009, which reduced the number of times that an animal testing inconclusive could be re-tested from two to one. An IR that fails to give a negative result at this re-test is considered to be positive.

Since 2008, the overall number of reactors and DCs that were slaughtered for TB control reasons has been variable, increasing up to 2008 and 2009 with subsequent declines and then further increases in the last three years. The recent increase in reactors is primarily attributable to increases in gamma-testing, which is more sensitive than the skin test. Gamma-testing is used to help clear infection in recurrent and persistent TB incidents and to prevent disease from becoming established in low incidence areas.

There was a sharp apparent increase in the number of DCs slaughtered in 2016 and 2017, where the total nearly doubled compared to 2015. In 2018, the total decreased sharply, coinciding with a large increase in the number of IRs slaughtered in 2017 and 2018 (1,750 and 2,815 respectively). These changes primarily reflect an issue with how some IRs were recorded in the SAM database. During 2016, official veterinarians were directed to apply more sensitive testing procedures in certain circumstances, and this included removing IRs. Until April 2017, it was not possible to record these cases as IRs on SAM in such a way as to enable the intended removal and compensation processes to take place. Consequently, these animals were recorded as DCs.

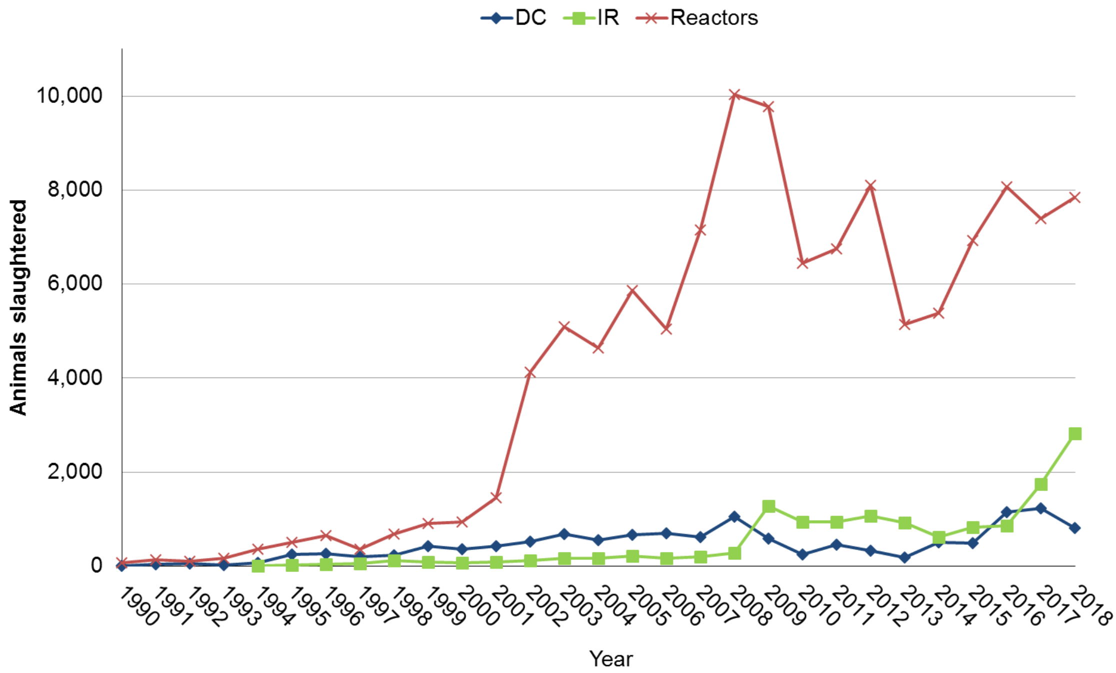



**Figure 4.2a:** Reactors, inconclusive reactors and direct contacts slaughtered for suspected TB, 1990 – 2018

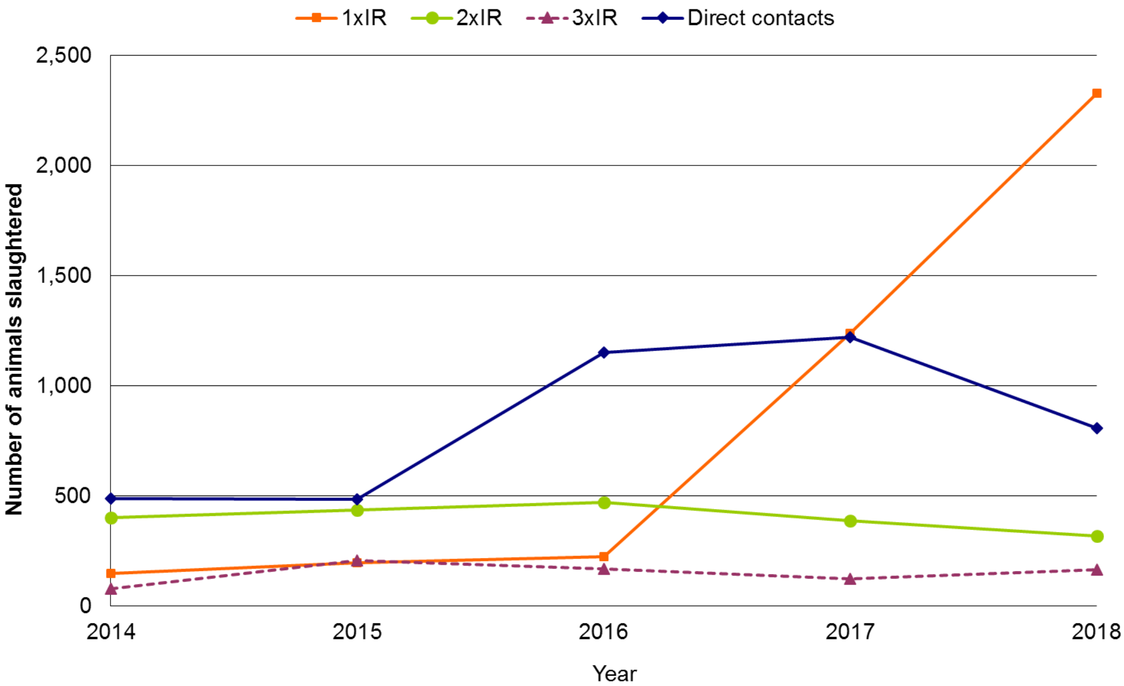



**Figure 4.2b:** Inconclusive reactors[7] and direct contacts slaughtered, 2014 – 2018

[7] Animals having two successive tests giving Inconclusive reactor measurements are generally considered to be skin test reactors, but may be described as "IRs After 2 [or more] tests as IR" to distinguish them from other reactors in some parts of this report. IRs may be re-classified as reactors when interpreted severely.

*4.2 Lesion status of suspected TB cases that were slaughtered*

The lesion status at post mortem examination (PME) of all suspected TB cases that were slaughtered for different TB control reasons in 2018, split by TB Area, are shown in Tables 4.1 a-e.

The overall proportion of reactors (at standard interpretation) in Wales with TB infection confirmed by either DL or culture of *M. bovis* (33%) was lower than the proportions observed in the High Risk Area (HRA) of England (44%) and the Edge Area of England (42%). However, when comparing TB Areas in Wales, the High East TB Area was the same as the HRA of England (44%), with other TB Areas the same or lower than Wales overall (High West; 29%, Intermediate North; 28%, Intermediate Mid; 33% and Low TB Area; 20%). The lower proportions in Wales compared to the HRA and Edge areas in England could be due, in part at least, to the progress Wales has made due to the introduction of annual testing in 2010, which means particularly in the lower incidence areas, disease is found earlier, so there are less lesions to find and culture. The *M. bovis* recovery rate from detected lesions is similar in both England and Wales.

Fifty-nine per cent of the samples submitted from slaughterhouses were *M. bovis* positive, compared to 71% for Great Britain, so unless detection of infection in slaughterhouses in Wales is very different to that in England, this would also support infection being detected earlier in Wales compared to England, in addition to more submissions in Wales coming from lesions not caused by *M. bovis*. In addition to this, samples are submitted for culture from animals which have tested positive to gIFN testing following two inconclusive skin tests at severe interpretation.

The proportion of samples with DLs that were *M. bovis* positive varied by TB Area and was highest in the High TB East Area (93%) and lowest in the Intermediate Mid TB Area (82%; Tables 4.1 a-e). There was also variation in the proportion of *M. bovis* positive samples from NDLs, the highest in the High TB East (6%) and the lowest in the High TB West and Low TB Areas (both 1%).

Overall in Wales, a larger proportion of samples from NDL animals had no culture results (pending or not cultured) compared with those from DL animals (73% vs. 55%). This was the case for most TB Areas apart from the Intermediate Mid TB Area, where the proportion of samples with no culture results was higher for DLs compared to NDLs (55% vs. 70%).

Over half (55%) of samples from DL animals in 2018 were not cultured (or were pending); although this was higher still in DCs (81%), gIFN reactors (85%) and reactors at severe interpretation (63%).

**Table 4.1:** Lesion status of animals for animals slaughtered in 2018, by TB Area

**(a) High East TB Area**

| | Total | Lesion status not Recorded | Detected lesions: % of Total[1] | Detected lesions: *M.bovis* +ve %[2] | Detected lesions: Pending or not cultured | No detected lesions: % of Total | No detected lesions: *M.bovis* +ve %[3] | No detected lesions: Pending or not cultured |
|---|---|---|---|---|---|---|---|---|
| **1. Dangerous contacts (DC)** | **218** | **0** | **5.0%** | **100.0%** | **8** | **95.0%** | **0.0%** | **179** |
| **2. Inconclusive reactors (IR)** | **358** | **0** | **4.7%** | **81.3%** | **1** | **95.3%** | **2.6%** | **265** |
| After 1 test as IR | 253 | 0 | 1.6% | 0.0% | 1 | 98.4% | 0.0% | 223 |
| After 2 tests as IR | 80 | 0 | 16.3% | 100.0% | 0 | 83.8% | 4.8% | 25 |
| After 3 tests as IR | 25 | 0 | 0.0% | 0.0% | 0 | 100.0% | 0.0% | 17 |
| **3. Reactors (R)** | **1,653** | **8** | **27.4%** | **93.2%** | **229** | **72.6%** | **6.9%** | **889** |
| IFN-gamma positive | 435 | 6 | 11.9% | 50.0% | 47 | 88.1% | 2.1% | 330 |
| At standard interpretation | 831 | 1 | 41.8% | 94.4% | 151 | 58.2% | 9.9% | 312 |
| At severe interpretation[4] | 387 | 1 | 13.5% | 90.5% | 31 | 86.5% | 3.4% | 247 |
| **TOTAL of items 1, 2, and 3** | **2,229** | **8** | **21.5%** | **92.5%** | **238** | **78.5%** | **5.6%** | **1,333** |

**(b) High West TB Area**

| | Total | Lesion status not Recorded | Detected lesions: % of Total[1] | Detected lesions: *M.bovis* +ve %[2] | Detected lesions: Pending or not cultured | No detected lesions: % of Total | No detected lesions: *M.bovis* +ve %[3] | No detected lesions: Pending or not cultured |
|---|---|---|---|---|---|---|---|---|
| **1. Dangerous contacts (DC)** | **509** | **2** | **3.4%** | **55.6%** | **8** | **96.6%** | **1.1%** | **400** |
| **2. Inconclusive reactors (IR)** | **2,274** | **2** | **1.5%** | **55.0%** | **15** | **98.5%** | **1.0%** | **1,937** |
| After 1 test as IR | 1,969 | 2 | 1.3% | 38.5% | 13 | 98.7% | 0.6% | 1,785 |
| After 2 tests as IR | 189 | 0 | 4.8% | 85.7% | 2 | 95.2% | 1.2% | 94 |
| After 3 tests as IR | 116 | 0 | 0.0% | 0.0% | 0 | 100.0% | 1.7% | 58 |
| **3. Reactors (R)** | **4,889** | **5** | **13.8%** | **90.4%** | **401** | **86.2%** | **1.1%** | **2,874** |
| IFN-gamma positive | 1,418 | 3 | 1.9% | 28.6% | 20 | 98.1% | 0.3% | 1,051 |
| At standard interpretation | 1,966 | 1 | 28.4% | 95.7% | 329 | 71.6% | 2.1% | 894 |
| At severe interpretation[4] | 1,505 | 1 | 5.7% | 67.6% | 52 | 94.3% | 0.6% | 929 |
| **TOTAL of items 1, 2, and 3** | **7,672** | **9** | **9.4%** | **87.0%** | **424** | **90.6%** | **1.1%** | **5,211** |

| (c) Intermediate North TB Area | Total | Lesion status not Recorded | Detected lesions: % of Total[1] | Detected lesions: *M.bovis* +ve %[2] | Detected lesions: Pending or not cultured | No detected lesions: % of Total | No detected lesions: *M.bovis* +ve %[3] | No detected lesions: Pending or not cultured |
|---|---|---|---|---|---|---|---|---|
| **1. Dangerous contacts (DC)** | **36** | **0** | **2.8%** | **0.0%** | **0** | **97.2%** | **0.0%** | **25** |
| **2. Inconclusive reactors (IR)** | **120** | **0** | **0.0%** | **0.0%** | **0** | **100.0%** | **0.0%** | **92** |
| After 1 test as IR | 85 | 0 | 0.0% | 0.0% | 0 | 100.0% | 0.0% | 76 |
| After 2 tests as IR | 24 | 0 | 0.0% | 0.0% | 0 | 100.0% | 0.0% | 10 |
| After 3 tests as IR | 11 | 0 | 0.0% | 0.0% | 0 | 100.0% | 0.0% | 6 |
| **3. Reactors (R)** | **551** | **1** | **11.6%** | **94.1%** | **30** | **88.4%** | **3.1%** | **258** |
| IFN-gamma positive | 238 | 1 | 3.4% | 100.0% | 6 | 96.6% | 1.1% | 142 |
| At standard interpretation | 211 | 0 | 25.6% | 93.8% | 22 | 74.4% | 5.6% | 67 |
| At severe interpretation[4] | 102 | 0 | 2.0% | 0.0% | 2 | 98.0% | 2.0% | 49 |
| **TOTAL of items 1, 2, and 3** | **707** | **1** | **9.2%** | **91.4%** | **30** | **90.8%** | **2.6%** | **375** |

| (d) Intermediate Mid TB Area | Total | Lesion status not Recorded | Detected lesions: % of Total[1] | Detected lesions: *M.bovis* +ve %[2] | Detected lesions: Pending or not cultured | No detected lesions: % of Total | No detected lesions: *M.bovis* +ve %[3] | No detected lesions: Pending or not cultured |
|---|---|---|---|---|---|---|---|---|
| **1. Dangerous contacts (DC)** | **34** | **0** | **0.0%** | **0.0%** | **0** | **100.0%** | **0.0%** | **18** |
| **2. Inconclusive reactors (IR)** | **48** | **0** | **2.1%** | **0.0%** | **0** | **97.9%** | **2.4%** | **5** |
| After 1 test as IR | 18 | 0 | 5.6% | 0.0% | 0 | 94.4% | 0.0% | 2 |
| After 2 tests as IR | 16 | 0 | 0.0% | 0.0% | 0 | 100.0% | 6.7% | 1 |
| After 3 tests as IR | 14 | 0 | 0.0% | 0.0% | 0 | 100.0% | 0.0% | 2 |
| **3. Reactors (R)** | **523** | **0** | **17.6%** | **85.2%** | **65** | **82.4%** | **2.9%** | **261** |
| IFN-gamma positive | 210 | 0 | 10.0% | 50.0% | 19 | 90.0% | 0.0% | 137 |
| At standard interpretation | 169 | 0 | 30.2% | 90.9% | 29 | 69.8% | 8.1% | 56 |
| At severe interpretation[4] | 144 | 0 | 13.9% | 66.7% | 17 | 86.1% | 0.0% | 68 |
| **TOTAL of items 1, 2, and 3** | **605** | **0** | **15.4%** | **82.1%** | **65** | **84.6%** | **2.6%** | **284** |

| (e) Low TB Area | Total | Lesion status not Recorded | Detected lesions: % of Total[1] | Detected lesions: *M.bovis* +ve %[2] | Detected lesions: Pending or not cultured | No detected lesions: % of Total | No detected lesions: *M.bovis* +ve %[3] | No detected lesions: Pending or not cultured |
|---|---|---|---|---|---|---|---|---|
| **1. Dangerous contacts (DC)** | **11** | **0** | **0.0%** | **0.0%** | **0** | **100.0%** | **0.0%** | **8** |
| **2. Inconclusive reactors (IR)** | **15** | **0** | **26.7%** | **100.0%** | **0** | **73.3%** | **25.0%** | **7** |
| After 1 test as IR | 5 | 0 | 20.0% | 100.0% | 0 | 80.0% | 0.0% | 4 |
| After 2 tests as IR | 10 | 0 | 30.0% | 100.0% | 0 | 70.0% | 25.0% | 3 |
| After 3 tests as IR | 0 | 0 | **0.0%** | 0.0% | 0 | 0.0% | 0.0% | 0 |
| **3. Reactors (R)** | **227** | **1** | **5.3%** | **80.0%** | **2** | **94.7%** | **0.0%** | **129** |
| IFN-gamma positive | 162 | 1 | 1.9% | 50.0% | 1 | 98.1% | 0.0% | 102 |
| At standard interpretation | 40 | 0 | 20.0% | 85.7% | 1 | 80.0% | 0.0% | 11 |
| At severe interpretation[4] | 25 | 0 | 4.0% | 100.0% | 0 | 96.0% | 0.0% | 16 |
| **TOTAL of items 1, 2, and 3** | **253** | **1** | **6.3%** | **85.7%** | **2** | **93.7%** | **1.1%** | **144** |

[1] The denominator for the proportion is the sum of the number of animals with detected lesions (DL) and those without (NDL). Animals whose "lesion status was not recorded" have been disregarded.

[2] The denominator for the proportion is the number with DLs that were cultured.

[3] The denominator for the proportion is the number without DLs, where recorded, that were cultured.

[4] These include *all* animals recorded as reactors irrespective of skin test measurements, but do not have measurements of a standard reactor i.e. it will include animals classified as a reactor during a TB incident because of oedema at the site of injection of bovine tuberculin as well as bovines classified as a reactor on the basis of severe interpretation.

The five-year trend in the proportion of slaughtered suspect TB cases with DLs is shown in Figure 4.3. By monitoring trends over time we can identify changes which might warrant further investigation to see if they represent real changes in the underlying disease, changes in the testing regime, or changes in tuberculin sensitivity. The proportion of reactors with DLs has declined from around 30% in 2014 to around 16% from 2016 to 2018. The proportion of DCs, 1x and 3x IRs with DLs has declined since 2014 whereas the proportion of 2xIRs increased again slightly in 2017 and 2018 (to 8% in 2018). In 2017 and 2018 there were no 3xIRs with DLs.

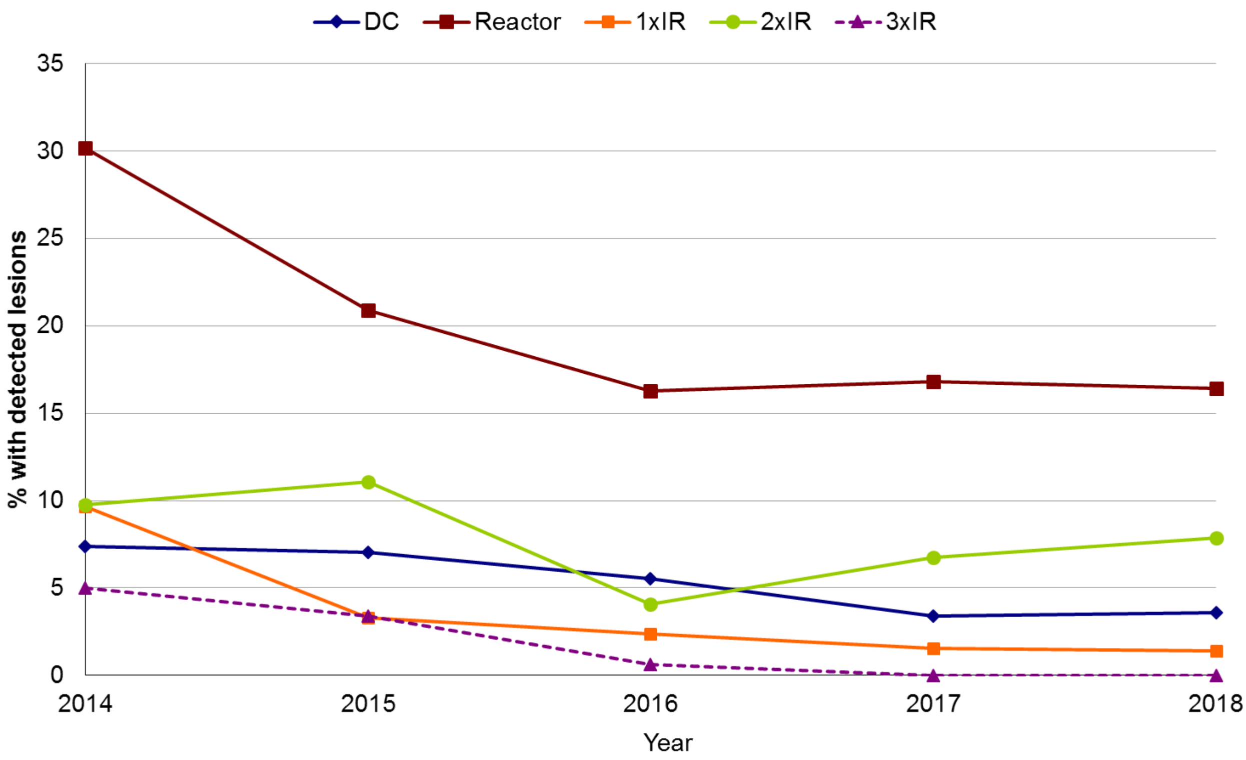



**Figure 4.3:** Proportion of slaughtered cattle with detected lesions[1],2014 – 2018

[1] Where lesion status was known; lesion status was not recorded in around 0.4% of slaughtered suspect TB cases

*4.3 Culture results of animals with detected lesions or no detected lesions*

In multiple-reactor incidents only a sample of reactors are cultured and generally no more than three animals with DL are cultured per incident. Usually only one culture positive sample is collected from each incident for genotyping by spoligotyping and VNTR methods (see Section 8). In addition, if the OTF status of the herd is withdrawn and a genotype is available, no further sampling is undertaken from additional DL reactors and DCs.

Of the 563 DL samples from reactors with culture results in 2018, 91% were *M. bovis* positive. A similar proportion of DL samples with culture results were *M. bovis* positive in England[1] in 2018 (94%). This proportion has ranged in Wales from 86% to 97% since 2003 (mean = 93%; SD = 3%; Figure 4.4).

[1] https://www.gov.uk/government/collections/bovine-tb-surveillance-in-great-britain#2018

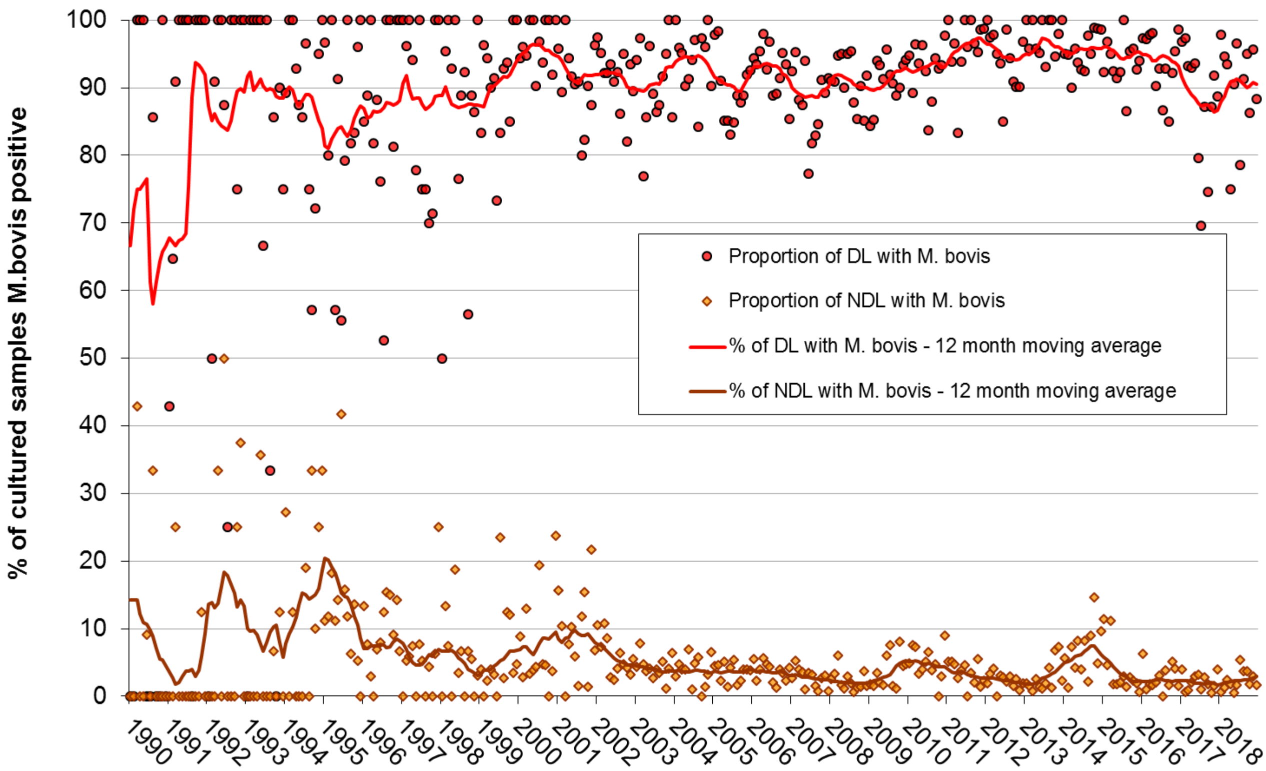



**Figure 4.4**: Monthly proportion of reactor culture samples from which *M. bovis* was obtained, 1990 – 2018

Of the 2,127 NDL samples with culture results in 2018, 48 (2.3%) were confirmed to be *M. bovis* positive. Importantly however, this does not mean that the remaining 98% were not infected since infected animals do not always have detectable lesions or yield positive culture results. Indeed, the earlier reactors are identified the less likely they are to have such lesions or provide positive culture results. Since 2002 there has been a gradual decline in the proportion that were *M. bovis* positive, although a slight increase was observed in 2014 (which coincided with an increase in the number of cattle slaughtered, and the number of reactors alongside an increase in gIFN testing, Figure 4.4). Prior to 2002 there had been substantial variation in the proportion of NDL samples that were *M. bovis* positive, with the 12-month moving average ranging from around 0% to 50% (mean = 8%; SD = 10%). This is, at least in part, a consequence of the small number of samples that were processed at this time, and is evident when looking at the monthly proportions which give us an indication of the variation around the moving average.

Of the 3,341 animals where both the lesion status and culture result was known (i.e. all DL and NDL animals with a positive or a negative result and therefore excluding all animals where lesions status was not known or where no cultures were carried out; excluding slaughterhouse cases), 673 (20%) had evidence of TB: either having detected lesions *OR* being culture positive (i.e. all DL, and NDL animals with positive results only; Figure 4.1).

In England[1] the proportion was significantly higher (74%; Z-test = 28, p<0.001). This difference could be due to contrasting criteria for culture submissions between England and Wales. Other possible explanations could be that the application of annual testing in all

[1] https://www.gov.uk/government/collections/bovine-tb-surveillance-in-great-britain#2018

counties in Wales has led to reactors being detected at an early stage of infection when many lesions are not sufficiently developed to be detected. Alternatively differences in cattle demography and management could affect the risk of exposure to *M. bovis* and susceptibility. There was no significant difference in the proportion of culture positive NDLs in England compared with Wales in 2018 (2.8% vs. 2.1%; Z-test = 0.2, $p > 0.05$).

# 5.0 Duration of bovine TB incidents in Wales

**Key points:**

- In each TB Area, all OTF-S incidents were closed within 240 days, compared to 40-57% of OTF-W incidents (Table 5.1)
- Incident duration was significantly longer in herds with over 300 animals and in dairy herds (Table 5.2)
- OTF-W incidents of very long duration were more common in the High TB Areas (West and East) (Figure 5.2)

The management of cattle herds is affected by the extent and duration of movement restrictions imposed as a consequence of a TB incident. Lengthening the time a herd is under restriction increases the socioeconomic burden for both the farmer and government managing the incident. However, such movement restrictions are necessary for ensuring infection has been eliminated from a herd through the identification and removal of any remaining infected animals. This reduces the risk of recurrence. Restrictions are maintained until there is sufficient evidence from negative tests to believe that infection has been removed from the herd. There are many factors which may increase the duration of time that herds are under movement restrictions. These include poor responsiveness of some animals to the skin test, intense cattle-to-cattle transmission (occurring, for example, in large herds), and continuing reinfection (e.g. from wildlife or neighbouring herds). In this section we look at trends in the duration of TB incidents and factors impacting those trends.

*5.1 Bovine TB incident duration in 2018 and the annual trend in median duration trends*

The duration of incidents closing in 2018 varies according to TB risk area (Table 5.1). The difference between the mean and the median reflects the number of outliers in the distribution which again varies by TB area – i.e. incidents lasting for many years.

The longest restriction duration for incidents closing in 2018 was nearly ten years (one herd in the High East TB Area). The duration of movement restrictions of OTF-S incidents in all TB Areas was significantly shorter than those of OTF-W incidents ($P<0.001$), where 80 to 100% of OTF-S incidents closed within 150 days, compared to 4% to 14% OTF-W incidents depending on TB Area. Using the Mann-Whitney test, the z-value indicates the difference between the duration of OTF-S incidents compared to OTF-W incidents:

- High East ($z=-6.581$)
- High West ($z=-6.868$)
- Intermediate Mid ($z=-4.627$)
- Intermediate North ($z=-4.573$)
- Low ($z=-4.409$)

This reflects the different management protocols for OTF-W and OTF-S incidents in Wales: OTF-S incidents require one clear whole herd test, while OTF-W incidents require two with a minimum of 60 days between each. Part of the reason that OTF-W incidents last longer than OTF-S incidents, on average, is the requirement for two consecutive clear tests as opposed to only one and the use of the higher-sensitivity severe interpretation of the skin test. Furthermore, additional post-mortem evidence of infection in OTF-W incidents indicates the presence of advanced stages of *M. bovis* infection (as well as being generated for epidemiological reasons other than confirmation of disease), and these incidents are likely to take longer to clear.

**Table 5.1**: Restriction durations of incidents closed in 2018

| TB Area | | Number of incidents closed in 2018<br>Total (% of total) | OTF-W (% of total) | OTF-S (% of total) |
|---|---|---|---|---|
| **High East** | Number of incidents closed in 2018 where duration of movement restrictions was: | | | |
| | Up to 100 days | 8 (2.9) | 2 (0.8) | 6 (30.0) |
| | 101 – 150 days | 27 (9.7) | 17 (6.6) | 10 (50.0) |
| | 151 – 240 days | 131 (47.1) | 127 (49.2) | 4 (20.0) |
| | 241 – 550 days | 97 (34.9) | 97 (37.6) | 0 |
| | 551 plus days | 15 (5.4) | 15 (5.8) | 0 |
| | Mean incident duration (days) | 275.1 | 287.0 | 121.9 |
| | Median incident duration (days) | 207 | 213.5 | 112.5 |
| | Duration range (days) | 59 – 3,593 | 59 – 3,593 | 80 - 186 |
| **High West** | Number of incidents closed in 2018 where duration of movement restrictions was: | | | |
| | Up to 100 days | 8 (2.6) | 0 | 8 (38.1) |
| | 101 – 150 days | 20 (6.6) | 11 (3.9) | 9 (42.9) |
| | 151 – 240 days | 119 (39.3) | 115 (40.8) | 4 (19.0) |
| | 241 – 550 days | 130 (42.9) | 130 (46.1) | 0 |
| | 551 plus days | 26 (8.6) | 26 (9.2) | 0 |
| | Mean incident duration (days) | 301.3 | 314.5 | 123.4 |
| | Median incident duration (days) | 245 | 251.5 | 118 |
| | Duration range (days) | 77 – 1,180 | 105 – 1,180 | 77 - 209 |
| **Intermediate North** | Number of incidents closed in 2018 where duration of movement restrictions was: | | | |
| | Up to 100 days | 9 (16.4) | 1 (2.2) | 8 (88.9) |
| | 101 – 150 days | 2 (3.6) | 1 (2.2) | 1 (11.1) |
| | 151 – 240 days | 24 (43.6) | 24 (52.2) | 0 |
| | 241 – 550 days | 19 (34.5) | 19 (41.3) | 0 |
| | 551 plus days | 1 (1.8) | 1 (2.2) | 0 |
| | Mean incident duration (days) | 233.4 | 260.7 | 93.7 |
| | Median incident duration (days) | 208 | 236.5 | 97 |
| | Duration range (days) | 80 - 655 | 95 - 655 | 80 - 103 |
| **Intermediate Mid** | Number of incidents closed in 2018 where duration of movement restrictions was: | | | |
| | Up to 100 days | 2 (3.6) | 0 | 2 (14.3) |
| | 101 – 150 days | 15 (26.8) | 6 (14.3) | 9 (64.3) |
| | 151 – 240 days | 14 (25.0) | 11 (26.2) | 3 (21.4) |
| | 241 – 550 days | 22 (39.3) | 22 (52.4) | 0 |
| | 551 plus days | 3 (5.4) | 3 (7.1) | 0 |
| | Mean incident duration (days) | 248.2 | 288.0 | 128.6 |
| | Median incident duration (days) | 181 | 259.5 | 121 |
| | Duration range (days) | 89 - 970 | 128 - 970 | 89 - 196 |

| | | Number of incidents closed in 2018 | | |
|---|---|---|---|---|
| **TB Area** | | **Total (% of total)** | **OTF-W (% of total)** | **OTF-S (% of total)** |
| **Low TB** | Number of incidents closed in 2018 where duration of movement restrictions was: | | | |
| | Up to 100 days | 4 (13.3) | 0 | 4 (28.6) |
| | 101 – 150 days | 10 (33.3) | 1 (6.3) | 9 (64.3) |
| | 151 – 240 days | 9 (30.0) | 8 (50.0) | 1 (7.1) |
| | 241 – 550 days | 7 (23.3) | 7 (43.8) | 0 |
| | 551 plus days | 0 | 0 | 0 |
| | Mean incident duration (days) | 171.5 | 221.5 | 114.3 |
| | Median incident duration (days) | 161 | 223 | 112 |
| | Duration range (days) | 80 - 318 | 147 - 318 | 80 - 185 |

The median duration of OTF-W incidents gradually increased between 1990 and 2000 before increasing to approximately 250 days in 2001, coinciding with the Foot and Mouth Disease outbreak in that year (Figure 5.1a). Subsequently, it has remained relatively stable averaging 240 days, with a decrease of 5.6% in the duration of OTF-W incidents in 2018 compared to 2010 (however, there was a 1.7% increase in 2018 compared to 2017). It is important to note that some or all of the decrease in the median duration of TB incidents since 2010 may be attributable to a change in the definition of OTF-W and OTF-S incidents.

From January 2011, some incidents that would have traditionally been classified as OTF-S were instead classified as OTF-W for epidemiological reasoning. This meant that some of the longer-lasting OTF-S incidents were lost from the OTF-S cohort, reducing the mean average. These incidents were still shorter than the existing OTF-W cases, further reducing the OTF-W mean average. For OTF-S incidents, the mean average since 2001 has been 118 days although since 2013 the median duration has been lower than the mean. In 2018 the median duration increased by 14.4% compared to 2017 (97 days to 111 days).

Figures 5.1 b and c show the median duration for OTF-W and OTF-S incidents, respectively, with the 25$^{th}$ and 75$^{th}$ percentiles illustrated as error bars which shows the wider variation in the duration of OTF-W incidents.

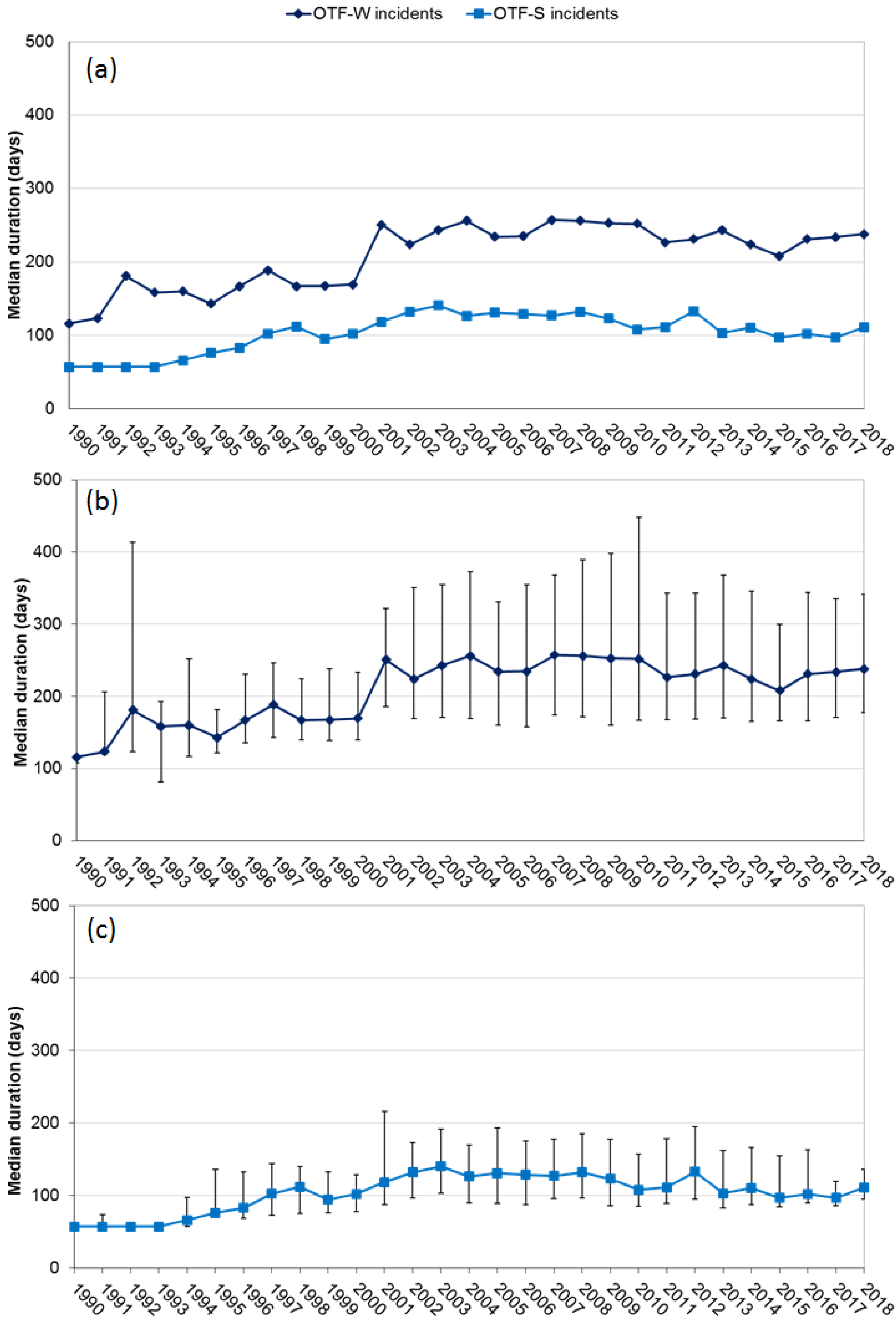



**Figure 5.1**: Median duration of OTF-W and OTF-S incidents ending between 1990 and 2018 (A), with interquartile ranges for OTF-W (B) and OTF-S (C) incidents presented separately

*5.2 Variation in TB duration by TB-free status, herd type, herd size and geographical area*

**Table 5.2:** Analysis of factors associated with incident duration (log-transformed), 2018

| | Number of incidents | Mean duration (days) | Median duration (days) | Linear regression analysis: Unadjusted[1] | | | Linear regression analysis: Adjusted[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Coefficient[3] | 95% CI | | Coefficient[3] | 95% CI | |
| **TB-free status type** | | | | | | | | | |
| OTF-W | 644 | 296 | 238 | *Ref* | | | *Ref* | | |
| OTF-S | 78 | 119 | 111 | -0.81*** | -0.92 | -0.70 | -0.69*** | -0.80 | -0.58 |
| **Herd size** | | | | | | | | | |
| 0 – 10 | 15 | 188 | 179 | -0.57*** | -0.83 | -0.30 | -0.29* | -0.53 | -0.05 |
| 11 – 50 | 138 | 206 | 179 | -0.48*** | -0.59 | -0.36 | -0.29*** | -0.40 | -0.17 |
| 51 – 100 | 162 | 266 | 192.5 | -0.33*** | -0.44 | -0.22 | -0.19*** | -0.29 | -0.08 |
| 101 – 200 | 165 | 254 | 225 | -0.28*** | -0.39 | -0.17 | -0.19*** | -0.29 | -0.09 |
| 201 – 300 | 87 | 327 | 259 | -0.06ns | -0.19 | 0.07 | -0.04ns | -0.16 | 0.08 |
| > 300 | 155 | 354 | 292 | *Ref* | | | *Ref* | | |
| **Herd type** | | | | | | | | | |
| Beef | 432 | 244 | 189 | *Ref* | | | *Ref* | | |
| Dairy | 287 | 327 | 271 | 0.29*** | 0.21 | 0.36 | 0.13** | 0.05 | 0.21 |
| Other/mixed | 3 | 170 | 176 | -0.22ns | -0.79 | 0.36 | -0.09ns | -0.59 | 0.41 |
| **TB Area** | | | | | | | | | |
| High West | 303 | 301 | 245 | *Ref* | | | *Ref* | | |
| High East | 278 | 275 | 207 | -0.11** | -0.20 | -0.03 | -0.03ns | -0.11 | 0.04 |
| Intermediate North | 56 | 248 | 181 | -0.21** | -0.35 | -0.06 | -0.01ns | -0.14 | 0.12 |
| Intermediate Mid | 55 | 233 | 208 | -0.23** | -0.38 | -0.08 | -0.15* | -0.28 | -0.02 |
| Low | 30 | 171 | 161 | -0.50*** | -0.69 | -0.31 | -0.18* | -0.35 | -0.01 |

*, **, *** and ns denote levels of statistical significance of p≤0.05, p≤0.01, p≤0.001 and not significant respectively.
[1] Results of univariable linear regression analyses of the logarithm of duration of TB incidents that ended in 2018 on each of the independent variables (OTF status, herd size, herd type or geographical area).
[2] Results of multivariable linear regression analyses of the logarithm of duration of TB incidents that ended in 2018 on the OTF status, herd size, herd type or geographical area, adjusted for the effects of other independent variables.
[3] The outcome 'duration' was log transformed for analysis due to non-normal distribution and unequal variance; the coefficient was derived following this log transformation.

Table 5.2 shows the duration of movement restrictions of incidents ending in 2018 by TB-free status, herd size, herd type and risk area. Also presented are regression coefficients, which indicate the size and direction of the associations between incident duration (outcome) and herd size, type and geographical area (predictors). The coefficients of the categories within the predictor variables are calculated *relative* to a reference category

("*Ref*") (see Materials and Methods for explanation of the choice of reference category). Coefficients greater than 0, i.e. positive coefficients, indicate that the incident duration is longer in that category than in the reference category, whereas negative coefficients indicate the duration is shorter compared with the reference category.

The median duration of movement restrictions following a TB incident increased with herd size and was significantly shorter in herds with fewer than 200 animals compared with the largest herds (>300 animals) and this effect remained after adjusting for herd type and location. This is not surprising since increasing herd size is likely to increase density-dependent transmission of infection. Duration of movement restrictions in herds with 201-300 cattle was not significantly different to herds with over 300 animals (the median was 259 days compared to 292 days in herds with over 300 cattle). Although the multivariable regression analysis attempts to adjust for herd size, this is likely to be incomplete because herd size is imperfectly measured, i.e. it does not account for the number and size of any epidemiological groups within a herd and cannot account for within-herd clustering.

After adjusting for herd size and location, incidents were significantly longer in dairy herds compared with beef herds. This is consistent with the effect observed over the previous five years.

Incident duration varied significantly between TB Areas. Relative to the High TB West Area, incidents were shorter in all other TB Areas in Wales, however this effect did not remain for all areas after adjusting for herd size, type and OTF status. Only the Intermediate Mid and Low TB Areas had a significantly shorter duration of movement restrictions than the reference category, the High TB West Area.

OTF-W incidents of very long duration (over 18 months) tended to be clustered in the High TB Areas in the West and East, affecting South West Wales and in counties along the border with England (Figure 5.2). This is clearly reflected in Figure 5.4, which shows the geographical location of herds under movement restrictions for more than 550 days. In areas where there were fewer incidents, including the Low TB Area, these tended to be of shorter duration. However, some isolated incidents of long duration did occur in areas where TB incidence was low (one in the Intermediate North and three in the Intermediate Mid TB Area lasting more than 550 days). There were no herds with OTF-S incidents closing in 2018 that had been under restrictions for longer than 240 days (Table 5.1, Figure 5.3).

Figure 5.5 shows incidents that were open for the whole of 2018 but started prior to 2018. There were 167 such incidents, with only one OTF-S, the remainder of which were OTF-W, and they were clustered in the High TB Areas in the East and West and along the border with England in the Intermediate North TB Area.

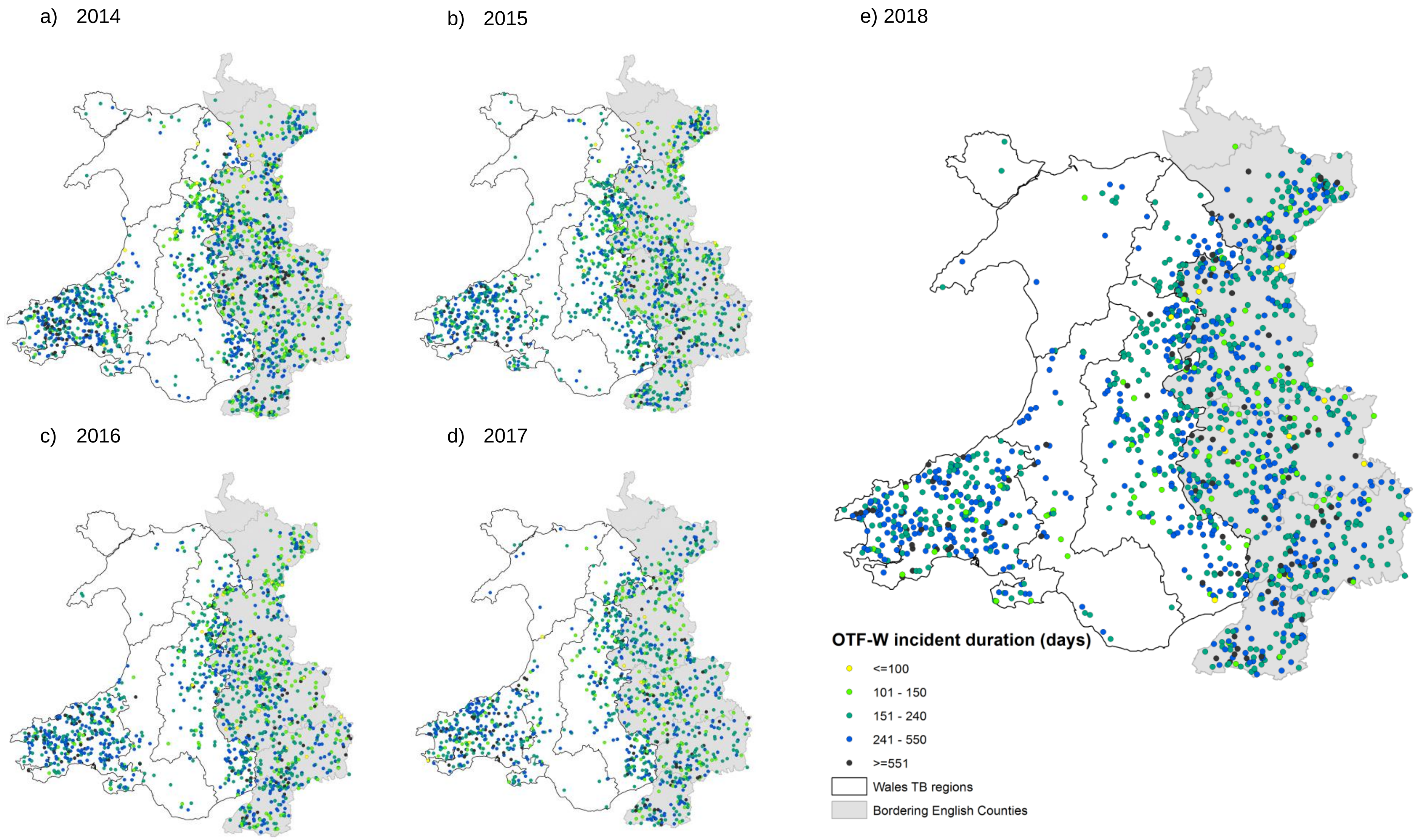



**Figure 5.2:** OTF-W incidents by duration, closing 2014 – 2018

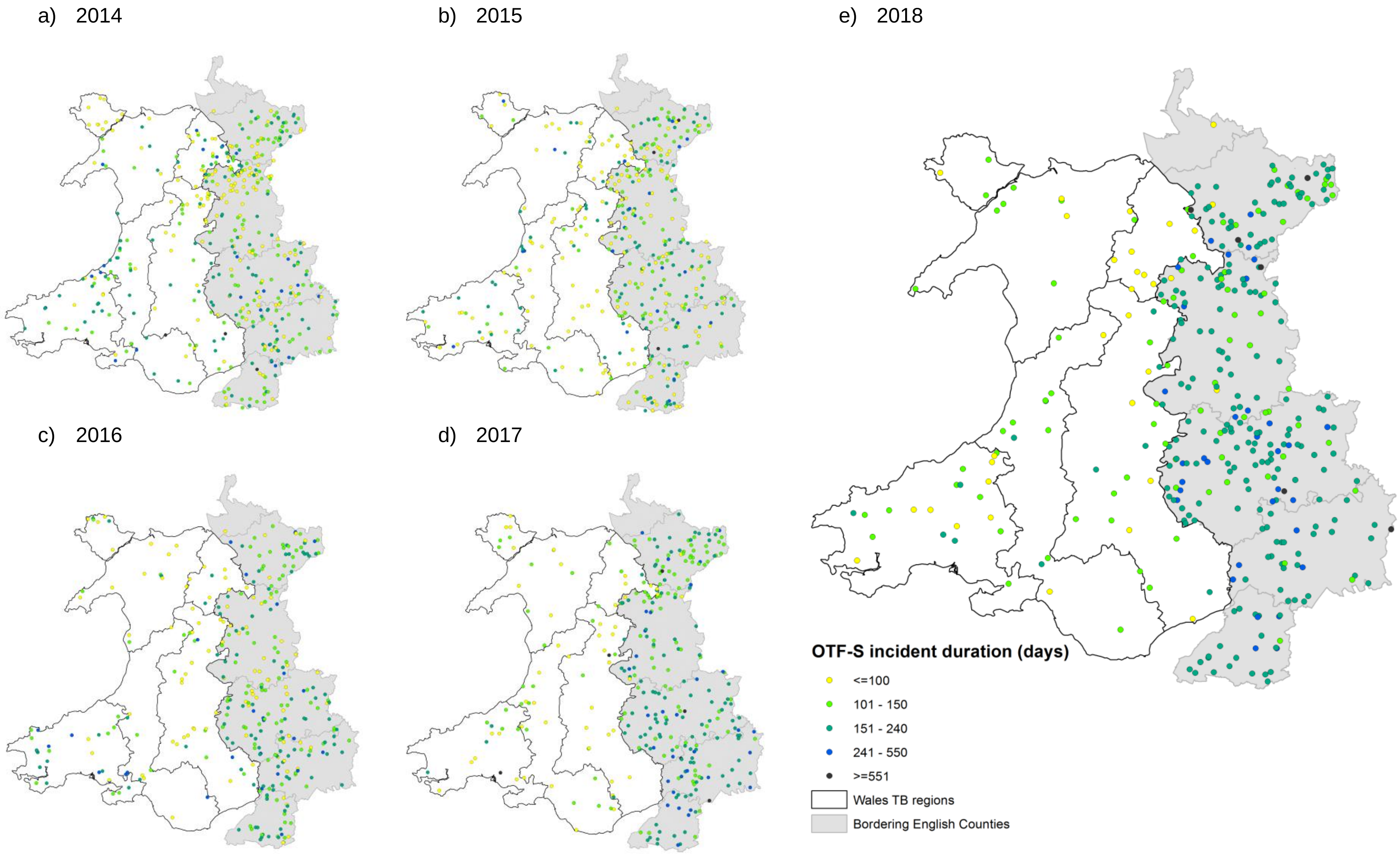



**Figure 5.3:** OTF-S incidents by duration, closing 2014 – 2018

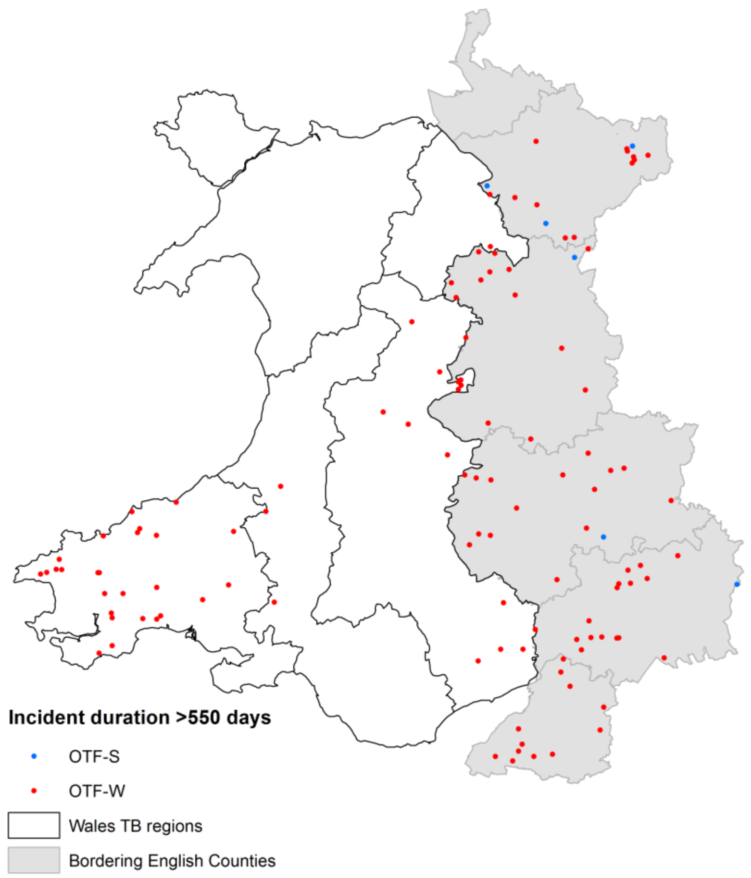



**Figure 5.4:** Incidents of longer than 550 days duration, closing in 2018

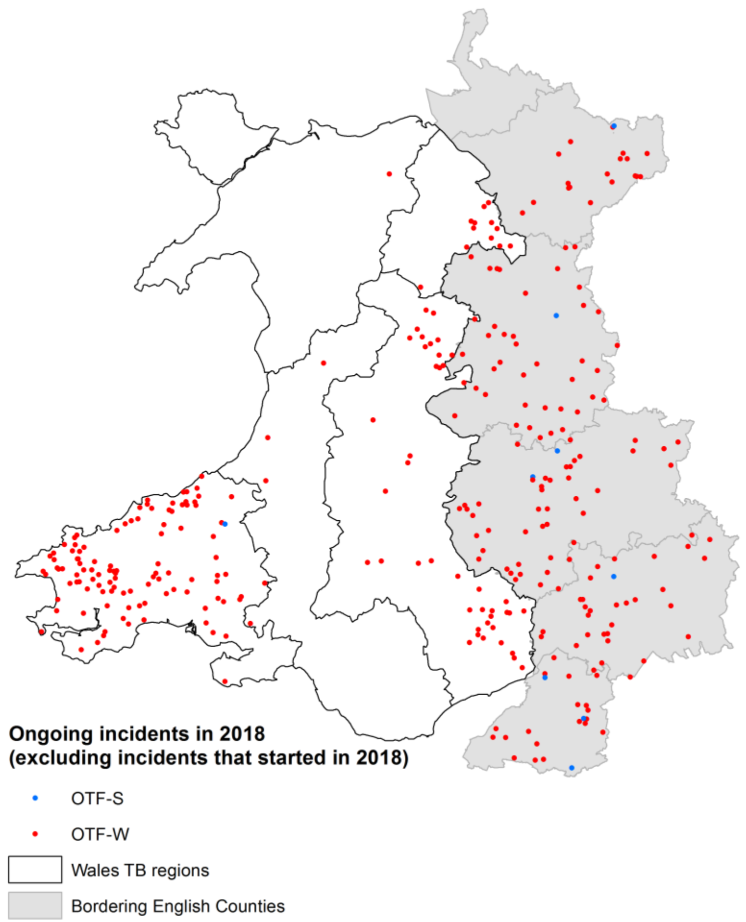



**Figure 5.5:** Open incidents at the end of the year which started prior to 2018

# 6.0 Recurrent incidents

**Key points:**

- The proportion of herds with a TB incident that had a history of TB was 3.5 times higher than the proportion with no TB history (Table 6.2)
- Herds with a history of TB, with herd sizes of 51-200 animals, beef herds and herds found in the High West and Intermediate Mid TB Areas were more likely to have a TB incident in 2018 compared to herds in these categories with no history of TB (Table 6.2)
- Intervals between incidents were longer for OTF-S incidents in 2018 compared to OTF-W (Table 6.3)

Recurrence of TB in a herd may be due to persistence of infection from a previous TB incident, or the result of a newly introduced infection. In this section we look at the proportion of herds with recurrent TB incidents, to identify how recurrence changes over time and to describe factors associated with recurrence.

A recurrent incident is defined in this report as the first TB incident disclosed during the Current Period (2018) where the herd was previously under restriction for TB at any time during a History Period. The History Period is defined as the 36 months preceding the start date of the recurrent incident or, where no recurrent incident has occurred in a herd, is the 36 months prior to the mid-point of the Current Period[1]. Further details are provided in Appendix 1.

Of all herds that had a history of TB consistent with the definition outlined above, 16% (265/1,612) had a new incident in 2018, similar to the proportions observed in preceding years. Eighty-two per cent of herds (9,480/11,542) did not have any TB incidents in either the Current or History period; a similar proportion as that seen in previous years.

Herds that had a new TB incident in 2018 were significantly more likely to have been placed under movement restrictions due to a TB incident during the History period compared with herds that remained OTF in the Current period ($p<0.01$ by Fisher's Exact test) in all TB Areas apart from the Low TB Area ($p>0.05$ by Fishers Exact test).

Additionally, herds that had a new OTF-W TB incident in 2018 were significantly more likely to have been restricted due to an OTF-W TB incident during the History period compared with herds that had a new OTF-S incident in the Current period ($p<0.05$ by Fisher's Exact test), in all TB Areas.

[1] The recurrence analyses included all herds active at the end of the Current Period (2018). Herds that were under restriction for four or more months in the Current Period due to an incident that started prior to the Current Period were excluded from the analyses. It was considered that such herds had limited opportunity to become cases since there may have been no further testing in the Current Period following the close of the incident. Setting a threshold of four months allows for the detection of possible recurrence at the 'six months' (6M) test scheduled after lifting of restrictions in herds within the first four months of the current year; Some latitude was allowed for practical issues relating to scheduling of tests towards year end of the Current Period.

**Tables 6.1 (a-e):** Incident and non-incident herds by TB history, 2018

| **a) High TB East** | **TB incidents in the history period (36 months)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Any incident | | ≥ 1 OTF-W incidents | | OTF-S incidents only | |
| | No previous incidents (a) | Number (b) | % (b/(a+b)) | Number (c) | % (c/(a+b)) | Number (d) | % (d/(a+b)) |
| **TB status in current period** | | | | | | | |
| OTF herds[1] | 1,994 | 487 | 20 | 435 | 18 | 52 | 2 |
| Any new TB incident | 145 | 98 | 40 | 90 | 37 | 8 | 3 |
| OTF-W herds | 127 | 96 | 43 | 89 | 40 | 7 | 3 |
| OTF-S herds | 18 | 2 | 10 | 1 | 5 | 1 | 5 |
| Total herds | 2,139 | 585 | 21 | 525 | 19 | 60 | 2 |

| **b) High TB West** | **TB incidents in the history period (36 months)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Any incident | | ≥ 1 OTF-W incidents | | OTF-S incidents only | |
| | No previous incidents (a) | Number (b) | % (b/(a+b)) | Number (c) | % (c/(a+b)) | Number (d) | % (d/(a+b)) |
| **TB status in current period** | | | | | | | |
| OTF herds[1] | 2,136 | 575 | 21 | 534 | 20 | 41 | 2 |
| Any new TB incident | 184 | 135 | 42 | 133 | 42 | 2 | 1 |
| OTF-W herds | 159 | 133 | 46 | 132 | 45 | 1 | 0 |
| OTF-S herds | 25 | 2 | 7 | 1 | 4 | 1 | 4 |
| Total herds | 2,320 | 710 | 23 | 667 | 22 | 43 | 1 |

| **c) Intermediate TB Mid** | **TB incidents in the history period (36 months)** | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Any incident | | ≥ 1 OTF-W incidents | | OTF-S incidents only | |
| | No previous incidents (a) | Number (b) | % (b/(a+b)) | Number (c) | % (c/(a+b)) | Number (d) | % (d/(a+b)) |
| **TB status in current period** | | | | | | | |
| OTF herds[1] | 1,838 | 131 | 7 | 89 | 5 | 42 | 2 |
| Any new TB incident | 43 | 15 | 26 | 12 | 21 | 3 | 5 |
| OTF-W herds | 34 | 14 | 29 | 12 | 25 | 2 | 4 |
| OTF-S herds | 9 | 1 | 10 | 0 | 0 | 1 | 10 |
| Total herds | 1,881 | 146 | 7 | 101 | 5 | 45 | 2 |

| d) Intermediate TB North | TB incidents in the history period (36 months) | | | | | |
|---|---|---|---|---|---|---|
| | | Any incident | | ≥ 1 OTF-W incidents | | OTF-S incidents only | |
| | No previous incidents (a) | Number (b) | % (b/(a+b)) | Number (c) | % (c/(a+b)) | Number (d) | % (d/(a+b)) |
| **TB status in current period** | | | | | | | |
| OTF herds[1] | 785 | 81 | 9 | 59 | 7 | 22 | 3 |
| Any new TB incident | 47 | 14 | 23 | 11 | 18 | 3 | 5 |
| OTF-W herds | 40 | 14 | 26 | 11 | 20 | 3 | 6 |
| OTF-S herds | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total herds | 832 | 95 | 10 | 70 | 8 | 25 | 3 |

| e) Low TB | TB incidents in the history period (36 months) | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Any incident | | ≥ 1 OTF-W incidents | | OTF-S incidents only | |
| | No previous incidents (a) | Number (b) | % (b/(a+b)) | Number (c) | % (c/(a+b)) | Number (d) | % (d/(a+b)) |
| **TB status in current period** | | | | | | | |
| OTF herds[1] | 2,727 | 73 | 3 | 31 | 1 | 42 | 2 |
| Any new TB incident | 31 | 3 | 9 | 2 | 6 | 1 | 3 |
| OTF-W herds | 19 | 3 | 14 | 2 | 9 | 1 | 5 |
| OTF-S herds | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total herds | 2,758 | 76 | 3 | 33 | 1 | 43 | 2 |

[1] Whether a herd was active in the History Period was not checked
[2] A herd was classified as OTF in 2018 if it did not suffer a new incident in 2018 or was under movement restrictions due to a previous incident for less than four months of 2018, and thus had the potential to have a recurrent incident later in the Current period. Herds under restriction for four or more months of 2018 due to an incident that started before 2018, were excluded from analyses (n=413)

Since 2015 there has been a slight decrease in the proportion of TB incident herds that had a previous TB incident, and this trend continued in 2018, in all TB Areas (Figure 6.1). As would be expected, the trend of all TB incidents closely follows that of OTF-W incidents. In 2015, the proportion of OTF-W incidents with TB history (recurrent TB) was highest in the High TB West (64%), and Intermediate North Areas (60%) but has since declined to 46% and 26% respectively. Other TB Areas have also seen a similar declining trend but with lower proportions. In the High East TB Area, the highest proportion was observed in 2016 (52%) but over the past two years has dropped to 43%. In 2018, the Low and Intermediate Mid TB Areas had the lowest proportions of recurrent OTF-W incidents (14% and 10% respectively). As expected, the Low TB Area had the fewest numbers of recurrent TB incidents in 2018 (three OTF-W incidents in total).

In all TB Areas, the proportion of OTF-S incidents that are recurrent is much lower compared to OTF-W incidents. The trend for declining recurrent incidents closely reflects the patterns of overall TB incidence, irrespective of incident classification. This is expected as declines in incidence in one year will result in fewer herds with a history of TB at a later date.

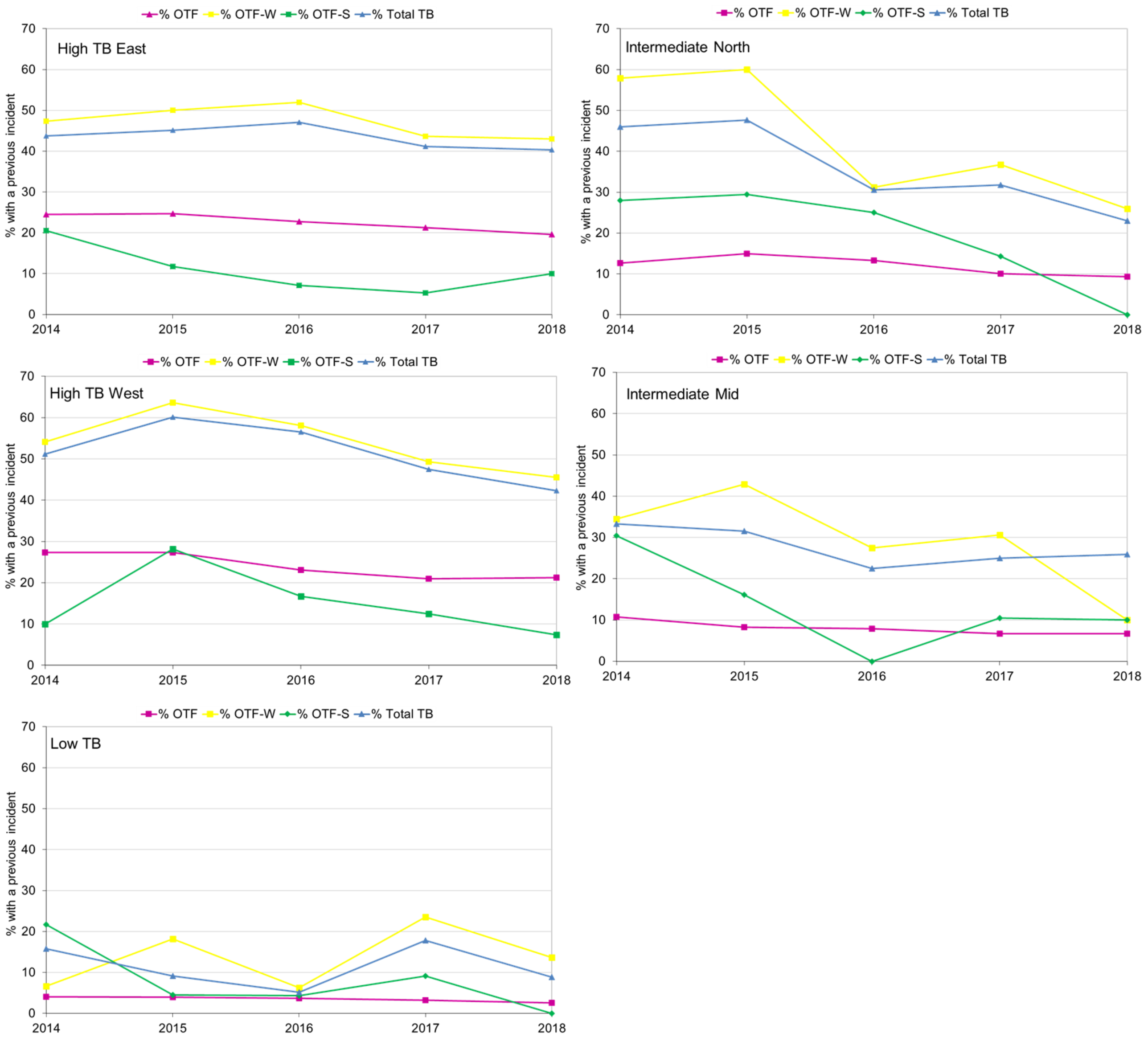



**Figure 6.1:** Proportion of herds with a history of TB, by OTF status and TB Area, 2014 – 2018

To account for the differences in the underlying risk in the population, a logistic regression analysis has been performed where the outcome is the odds ratio after adjustment for herd size, herd type and county. The odds ratio represents the probability of a herd having a TB incident in the current year following an incident in the previous 36 months, compared with the odds of a TB incident occurring where there is no history of an incident.

A total of 416 herds defined as ‘Other/ Mixed’ herd type were removed from the logistic regression analysis as the model would not run with them included, due to only two herds having recurrent TB which resulted in very wide/misleading confidence intervals.

**Table 6.2:** Herds with and without an incident in 2018, by TB history

| | TB incident in the History Period[1] | | No TB incident in the History Period[1] | | Odds ratio (adjusted)[2] | 95% CI for odds ratio | |
|---|---|---|---|---|---|---|---|
| | Herds | Incident in 2018 (%) | Herds | Incident in 2018 (%) | | | |
| **Herd size** | | | | | | | |
| 0 - 10 | 58 | 1 (1.7) | 1,996 | 10 (0.5) | 2.5 ns | 0.3 | 19.9 |
| 11 - 50 | 313 | 20 (6.4) | 3,471 | 104 (3) | 1.5 ns | 0.9 | 2.5 |
| 51 - 100 | 363 | 44 (12.1) | 1,917 | 114 (5.9) | 1.5 | 1.0 | 2.2 |
| 101 - 200 | 403 | 66 (16.4) | 1,288 | 89 (6.9) | 1.7 | 1.2 | 2.4 |
| 201 - 300 | 194 | 42 (21.6) | 439 | 54 (12.3) | 1.1 ns | 0.7 | 1.7 |
| >300 | 277 | 90 (32.5) | 407 | 78 (19.2) | 1.3 ns | 0.9 | 1.9 |
| Undetermined | 0 | 0 (0) | 0 | 0 (0) | - | - | - |
| **Herd type[3]** | | | | | | | |
| Beef | 1,001 | 122 (12.2) | 8,072 | 291 (3.6) | 1.6 | 1.3 | 2.0 |
| Dairy | 607 | 141 (23.2) | 1,446 | 158 (10.9) | 1.2 ns | 0.9 | 1.6 |
| **TB Area** | | | | | | | |
| High East | 584 | 97 (16.6) | 2,051 | 144 (7) | 1.5 | 1.1 | 2.0 |
| High West | 708 | 134 (18.9) | 2,222 | 184 (8.3) | 1.3 ns | 1.0 | 1.6 |
| Intermediate Mid | 146 | 15 (10.3) | 1,814 | 43 (2.4) | 2.2 | 1.2 | 4.2 |
| Intermediate North | 94 | 14 (14.9) | 795 | 47 (5.9) | 1.6 ns | 0.8 | 3.1 |
| Low | 76 | 3 (3.9) | 2,636 | 31 (1.2) | 1.7 ns | 0.5 | 5.8 |
| **Total** | 1,608 | 263 (16.4) | 9,518 | 449 (4.7) | | | |

[1] Herds under restriction any time in the history period, unless the restriction lasted for more than four months into 2018; in which case the herd was excluded from analyses; the History Period is defined as the 36 months preceding the start date of the recurrent incident or, where no recurrent incident has occurred in a herd, is the 36 months prior to the mid-point of the Current Period

[2] The odds that herds under movement restrictions in the 36-month history period had a new TB incident in 2018 when compared with herds that had no history of movement restrictions.

ns Not statistically significant

[3] A total of 416 herds defined as Other/ Mixed herd type were dropped from the logistic regression analysis since the analysis could not run correctly with them included. There were only four herds with a TB incident in the history period, two of which had a TB incident in 2018, and of the 412 herds with no TB history, only one had a TB incident in 2018.

The odds of a new incident occurring in herds with TB history were consistently greater than for those with no TB history. However, the odds ratios were only statistically significant for herds with 51-100 and 101-200 animals, beef herds and for the High East and Intermediate Mid TB Areas of Wales (Table 6.2). The confidence intervals for the odds ratios across other herd size categories, dairy herds and other TB areas overlap, meaning that it is not possible to discern true differences in these categories.

Table 6.3 shows descriptive statistics for the time elapsed between the end of movement restrictions in the most recent TB incident in the history period and the start date of the first incident in the current period.

**Table 6.3:** Time elapsed between the end of movement restrictions in the most recent TB incident in the history period and the start date of the first incident in the current period

| Previous incident type[1] | 2018 incident type[2] | Time elapsed (days)[3] | | | | |
|---|---|---|---|---|---|---|
| | | Mean | Median | SD | Min | Max |
| Any | Any | 507 | 477 | 295 | 71 | 1,092 |
| OTF-W | Any | 505 | 477 | 291 | 71 | 1,092 |
| OTF-S | Any | 540 | 534 | 358 | 105 | 1,074 |
| Any | OTF-W | 506 | 477 | 296 | 71 | 1,092 |
| OTF-W | OTF-W | 505 | 477 | 291 | 71 | 1,092 |
| OTF-S | OTF-W | 530 | 467 | 371 | 105 | 1,074 |
| Any[4] | OTF-S | 565 | 545 | 271 | 252 | 962 |
| OTF-W | OTF-S | 533 | 533 | 189 | 399 | 666 |
| OTF-S | OTF-S | 586 | 545 | 357 | 252 | 962 |

[1] Any: The most recent incident in the history period regardless of whether OTF-S or OTF-W incident; OTF-W: the last incident where the last incident was OTF-W; OTF-S: the last incident where the last incident was OTF-S

[2] Any: OTF-S or OTF-W incident(s) in 2018; OTF-W: OTF-W incident(s) occurred at any time in 2018 (not necessarily the first); OTF-S: only OTF-S incident(s) occurred in 2018

[3] For herds that had an OTF-S incident in the current period followed later in the year by an OTF-W incident, the date of the OTF-W incident was used but the OTF status was classified as OTF-W. Includes only recurrent incidents where the preceding incident ended between 1st January 2015 and the end of April 2018; Time elapsed was calculated as the number of days between the end of the last incident and the start of the first new incident in 2018. If the first incident in 2018 was OTF-S but the herd subsequently had an OTF-W incident, the 2018 incident type is shown as OTF-W but the date of the first incident (OTF-S) is used to calculate the time elapsed.

Of the 265 recurrent incidents included in the analyses, the time elapsed between incidents ranged from 71 days to 36 months (median = 18 months). The median duration between incidents tended to be slightly longer where the 2018 incident type was OTF-S compared with where the 2018 incident type was OTF-W (Table 6.3).

Figure 6.2 illustrates the distribution of recurrent incidents in Wales and bordering English counties between 2014 and 2018. The distribution of recurrent incidents has been similar over the last five years, but the decline in the High East and West TB Areas is evident. The majority of recurrent herds in 2018 had experienced just one previous OTF-W incident in the history period, only two herds' experienced three incidents in 2016 to 2018, and there were no herds with more than three recurrent OTF-W incidents from 2014 to 2018.

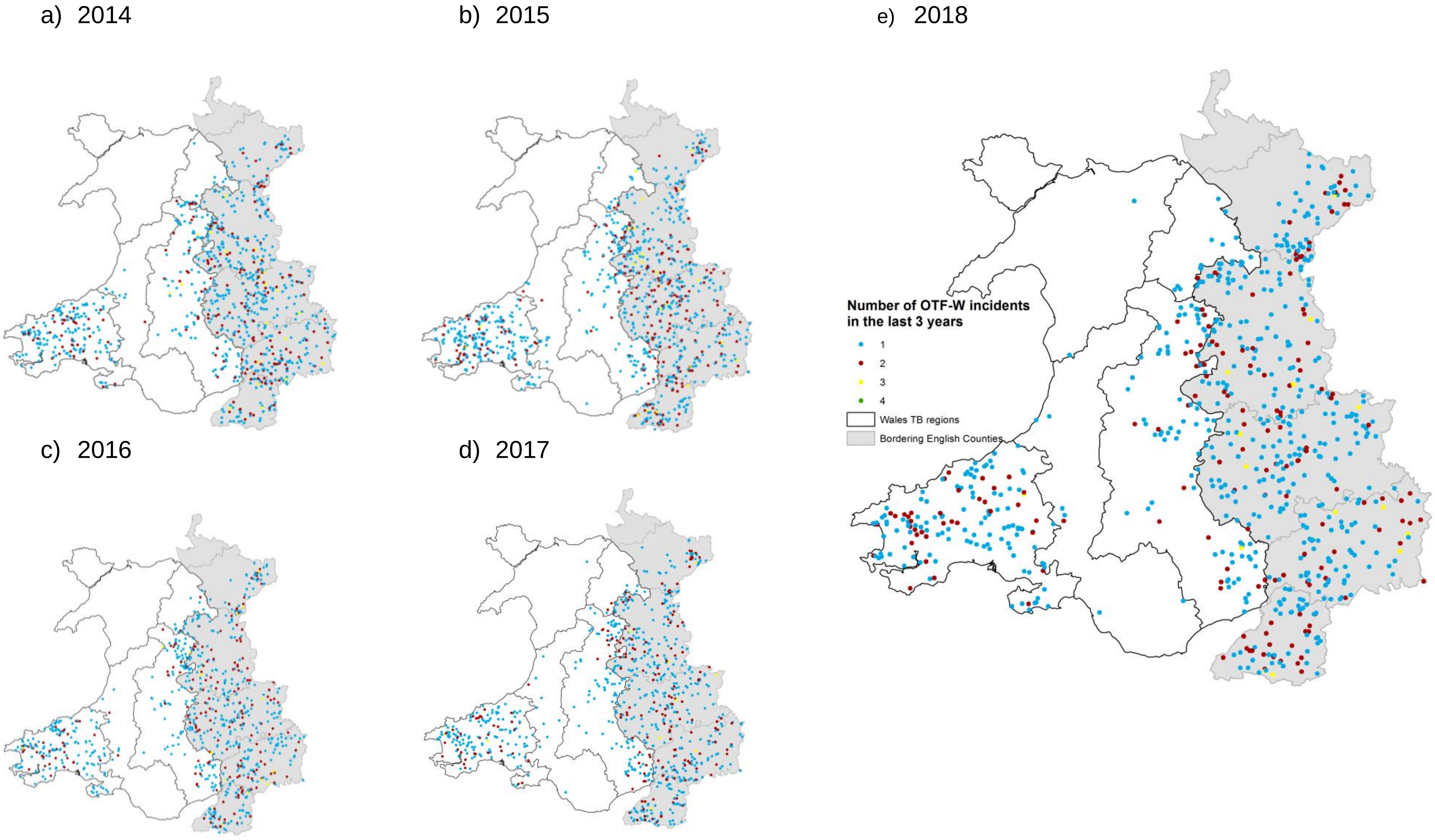



**Figure 6.2:** Herds with new bovine TB incidents in 2014 - 2018 that had had between one and four OTF-W incidents in the previous 36 months (recurrent incident herds)

# 7.0 Inconclusive reactor herds that subsequently suffered an incident

**Key points:**

- 17% (134/773) of IR-only herds that were clear at retest went on to have an incident in the subsequent 15 months compared with only 5% (479/8,977) of non-IR herds that tested clear at a routine whole herd test
- More dairy herds which were clear at the IR retest went on to have a TB incident at a subsequent test, compared with beef herds (22% vs 14%) (Table 7.1)
- 51% of IR-only animals tested clear at the first retest and remained clear for the follow-up period of 15 months (Figure 7.6)

This section analyses the fate of herds in the fifteen months following an *initial* herd test where:

- the herd was not already under restriction and there were no unresolved inconclusive reactors (IR) in the herd at the time of the initial herd test
- one or more IRs were found
- an incident was not disclosed by the initial herd test
- the test took place in the 12 months preceding the reporting year to allow for a 15 month follow-up period

This type of initial herd test is described as an *IR-only test.* The current minimum interval between retests of IRs is 60 days. IRs are tested either on their own or, in a herd where reactors were found, with the rest of the herd. It is important to quantify IR-only herds that suffer subsequent incidents as animals in these herds may in fact be infected at the IR-only test.

When IRs are identified in unrestricted herds, the whole herd is placed under movement restrictions which remain in force if there are:

- Any reactor animals in addition to the IR, or
- If the herd has had a confirmed (OTF-W) incident in the last three years.

In all other cases, providing there is no suspicion of TB, only the IRs will be subject to movement restrictions and the herd OTF status will be restored for domestic trade purposes, however export trade is restricted pending re-testing of the IRs[11].

There were 973 IR-only herds that had IR-retests in Wales in 2018, of which 158 (16%) had an OTF-W incident at the IR-retest and 28 (3%) had an OTF-S incident. The remaining 787 (81%) were clear at the IR-retest. Therefore a new TB incident was detected at the IR-retest in 186 (19%) herds with IR-only tests in 2018.

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733938/AG-TBYHW-03.pdf

Of the 787 herds that tested clear at an IR retest, 773 subsequently had a whole herd test (WHT) within the 15-month follow up period. Of these herds, 17% (n=134) went on to have an incident at the next WHT, compared to 5% (479/8,977) of non-IR herds that had a whole herd test in 2018; significantly more IR-only herds that were clear at a retest went on to have a TB incident compared with non-IR herds that tested clear at a routine whole herd test in the same period (17% vs. 5%, $p<0.001$ Fishers Exact test). The proportions observed in 2018 were similar to those observed in recent years.

Figures 7.1 and 7.2 show the 10 year trends in the proportion of IR-only herds with a new TB incident at the IR retest or subsequent whole herd test since 2009. The proportion of IR-only herds with a subsequent OTF-S incident has decreased considerably since 2009, to 3% in 2017 and 2018, related to the change in the way incidents were classified from 2011. Between 2006 and 2009 there was an increase which was most likely due to the application of interferon-gamma tests for second retests, introduced in 2006, which tended to detect many animals with borderline immunological responses to the skin test. The proportion of IR-only herds that had a subsequent OTF-W incident at the IR retest was around 9% up to 2011 before increasing to 17% in 2013. This increase would be expected as more herds were classified as OTF-W from 2011 onwards. However despite this increase, the proportion itself has remained relatively stable since 2013, between 15% and 17%.

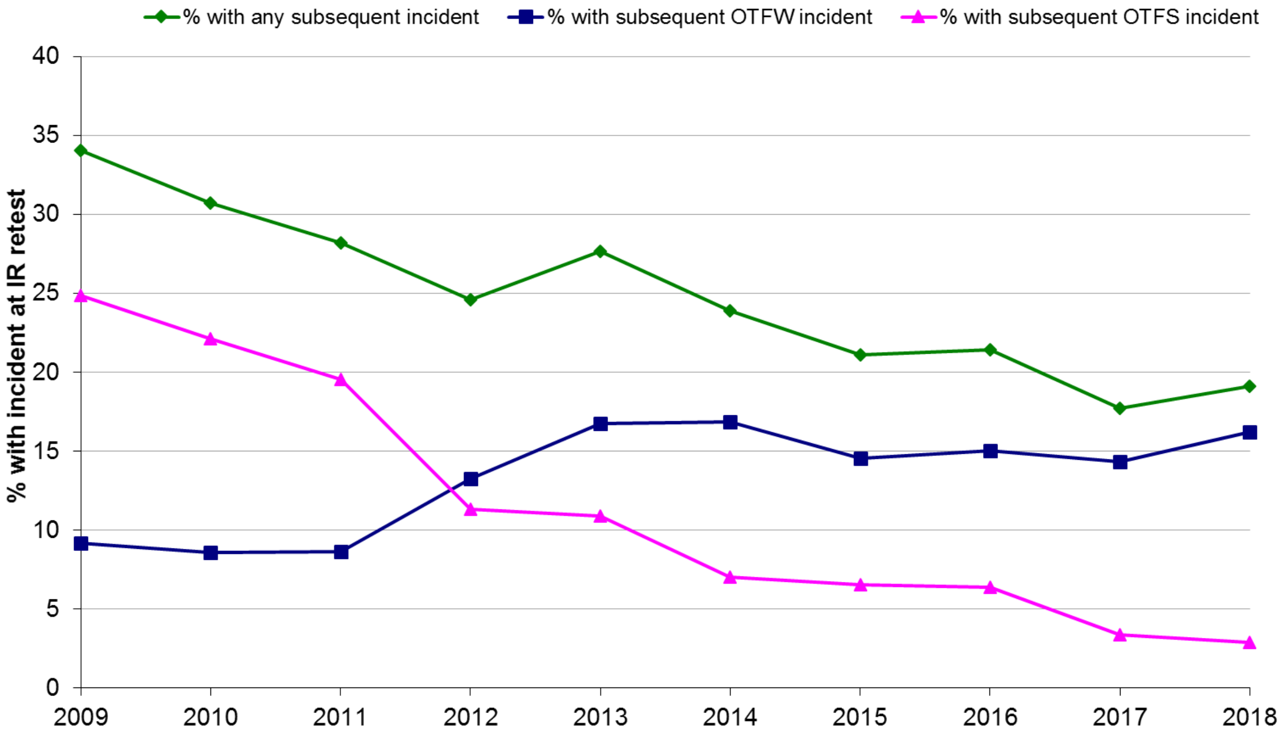



**Figure 7.1:** Proportion of IR-only herds with a new TB incident at the IR-retest

The proportion of herds that had any incident at the test subsequent to a clear IR retest decreased from 24% in 2009 to 15% in 2014 (Figure 7.2); fluctuating between 17% and 20% since. Following the change to the way incidents were classified from 2011, the trend for herds with OTF-W incidents following clear IR retests tracked the trend for all incidents, albeit at a slightly lower proportion. This is as expected since OTF-W incidents now make up the majority of TB incidents. Conversely, the proportion of herds that had an OTF-S incident at the next test subsequent to a clear IR retest, decreased since 2010, to 2% or lower between 2016 and 2018.

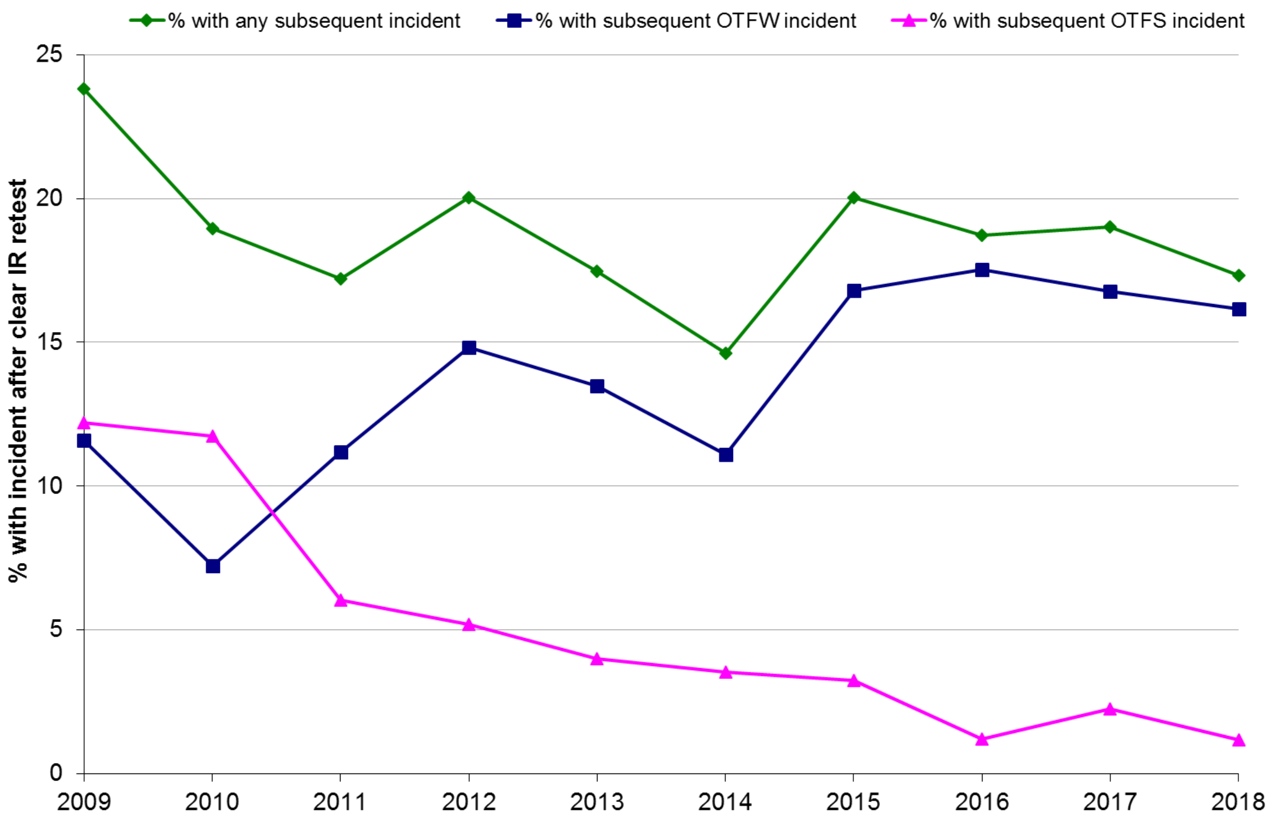



**Figure 7.2:** Proportion of herds that had a new TB incident following a clear IR-retest[1]

*[1]Herds that did not have a whole herd test within the 15 month follow up period were excluded from the denominator*

The proportion of IR-only herds that had a new incident at the IR retest varies by herd size, herd type, and TB Area (Table 7.1). For example, 21% of IR-only beef herds had an incident at the IR retest compared to 17% in dairy herds. Small herds (50 or fewer cattle) and large herds (>300 animals) had the highest proportions compared to other herd sizes (23% in 0-10 animals, 21% in 11-50 animals and 21% >300 animals), and when comparing TB Areas, the Intermediate North had the highest proportion (27%), followed by the High East (26%). Demographic and geographical factors which are associated with higher rates of TB (Section 2) are also associated with higher levels of IR-only herds going on to have a subsequent incident.

Similarly to the IR-only herds, the proportion of clear herds that had a new incident at a subsequent whole herd test in the 15 month period also varied by herd size (highest in herds with >300 cattle; 28%), herd type (14% of beef herds vs. 22% dairy), and geographical area (highest in the Intermediate Mid (31%) and the High East TB Areas (21%)). This suggests that in some TB areas, IR-only herds are more likely to suffer an incident at a subsequent whole herd test than at the initial retest. Figures 7.3 a-c show the trends in the proportion of IR herds with subsequent incidents vary across TB areas.

Figure 7.4 shows the geographical distribution of IR-only herds that had no subsequent incident, a new TB incident at the IR retest or a new TB incident at the test subsequent to a clear IR retest in 2018. The density of herds with at least one IR over the last five years also shows a general decrease (Figure 7.5); this pattern is reflective of herd density (Section 1; Figure 1.1).

**Table 7.1:** TB incidents in the fifteen months subsequent to tests in which only inconclusive reactors (IRs) were found, and TB incidents in the fifteen months following a clear whole herd test, 2018

| | IR-only herds with retest[1] | IR only herds with incident at retest (%) | | Herds clear at retest with subsequent WH test | IR only herds with incident at subsequent WH test (%) | | Clear herds with a subsequent test[1] | Incident at subsequent test (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Total | OTF-W | | Total | OTF-W | | Total | OTF-W |
| **Herd size** | | | | | | | | | |
| 1-10 | 30 | 7 (23.3) | 5 (16.7) | 20 | 1 (5) | 0 (0) | 1,354 | 7 (0.5) | 4 (0.3) |
| 11-50 | 188 | 40 (21.3) | 34 (18.1) | 144 | 16 (11.1) | 13 (9) | 3,182 | 96 (3) | 72 (2.3) |
| 51-100 | 215 | 37 (17.2) | 26 (12.1) | 174 | 29 (16.7) | 27 (15.5) | 1,942 | 109 (5.6) | 90 (4.6) |
| 101-200 | 271 | 51 (18.8) | 44 (16.2) | 218 | 37 (17) | 34 (15.6) | 1,491 | 106 (7.1) | 95 (6.4) |
| 201-300 | 124 | 20 (16.1) | 18 (14.5) | 103 | 19 (18.4) | 19 (18.4) | 484 | 60 (12.4) | 59 (12.2) |
| >300 | 145 | 31 (21.4) | 31 (21.4) | 114 | 32 (28.1) | 32 (28.1) | 524 | 101 (19.3) | 96 (18.3) |
| **Type** | | | | | | | | | |
| Beef | 559 | 115 (20.6) | 90 (16.1) | 435 | 59 (13.6) | 53 (12.2) | 7,268 | 325 (4.5) | 278 (3.8) |
| Dairy | 409 | 70 (17.1) | 68 (16.6) | 334 | 75 (22.5) | 72 (21.6) | 1,547 | 153 (9.9) | 137 (8.9) |
| Other/mixed | 5 | 1 (20) | 0 (0) | 4 | 0 (0) | 0 (0) | 162 | 1 (0.6) | 1 (0.6) |
| **TB Area** | | | | | | | | | |
| High East | 271 | 70 (25.8) | 62 (22.9) | 199 | 41 (20.6) | 38 (19.1) | 2,076 | 192 (9.2) | 175 (8.4) |
| High West | 412 | 61 (14.8) | 57 (13.8) | 343 | 70 (20.4) | 67 (19.5) | 2,256 | 190 (8.4) | 167 (7.4) |
| Intermediate Mid | 165 | 25 (15.2) | 17 (10.3) | 45 | 14 (31.1) | 12 (26.7) | 1,592 | 36 (2.3) | 29 (1.8) |
| Intermediate North | 64 | 17 (26.6) | 13 (20.3) | 138 | 6 (4.3) | 6 (4.3) | 714 | 38 (5.3) | 31 (4.3) |
| Low | 61 | 13 (21.3) | 9 (14.8) | 48 | 3 (6.3) | 2 (4.2) | 2,339 | 23 (1) | 14 (0.6) |
| **Total** | **973** | **186 (19.1)** | **158 (16.2)** | **773** | **134 (17.3)** | **125 (16.2)** | **8,977** | **479 (5.3)** | **416 (4.6)** |

[1] Only herds that had a whole herd test are included here as those with clear animal level tests cannot be guaranteed free of TB infection

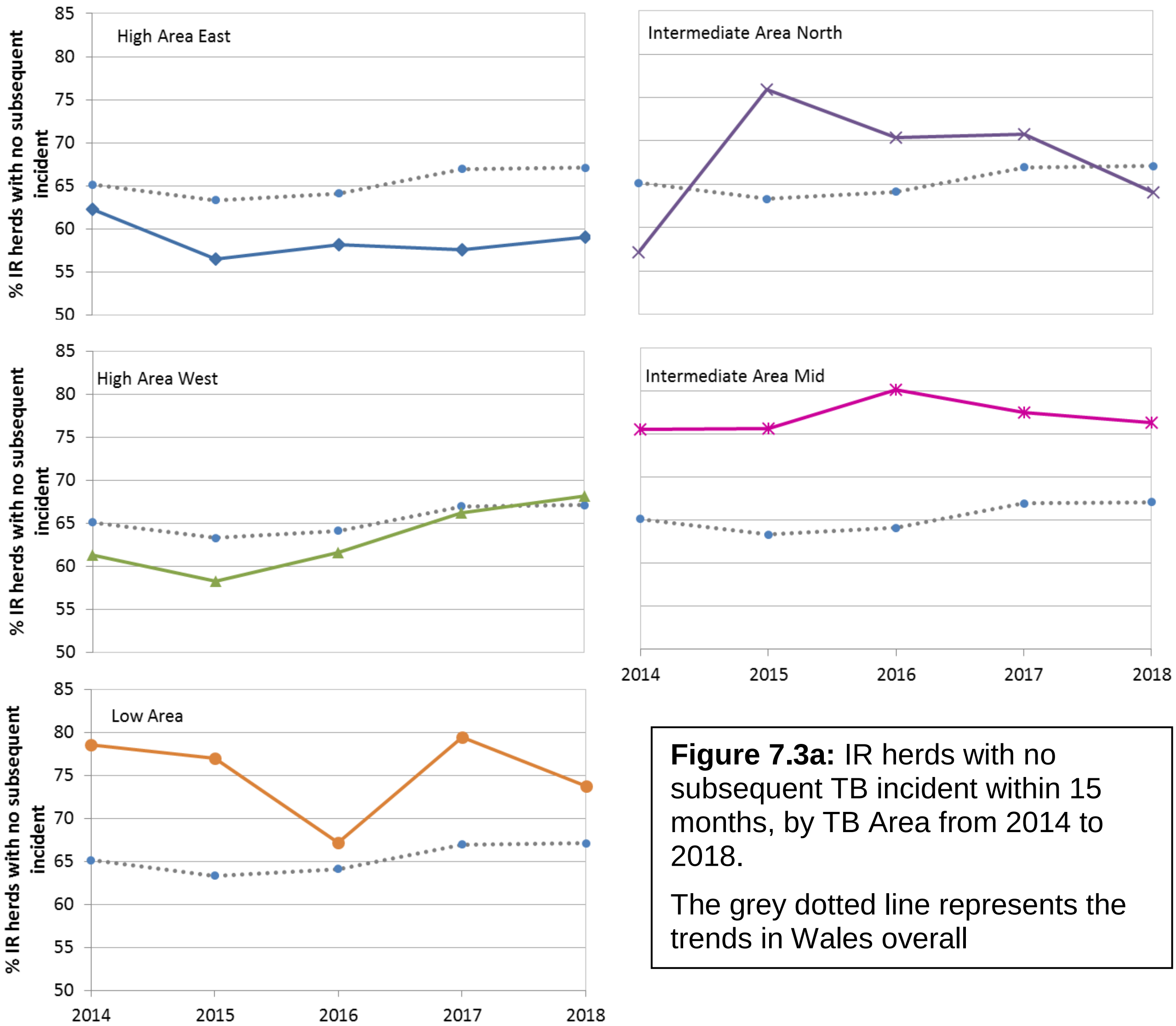



**Figure 7.3a:** IR herds with no subsequent TB incident within 15 months, by TB Area from 2014 to 2018.

The grey dotted line represents the trends in Wales overall

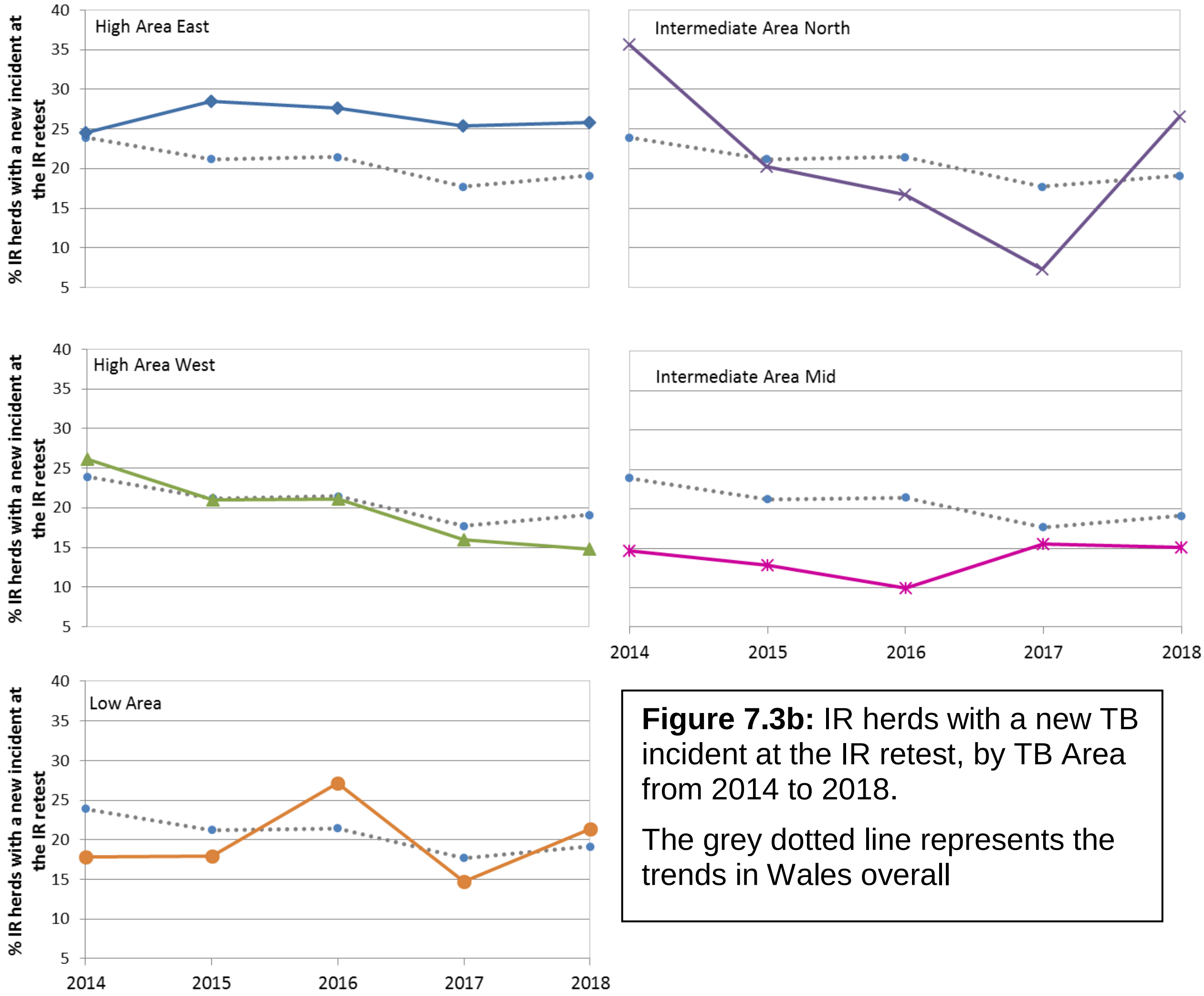



**Figure 7.3b:** IR herds with a new TB incident at the IR retest, by TB Area from 2014 to 2018.

The grey dotted line represents the trends in Wales overall

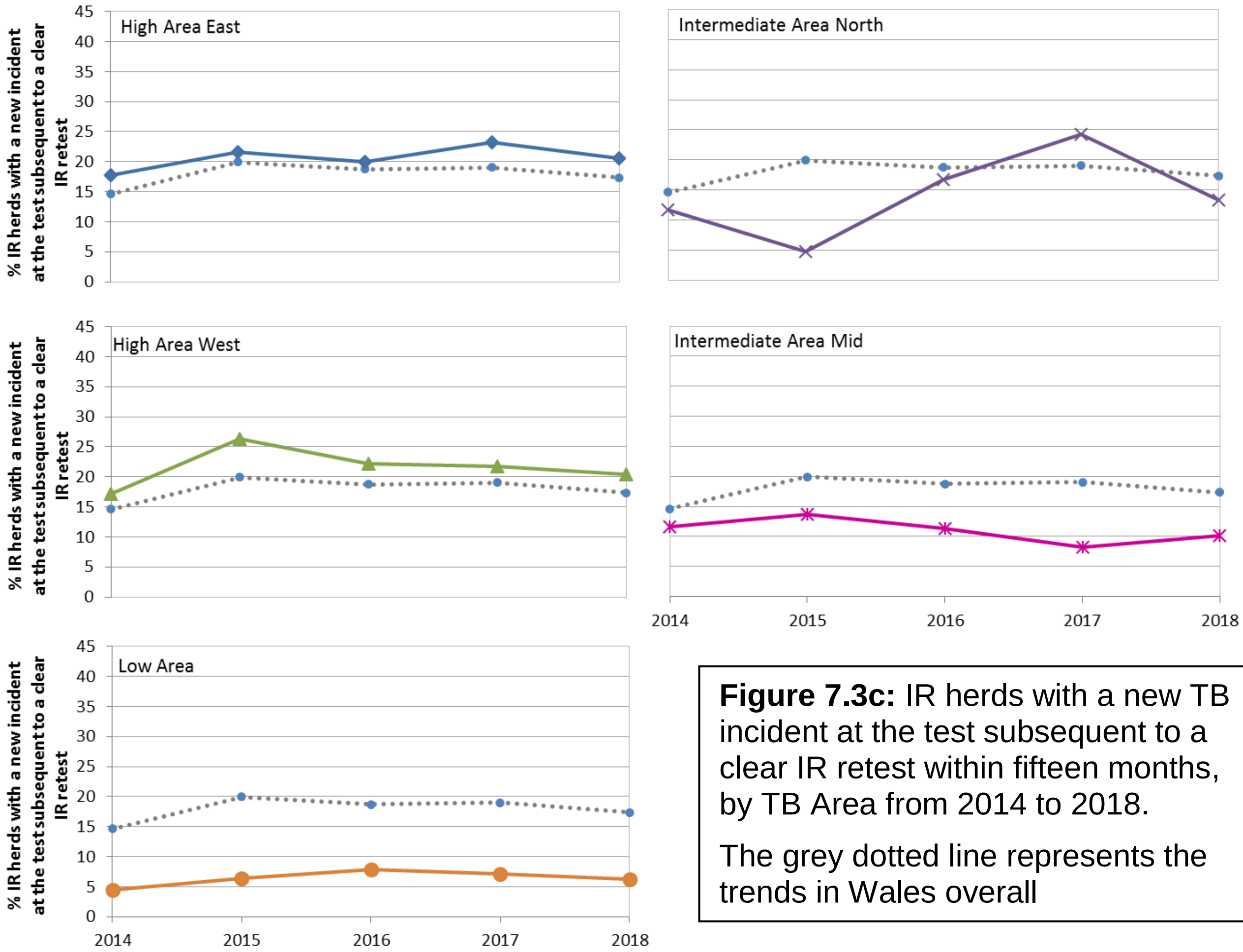



**Figure 7.3c:** IR herds with a new TB incident at the test subsequent to a clear IR retest within fifteen months, by TB Area from 2014 to 2018.

The grey dotted line represents the trends in Wales overall

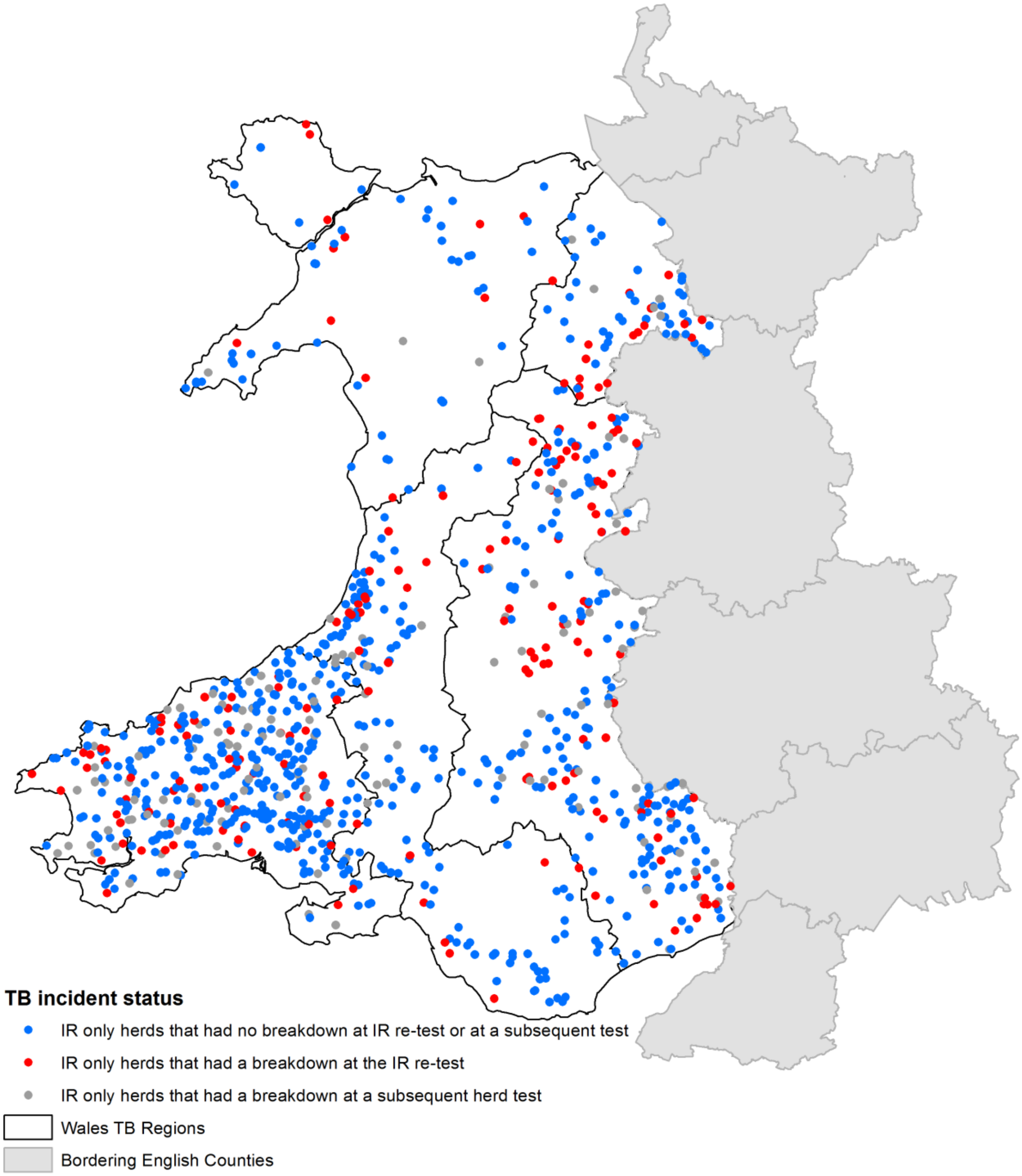



**Figure 7.4:** IR herds with no subsequent incident; a new TB incident at the IR retest or a new TB incident at the test subsequent to a clear IR retest within fifteen months, 2018

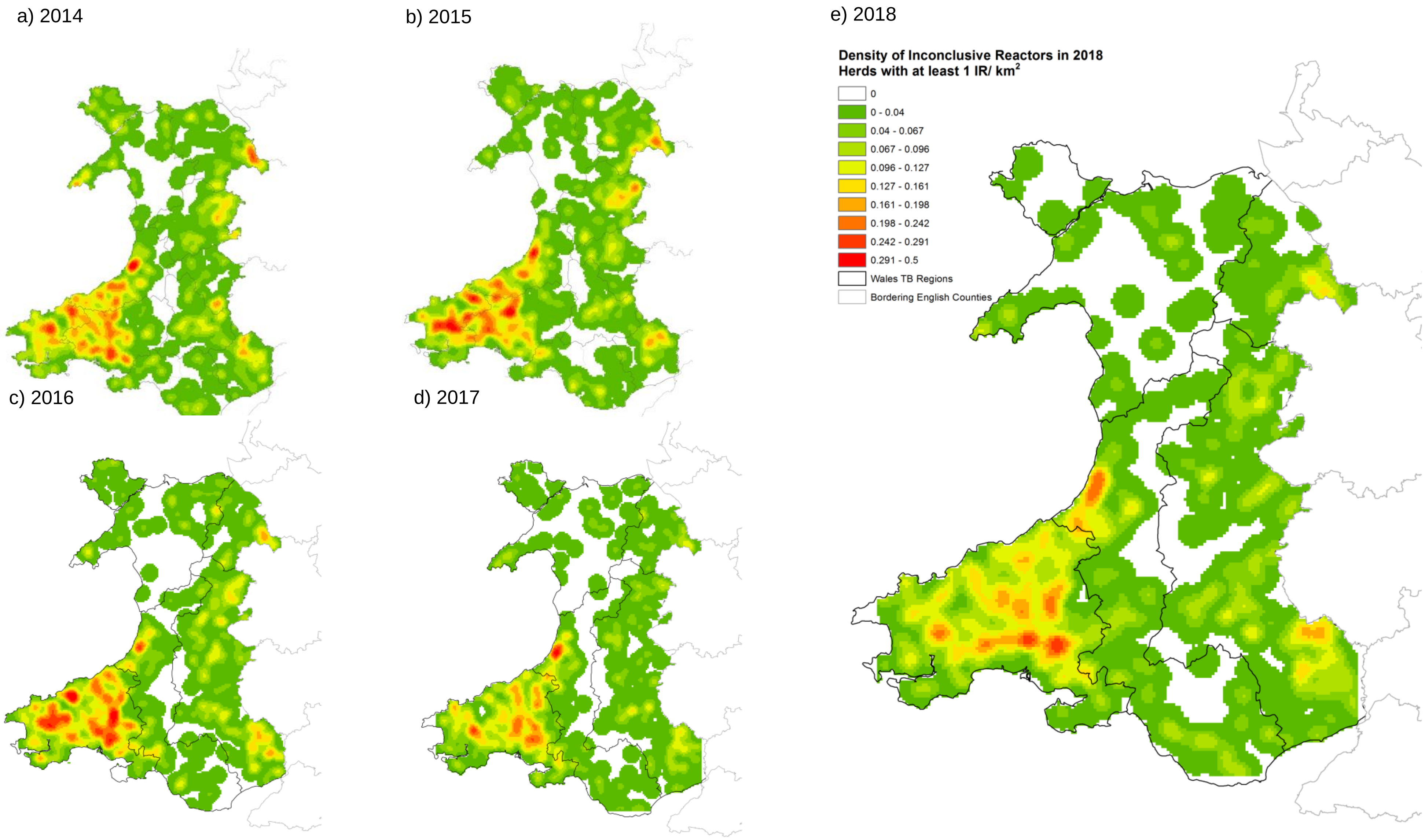



**Figure 7.5:** Density of herds with at least one inconclusive reactor, 2014 – 2018

*7.1 Understanding the fate of IRs*

Determining what happens to IRs at the animal level is crucial for reviewing the policy applied to these animals. A flow-diagram identifying the fate of IRs taking into account testing history and slaughterhouse surveillance has been developed (Figure 7.6).

The cohort of animals that were followed were those with an inconclusive reaction at the initial test outside of an incident in 2017, and these animals were followed for 15 months after the initial test. Figure 7.6 is split into two sections. The initial IR sequence (above the grey line) follows animals through to testing clear or becoming a 2xIR, 3xIR[12], reactor or being removed. The subsequent IR sequence (below the grey line) describes what happens to animals that test clear at IR retesting. An IR can test clear at the first or third retest, and this is represented by the two streams in the subsequent IR sequence. If an animal becomes a 2xIR using the standard interpretation of the test, it is removed for slaughter. If it becomes a 2xIR using the severe interpretation of the test, it has a second retest using the gamma interferon (gIFN) test. Passing that triggers another skin test and if the animal becomes a 3xIR, it is removed for slaughter as a reactor.

Of the 2,940 IR-only animals that had an inconclusive reaction to the skin test in 2017, 2,298 (78%) tested clear at the first retest, and 1,183 (51%) of these remained clear during the follow up period. A further 523 were routinely slaughtered and screened negative in the slaughterhouse. Of the 1,183 animals that tested clear during the follow-up period, 41 (3%) tested clear again but the herd went on to become a reactor within three months of the test and another 70 animals (6%) within 12 months (data not shown). In this same period there were 166,830 clear tests at the initial IR test, of which 130,666 (78%) remained clear. The remaining 22% was made up of those animals not tested again (19%), IRs not slaughtered (2%), standard reactors (0.3%) and severe reactors, DCs and slaughtered IRs (0.3%). The remaining animals (less than 0.03%) were either missing a clear test from a negative slaughterhouse case (n=41), or were slaughterhouse cases (n=6).

Of the 2,298 IR-only animals which tested clear at the first retest, 112 (5%) became a reactor or an IR within the original incident, and a further 136 (6%) became a reactor or an IR at a test subsequent to the original incident. Five animals from this cohort went on to be slaughterhouse cases within the 15 months following their initial 1xIR result.

Of a total of 29 animals which were neither subjected to a gIFN test nor slaughtered despite a 2xIR result, 25 tested clear at their second retest. There were 124 animals cleared by gIFN 2xIR that also tested clear at their third retest. Four of these animals went on to become reactors (both at severe

[12] Animals having two successive tests giving inconclusive reactor measurements are generally considered to be skin test reactors, but may be described as "IRs After 2 [or more] tests as IR" to distinguish them from other reactors in some parts of this report. IRs may be re-classified as reactors when interpreted severely.

interpretation) during the 15 month follow-up period and six became an IR again, all during the original incident. Thirty-one animals which tested clear at the third retest tested clear again and none of these experienced a TB incident within 12 months.

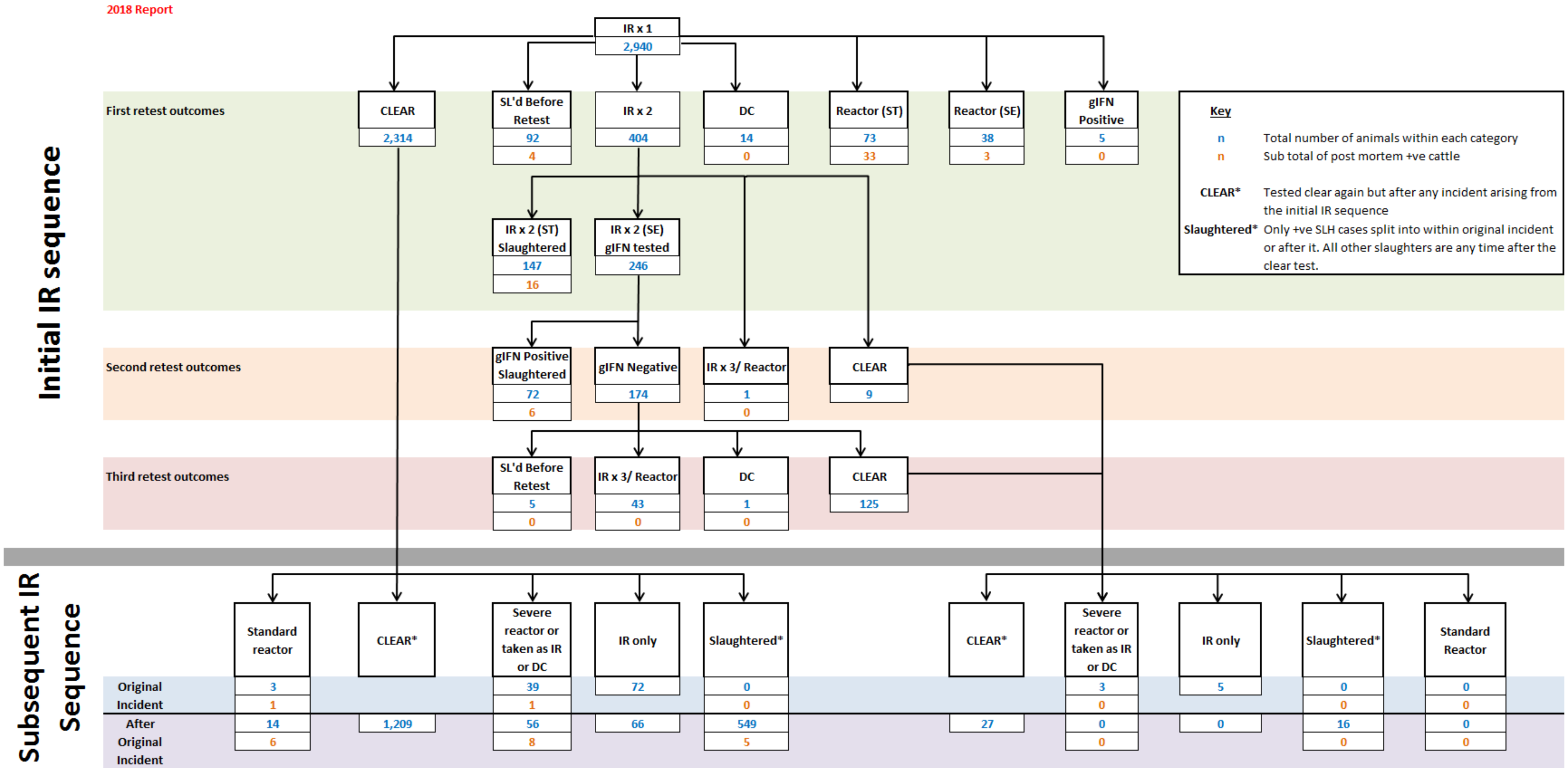



**Figure 7.6:** Flow diagram illustrating the fate of animals which had an inconclusive reaction to the SICCT test in 2018

# 8.0 Genotypes identified in bovine and non-bovine species in Wales

**Key points:**

- There were 416 isolates from cattle from TB incidents in Wales that started in 2018 and all were spoligotyped.
- The most common spoligotype in Wales (spoligotype 9) had two main clusters: one in the High TB West and one in the High TB East Area (Figure 8.1).
- Twenty-five non-bovine isolates were genotyped in 2018.

The APHA has a database of genotypes for over 13,000 isolates of TB from Wales (1988 to end 2018). These genotyped isolates of *M. bovis* show clear geographical clustering. Since 2002 the combination of spoligotype and the variable number of tandem repeat (VNTR) profile is known for the majority of OTF-W incidents. In combination with home range maps the genotype of *M. bovis* can help to decide on the origin of infection, in particular if the farmer has purchased animals from an area where the prevalent genotype differs from the local one. The current distribution of genotypes is shown in Figure 8.1

*8.1 Overview of the isolates in the spoligotype database (Wales only).*

Each of these isolates was spoligotyped and VNTR data (using characterization of 6 standard genomic loci) is available for 94% of these isolates. The distribution of bovine and non-bovine isolates by year is shown in Table 8.1.

**Table 8.1:** The frequency of bovine and non-bovine isolates genotyped by year 1988 to 2018.

| Year | Bovines** | Non-bovines |
|---|---|---|
| 1988 | 1 | 2 |
| 1989 | 8 | 0 |
| 1990 | 9 | 0 |
| 1991 | 48 | 0 |
| 1992 | 58 | 0 |
| 1993 | 51 | 4 |
| 1994 | 128 | 5 |
| 1995 | 122 | 2 |
| 1996 | 180 | 11 |
| 1997 | 143 | 21 |
| 1998 | 202 | 10 |
| 1999 | 276 | 6 |
| 2000 | 291 | 1 |
| 2001 | 381 | 0 |
| 2002 | 258 | 2 |
| 2003 | 1,010 | 2 |
| 2004 | 675 | 1 |
| 2005 | 814 | 3 |
| 2006 | 809 | 59 |
| 2007 | 867 | 12 |
| 2008 | 1,095 | 32 |
| 2009 | 964 | 5 |
| 2010 | 722 | 13 |
| 2011 | 555 | 17 |
| 2012 | 606 | 11 |
| 2013 | 445 | 14 |
| 2014 | 543 | 17 |
| 2015 | 468 | 37 |
| 2016 | 365 | 22 |
| 2017 | 348 | 18 |
| 2018 | 416 | 25 |
| unknown year* | | 7 |
| **Total** | **12,858** | **359** |

*Seven *M. microti* isolates from cats originating from the Glamorgans do not have a year assigned.
** Year the bovine incident commenced

*8.2 Cattle isolates from Wales for TB incidents commencing in 2018.*

There were 416 isolates from cattle for incidents in Wales that started in 2018 and all were spoligotyped (2017 = 348). Full genotype (spoligotype plus 6 VNTR loci) was obtained for 94% of these isolates (2017 = 90%). The 6% of isolates that gave spoligotyping results but failed to produce full VNTR results (one or more of the six loci tested may fail) is mainly due to poor isolate/sample quality. The 393 cattle isolates with full genotype represent 363 separate TB incidents in cattle herds in Wales (2017 = 296). An average of 1.08 isolates were spoligotyped per TB incident (2017 = 1.05) [NB. One TB incident had two different genotypes].

*8.3 Genotype frequency in cattle TB incidents*

The frequency and percentage of each genotype found in the 363 TB incidents (393 individual cattle) from 2018 are shown in Table 8.2. Genotypes 17:a, 9:b, 9:c and 22:a, which made up nearly 90% of Welsh isolates in 2018, have home ranges in Wales.

**Table 8.2:** Frequency and percentage of genotypes in OTF-W incidents in cattle, 2017 and 2018.

| Genotype | 2018 | | 2017 | |
|---|---|---|---|---|
| | **Frequency** | **Percentage** | **Frequency[1]** | **Percentage** |
| 9:b | 151 | 38.4 | 88 | 29.6 |
| 17:a | 114 | 29.0 | 105 | 35.4 |
| 9:c | 48 | 12.2 | 43 | 15.1 |
| 22:a | 36 | 9.2 | 24 | 8.0 |
| 25:a | 9 | 2.3 | 6 | 1.9 |
| 9:a | 4 | 1.0 | 1 | 0.3 |
| 10:a | 3 | 0.8 | 1 | 0.3 |
| 11:a | 3 | 0.8 | 0 | 0.0 |
| 17:c | 2 | 0.5 | 0 | 0.0 |
| 17:j | 2 | 0.5 | 2 | 0.6 |
| 21:a | 2 | 0.5 | 1 | 0.3 |
| 35:a | 2 | 0.5 | 4 | 1.3 |
| 9:m | 2 | 0.5 | 2 | 0.6 |
| 104:a | 1 | 0.3 | 1 | 0.3 |
| 11:o | 1 | 0.3 | 0 | 0.0 |
| 12:a | 1 | 0.3 | 0 | 0.0 |
| 15:a | 1 | 0.3 | 0 | 0.0 |
| 17:o | 1 | 0.3 | 1 | 0.0 |
| 17:s | 1 | 0.3 | 0 | 0.0 |
| 17:t | 1 | 0.3 | 0 | 0.0 |
| 22:7-5-2-4*-4-3.1 | 1 | 0.3 | 0 | 0.0 |
| 25:b | 1 | 0.3 | 0 | 0.0 |
| 9:ac | 1 | 0.3 | 1 | 0.3 |
| 9:ar | 1 | 0.3 | 0 | 0.0 |
| 9:an | 1 | 0.3 | 0 | 0.0 |
| 9:d | 1 | 0.3 | 2 | 0.6 |
| 9:f | 1 | 0.3 | 1 | 0.3 |
| 9:u | 1 | 0.3 | 1 | 0.3 |
| **Total** | **393** | | **296[1]** | |

[1] For 2017, not all genotypes are shown in this table if they did not appear again in 2018. The overall total for 2017 was 296.

The geographical distribution of the major spoligotypes identified in OTF-W incidents in 2018 is presented in Figure 8.1. The most common spoligotype in Wales (spoligotype 9) had two main clusters: one in the High West TB Area and the other in the High East TB Area. Spoligotype 9 is much less common over the border in England, where spoligotype 17 predominates. Spoligotype 17 is the second most common type in Wales, with a large cluster seen in the High East TB Area and into the Intermediate Area in the North.

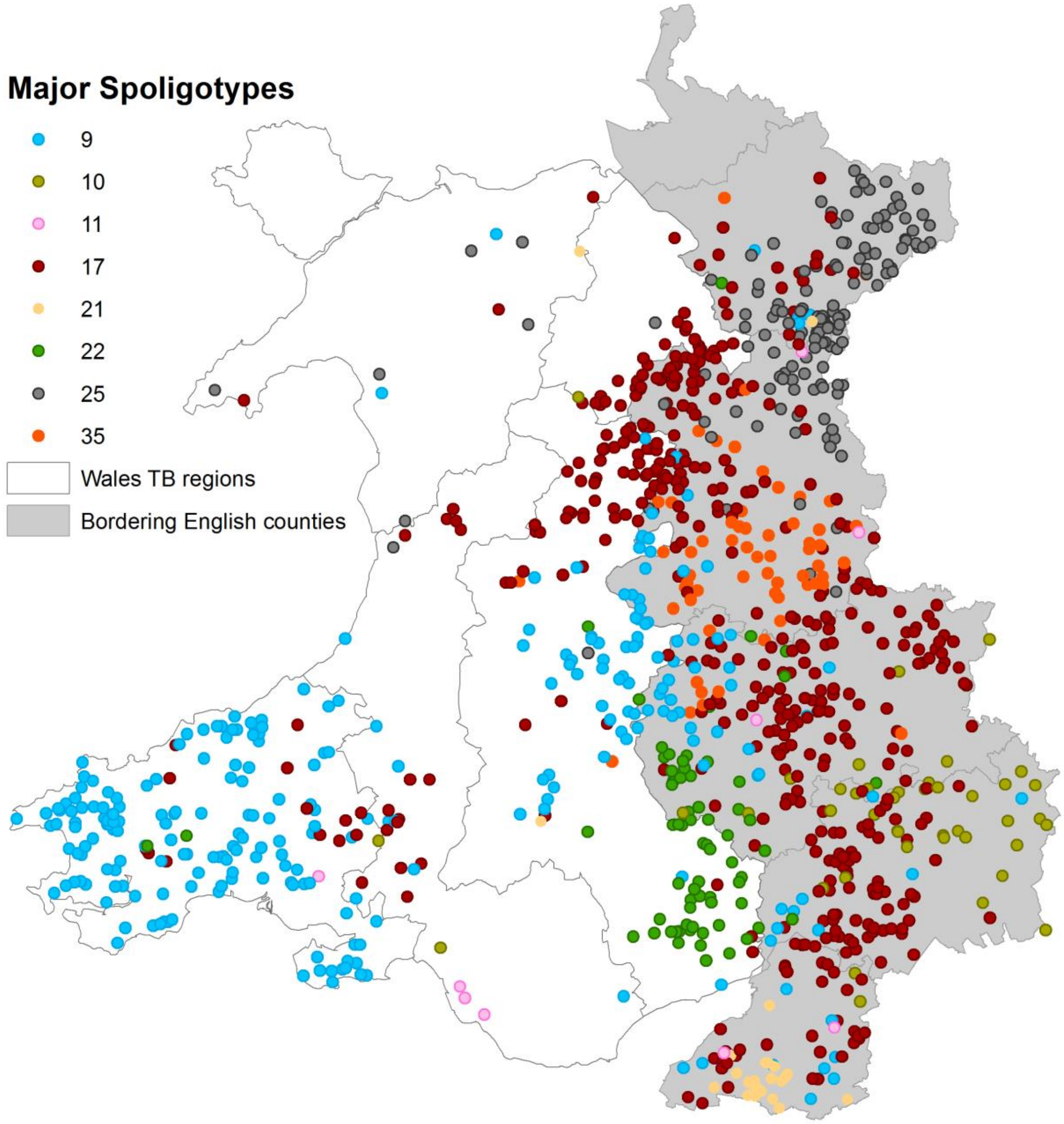



**Figure 8.1:** Geographical distribution of the major spoligotypes in Wales and English bordering counties in 2018

*8.4. Non-bovine isolates from Wales, 2018.*

Twenty five non-bovine isolates were genotyped in 2018 (2017 = 18). This total included 18 badger samples (2017 = 13), three deer (consisting of two incidents), one cat, one guanaco and two alpaca (one incident) samples.

Full genotype was available for all 18 badger isolates, with three of the 18 being out of home range. Two of the three deer isolates were within home range (the third had no home range available for that genotype). The alpaca incident was out of home range and both the cat and the guanaco isolates failed to give a full genotype.

# Appendix 1 - Materials and Methods

## *Data extraction and manipulation*

The data on herds, animals, bovine tuberculosis (TB) incidents and tests applied to the British cattle population were downloaded from the Animal and Plant Health Agency's (APHA) SAM RADAR TB reception database on 4th April 2019, and includes skin tests entered on to SAM and completed on or before 2$^{nd}$ April 2019. Data prior to late September 2011 derives from the APHA VetNet system, which was migrated into SAM when that system went live at the end of September 2011. Information relating to culture results of all TB suspect samples exists on SAM but is derived from the APHA's LIMS system and prior to that from the APHA TB Culture System (TBCS), plus a short cross-over period when both were in use. Apparent missing results data on SAM have been retrieved directly from LIMS where possible, in particular for samples from around the time of SAM TB going live.

Data is downloaded three months after the reporting year in order to capture confirmation by culture of incidents commencing in the reporting year. This date is, however, too early to capture all events during most of these incidents, for example the dates of removal of movement restrictions, from which the duration of incidents is calculated. Therefore, incidents that *ended* during the reporting year are used to calculate the duration of incidents and the total number of reactors in an incident.

Since 2012 denominator herd numbers have been those active at the end of the reporting period rather than those in existence for 6 months of it, to match methodologies of the National Statistics which may account for minor differences observed with reports prior to 2012.

## *Data Issues*

Incidents have been screened at Weybridge to determine duplicate, concurrent, and missing incidents in order to include all herd incidents and only one at any one time for each herd. Greater than one incident on the same CPHH at the same time can exist in SAM, which we have attempted to eliminate. Incidents clearly missing from SAM, with reactors or lesions at tests but no incident apparently in existence on SAM, have been included, although these are now very few. The status of incidents will also have been upgraded if post mortem results exist on LIMS or the TBCS that have not been put onto SAM although this is now much less common than at the outset of SAM.

Inaccurate or missing TB10 information, which mark the end of restrictions, had also been a serious issue within SAM and one addressed since the 2012 report. Revisions in SAM, policy changes and user training have reduced most errors in this respect and the situation is greatly improved, although a very small number of incidents with obviously incorrect or missing TB10 dates may still get corrected for this report. It should be noted that management of the closure of incidents involves the receipt of a BT5 form which provides evidence of cleansing and disinfection on the incident premises. This is required before a TB10 can be issued to formally close the incident. Delays to the BT5 receipt, or non-receipt at all will artificially prolong the duration of incidents, which in effect should last until the final clearing skin test. Policy introduced late in 2015 has attempted to penalise non-returners of the BT5 and the situation appears to be much improved, although slow returns will artificially lengthen the incident duration. A similar delay can also be due to noted discrepancies within the BCMS Cattle Tracing System, whereby animals observed on the farm do not all match those reported in BCMS and which have to be corrected prior to the lifting of restrictions.

Ongoing effort is been made to correct as much of the data inconsistencies as possible, and we are fairly confident we have used a dataset that is broadly correct. It is possible that future scrutiny of the data may uncover further minor corrections, but it is not envisaged that trends observed within this report will be significantly affected.

## *Officially TB-free status terminology*

A full glossary of terms and abbreviations used in this report is given in Appendix 2. However, terms relating to the officially TB-free status of herds are frequently used throughout most sections of this report and therefore a clear understanding of their definitions is necessary.

Bovine TB incidents with evidence of *Mycobacterium bovis* infection detected in at least one animal from the herd at post mortem examination (PME) or sample culture (including those triggered by slaughterhouse surveillance), as well as incidents where there is no evidence of infection at PME but there is epidemiological evidence that the herd is at high risk of being infected, are in this report referred to as 'officially TB free status withdrawn (OTF-W)'. New TB incidents with no evidence of *M. bovis* infection detected at PME or in sample culture, and with no epidemiological risk of infection, are referred to as 'officially TB free status suspended (OTF-S)'. Animals that are slaughterhouse cases must always have provided samples from which *M. bovis* is recovered.

The number of OTF-W and OTF-S TB incidents in this report may differ from other official TB statistics due to slight differences in data interpretation and the aforementioned data cleansing. Bovine TB incidents commence when one or more animal has skin test or interferon-gamma results indicative of TB (a "reactor") or when any infected animal is detected at slaughter. This report treats any slaughterhouse case first detected by lesion(s) disclosed at slaughterhouse surveillance from which *M. bovis* is isolated by culture as being able to trigger an OTF-W incident if the herd of origin is not under restriction at the time the lesions were found, whether or not there are reactors found subsequently in the herd. The report uses cleaned incident data to ensure all genuine incidents are included and concurrent incidents are counted only once; and ignores herds placed under restriction because their test is overdue.

Unclassified incidents are those without results to determine the status of the incident. Some tables within the report reject these incidents; others combine them with the OTF-S incidents. These may be genuine incidents that are missing results, or begun as a result of tracing or connection with another incident herd and thus not a regular incident. Attempts have been made to exclude those that do not appear to be genuine incidents.

## *Calculations of incidence and prevalence*

Several methods are used in this report to describe the level of TB in Wales. The first is the number of new incidents that started in a given year divided by the number of herds in Wales that were 'live' in that year (see Appendix 2 for definition of 'live herds'). This is reported as the number of new incidents per 100 live herds and is thus a measure of the proportion of Welsh herds that sustained a new incident. This is the standard method of reporting TB incidence in GB. However, this method does not take into account the dates on which tests occur and can cause difficulties when making comparisons of incidence rates between populations having differing testing intervals in the immediate past, although this is of less relevance in Wales where all areas are routinely tested annually.

Consequently, the second method used to estimate the incidence of TB in Wales in this report calculates the number of new incidents relative to the 'herd time spent at risk'. The time at risk is calculated for each herd at each test or incident as the time spent not under restriction since the previous herd-level test. As all herds are tested annually In Wales, the maximum time at risk expected would be around 12 months. If this time exceeds 18 months due to previous herd inactivity, then the time at risk for that herd is capped at 18 months. If a herd is not tested in a given year, it does not contribute towards the incidence rate calculations for that year because detection of TB in the majority of animals in the herd was not possible aside from slaughterhouse surveillance. But if a herd has more than one test and/or incident in a year the respective times at risk are added together. It should be noted that all information regarding time at risk is based only on herd-level tests because the sensitivity of individual animal-level tests for determining the TB status of the herd is low. Thus when a new incident is disclosed following an animal-level test, the accumulated time at risk is attributed to the incident, rather than being deferred until the planned but forestalled herd level test.

The third method used to estimate the level of TB infection in cattle herds in Wales is concerned with the effect of the disease on the management of the herd at a single point in time, regardless of when infection entered the herd. That is, the total number of herds that are under movement restrictions due to a TB incident on a given date divided by the total number of active herds at that point in time. This is termed the *prevalence* of TB. As stated above, herds restricted due to an overdue test rather than a TB incident are not classified as 'restricted' in this report and therefore estimates of the proportion of herds under restriction will be lower in this report than in some of the official TB statistics.

## *Method for classification of recurrent-incident herds*

Recurrent TB is defined as a TB incident disclosed during the *Current Period* occurring in a herd that was under restriction for TB at any time during the *History Period*. A key date or *Reference Date* is first calculated for each herd. It falls as near as possible to the *middle Date* in the Current Period (2nd July 2018[1]), unless a TB incident starts in the Current Period.

- If there is one or more OTF-W in the Current Period, the Reference Date is day 1 of the disclosing test of the OTF-W nearest to the Middle Date of the Current Period;
- If there are no OTF-W incidents but one or more OTF-S in the Current Period, the Reference Date is day 1 of the disclosing test nearest to the Middle Date;
- If no TB incident is disclosed in the Current Period, the Reference Date is the Middle Date of the Current Period (2nd July).

Where the herd is under movement restriction for four or more months at the start of the Current Period, recurrence cannot be defined and the herd is excluded from the analyses.

[1] 2nd July is actually day 183 of a 365-day year or day 184 of a 366-day year.

The *History Period* is the 36 months ending on the day before the Reference Date. In this report, restrictions in the History Period end on the day of issue of a TB10 form. The three types of History Period are:

- (A), if the herd is under restriction on one or more days in the History Period for an OTF-W incident;
- (B), if at any time during the History Period, the herd is not under restriction for an OTF-W incident but *is* under restriction for an OTF-S incident;
- (C), if the herd is not under restriction for TB at any time during the History Period.

There are also three types of *Current Period*: (1) if any OTF-W incidents start in the period; (2) if no OTFW incidents start, but one or more OTF-S incident starts, and (2) if the herd remains OTF through the entire Current Period.

## *Statistical analysis*

Statistical tests were performed where appropriate. For data in 2 x 2 tables, Fisher's Exact test was used. Comparisons between the means of continuous variables where the variable was not normally distributed were performed using the Wilcoxon Rank Sum test. The Z-test was used to compare differences in proportions.

Univariate Linear (continuous outcomes), Logistic (binary outcomes) and Poisson (count data) regressions were used to assess the associations between predictor variables such as herd size, herd type and geographical area and outcomes such as incidence and recurrence rates. The confounding effects of these predictor variables upon one another were adjusted by including all predictors in a multivariable model. However, the number of factors available for use in multivariable analysis was limited by the source data.

Predictor variables were generally categorical; continuous variables were categorised. Categories were chosen based either on quantiles of the distribution of the population or (more often) biologically relevant categories. For example, for the predictor ‘herd size’, categories could ideally be based on either equal numbers of herds or equal numbers of animals; as a result, the numbers of herds in the categories for large herd sizes tended to be smaller than for smaller herd sizes.

The reference category chosen for categorical predictors in regression analyses varied. Ideally the reference category was both biologically relevant and had a sufficient number of observations or cases to be statistically sound. However, if the most biologically relevant category had insufficient observations/cases or there was no clear biological advantage in selecting a reference category, then the category with the most observations/cases was chosen.

All data analyses were performed using Stata v12.0 or v14.0.

## *OTF-W-2 herds*

The term officially tuberculosis free status withdrawn (OTF-W) is applied to a herd with a TB incident in which additional evidence of *Mycobacterium bovis* infection has been identified in at least one slaughtered animal (see Appendix 2 for more detail). This case definition has been used in previous iterations of the report and in the related reports for England and Great Britain.

In January 2011 changes were implemented in Wales that were designed to ensure that the officially tuberculosis free (OTF) status of cattle herds was withdrawn rather than merely suspended in cases of incidents that met defined epidemiological criteria. These criteria included herds with a pre-existing history of infection with bovine tuberculosis (TB), consideration of the local disease situation, where an additional epidemiological risk is identified by the Animal and Plant Health Agency, and since 2016 all TB incidents with two or more reactors. This cohort has become known as OTF-W-2 herds. In common with other herds where OTF status is withdrawn (OTF-W), two consecutive clear herd tests are required to restore their OTF status rather than the single clear test required by herds with only a suspended OTF status (OTF-S).

In reports prior to 2014, OTF-W-2 herds were difficult to identify within the data available for analysis, and so were included in the OTF-S cohort. These difficulties with the data have now been resolved and, as such, OTF-W-2 herds are now identified and included in the OTF-W cohort. This change has been applied retrospectively to the data for all incidents since the policy was introduced in 2011, so there will be some differences in the data presented in this report compared to the reports for 2011, 2012 and 2013. OTF-W-2 incidents are not reported as a distinct cohort anywhere within this report.

# Appendix 2 – Definitions and abbreviations

**Appendix Table 1**: Definitions of terms used throughout the report

| Abbreviation | Detail | Definition or description |
|---|---|---|
| APHA | Animal and Plant Health Agency | The Animal and Plant Health Agency (APHA) was launched on the 1st October 2014. It merged the former Animal Health and Veterinary Laboratories Agency with the Plant and Bee Health and GM Inspectorates and the Plant Varieties and Seeds Office (previously based in Fera), creating a single agency responsible for animal, plant and bee health. |
| | Annualised | Conversion of a variable into a yearly sum (e.g. by multiplying a quarterly incidence by 4). |
| TB | Bovine tuberculosis | Disease of cattle and other mammals caused by infection with *Mycobacterium bovis.* |
| | Contiguous herd | Strictly speaking, a herd that has a common boundary with the herd of interest, but includes herds separated only by a short distance e.g. across a road or river, or where an epidemiological assessment indicates they are likely to be at risk of exposure to infection. |
| DC | Direct contact | Animals in an OTF-W herd whilst not reactors are considered to be at such high risk of being infected that slaughter is justified, usually for the reason of contact with infected cattle. |
| DL | Detected lesions | Lesions typical of bovine TB detected in the carcass of a SICCT or IFN-$\gamma$ test reactor at *post mortem* examination or during routine slaughterhouse inspection of cattle. |
| | Disclosing test | The test that triggers the start of a new TB incident (OTF-S or OTF-W) which in turn marks the start of movement restrictions. For the purposes of analysis it includes the detection of a slaughterhouse case. |
| | Eradication programme[1] | Programme to result in biological extinction of an animal disease or zoonosis and-or to obtain the free or officially free-status of the territory according to EU legislation, where such possibility exists. |
| | Genotype | The genotype currently used for the molecular epidemiology of TB in GB (and therefore Wales) is a combination of Spoligotype and VNTR type. |
| HCW | Health Check Wales | A surveillance initiative operating between 1st October 2008 and 31st December 2009 during which all herds in Wales were tested. Annual testing of herds has continued thereafter. |
| | Herd | A bovine herd defined in the County/Parish/Holding/Herd notation. A Live herd is one flagged active on SAM (formerly VetNet) at the end of the study year. Unless stated, all such herds are included in the denominator for the analysis of incidence, whether or not they had been tuberculin tested or under restriction in the year. It is acknowledged that this definition of a herd does not give the same values as the Agricultural Census or the Cattle Tracing System (CTS). On the other hand, unlike census or CTS data, SAM gives separate data for each herd within a holding, is maintained continuously for all herds (not just by sample surveys), and represents all herds no matter how small. Delays in reflecting the true activity periods of herds in SAM, can affect the accuracy of SAM-derived estimates of numbers of herds. All herds reported in Section 1 refer to live/active herds according to SAM at the end of the reporting year. |

| Abbreviation | Detail | Definition or description |
|---|---|---|
| | Herd size | For a TB incident, herd size is the largest size entered in SAM for a test conducted at any time during the incident. For officially TB free herds, herd size has been changed in 2017 to take a median size recorded on the BCMS Cattle Tracing Scheme for the holding over the most recent 12 months with a recorded size, and this has been supplemented for those holding with more than one herd in existence at the same time or not present in BCMS with the herd size recorded at the most recent whole herd test. Where no size is retrievable from either source the typical number of animals indicated on SAM has been used. The change to using CTS was largely driven with the aim of reducing the numbers without a retrievable size from the testing history and where recent tests presented no eligible stock. |
| | Herd test | A surveillance or control test triggered by a herd level event, rather than a test triggered for an individual animal. For example, a routine herd test is a herd test applied because a regular surveillance test is due, whereas a pre-movement test is not a herd test. |
| | Herd years at risk | The sum of the time (days, months or years) herds in the population are unrestricted and are therefore at risk of a new incident. The time at risk is calculated for each herd at each SICCT test or start of a TB incident as the total time the herd was not under restriction since the last test before or at the beginning of the time period for which the rate is being calculated and then summed across all herds. |
| | Herd types | *'Beef' includes* Beef, Finishing, Suckler, Beef dealer, Beef Heifer Rearer, Beef Bull Hirer and Stores herds<br>*'Dairy*' includes Dairy, Dairy Dealer, Dairy Bull Hirer, Dairy Producer, Dairy Heifer Rearer and Domestic herds;<br>*'Other'* includes Calf Rearers, unspecified Dealer Herds, AI, buffalo herd and herds described on SAM as 'Other herds'. It may also include atypical herd premises such as temporary gatherings and quarantine facilities, although these are typically not subject to testing. |
| | Homerange | The geographical area in which a genotype is most frequently recovered. A simple algorithm to define homerange area for the common genotypes of M. bovis was developed as part of Defra Project SE3257. A 5 km square is considered as part of the homerange if there have been three different incidents of that genotype, on at least 2 holdings, within a 5 year window. A 10km buffer is then applied in order to create coherent homerange area for each genotype. |
| | Incidence | For the purposes of this report, incidence is the ratio between the number of a TB incidents detected ("disclosed") and a denominator for the population, which is either (a) the number of "live or active" herds regardless of whether they have been tuberculin tested, or (b) the total time that herds have been at risk of being detected with TB (i.e. accounts for testing history). |
| IR | Inconclusive reactor | An animal showing a particular pattern of reactions to a comparative intradermal tuberculin test that uses bovine and avian reagents, where the difference in size of reactions to bovine and avian tuberculin is not large enough to cause it to be described as a reactor. In Wales, both standard and severe interpretation inconclusive reactors are recognised.<br>Animals having two successive tests giving Inconclusive reactor measurements are generally considered to be skin test reactors, but may be described as "IRs After 2 [or more] tests as IR" to distinguish them from other reactors in some parts of this report. IRs may be re-classified as reactors when interpreted severely. |

| Abbreviation | Detail | Definition or description |
|---|---|---|
| IAA | Intensive Action Area | An area with high TB prevalence in North Pembrokeshire, adjacent to Ceredigion, in which additional cattle control measures (including twice-yearly routine testing and enhanced testing for OTF-S incidents) have been applied since May 2010. |
| IFN-γ or gIFN | Interferon-gamma test | Laboratory-based blood test used in parallel with the tuberculin skin test to improve the sensitivity of the testing regimen. The in vitro gamma-interferon (IFN-γ) assay is only approved as an **ancillary** diagnostic tool and measures the release of IFN-γ in whole blood cultures stimulated with tuberculin. Most frequently used to enhance the sensitivity of testing in OTF-withdrawn herds. |
| IQR | Inter-quartile range | A measure of statistical dispersion (equal to the difference between the upper and lower quartiles): referring to the 25th and 75th percentile of the median value described. |
| | Linear regression | A statistical approach for modelling the relationship between a continuous outcome variable (e.g. restriction duration, which can take any value) and one or more 'predictor' variables (e.g. herd size, herd type or TB Area). |
| CPHH | Live herd or Active herd | Bovine herd defined in the County/Parish/Holding/Herd notation which was flagged as active on SAM on 31st December, 2018. This does rely on a degree of accuracy of the activity dates given on SAM for herds. This gives different values from the Agricultural Census, as SAM gives separate data for each herd within a holding, is maintained continuously for all herds (not just by sample surveys), and represents all herds no matter how small. |
| | Logistic regression | A statistical approach for modelling the relationship between a binary outcome variable (e.g. positive or negative result) and one or more 'predictor' variables (e.g. herd size, herd type or TB Area). |
| *M. avium* | *Mycobacterium avium* | The causative organism of avian tuberculosis, which occasionally infects cattle. |
| *M. bovis* | *Mycobacterium bovis* | The causative organism of bovine tuberculosis. |
| | Monitoring programme[1] | Programme to investigate an animal population or subpopulation, and/or its environment (including wild reservoir and vectors), to detect changes in the occurrence and infection patterns of an animal disease or zoonosis. |
| | Movement restrictions / restrictions | Prohibitions on the free movement of animals into and out of a herd. Movement restrictions may be imposed on a herd because of the presence, or the suspicion of the presence, of *M. bovis* infection or because statutory tests are overdue. Herd restrictions due to overdue tests are excluded from analyses in this report to avoid overestimates of disease. |
| | New TB incident | A herd previously OTF in which at least one test reactor, IR taken as a reactor, or a culture-positive slaughterhouse case has been found. The *restriction*, and thus the incident, begins on the disclosing test date and ends on the date that *Form TB10* is issued. To qualify as being "new", the incident must have been *disclosed* in the period specified. |
| NDL | No detected lesions | No lesions typical of bovine TB detected in the carcass of a SICCT or IFN-γ test reactor at *post mortem* examination or during routine slaughterhouse inspection of cattle. |
| OTF | Officially bovine tuberculosis free | See Appendix 3 for Extract from European Union (1998), Council Directive 98/46/EC for full definition of the officially TB free status. |

| Abbreviation | Detail | Definition or description |
|---|---|---|
| OTF-W | Officially bovine tuberculosis free status withdrawn | This term refers to a herd with a TB incident in which additional evidence of *M. bovis* infection has been identified in at least one slaughtered bovine animal, i.e. *M. bovis identified* in a cultured tissue sample and/or lesions detected in the carcass of a SICCT or IFN-γ test reactor. It also includes other incidents upgraded to OTF-W for epidemiological reasons. |
| OTF-S | Officially bovine tuberculosis free status suspended | This is the status of a herd with a TB incident where there is a suspicion of infection being present but no evidence of *M.bovis* infection has been identified nor the herd perceived of being at greater epidemiological risk of being truly infected. |
| | Poisson regression | A type of statistical modelling based on a particular type of numerical distribution that is used to compare rates of rare occurrences between different population groups, different areas, or different times. |
| PME | *Post mortem* examination | Examination (to various extents) of the carcass and organs of slaughtered cattle for suspected lesions of bovine TB. Such post mortem examinations included those undertaken at an APHA Regional Laboratory, those undertaken at the slaughterhouse following *in vivo* suspicion of infection (e.g. reactors, IRs and DCs), and those undertaken as part of routine meat inspection. |
| | Prevalence | For the purposes of this report, prevalence is the proportion of active herds under movement restrictions on a given date due to a TB incident, and excludes herds restricted due to an overdue test. |
| R | Reactor | An animal showing a particular pattern of reactions to a single intradermal tuberculin comparative test (SICCT test) or to a gamma interferon (IFN-γ) assay that uses bovine and avian reagents, and not including an animal first suspected to have TB at the slaughterhouse. An inconclusive reactor (IR) will be treated as a reactor if a retest yields a second inconclusive result, but will not count towards statistics for reactors throughout this report. |
| | Recurrent herd | A herd that had a TB incident disclosed in the reporting year that had also been under movement restrictions for a different TB incident in the previous 36 months. |
| Ref | Reference category | In regression analyses the reference group acts as a baseline against which we compare other groups of interest. |
| | Risk Area | On 1 January 2013, a new TB surveillance testing regime was introduced for bovine herds in England. TB testing intervals for bovines are now either on an annual or four yearly basis at county rather than parish level. In the England surveillance report, data is presented by risk area: High Risk Area (HRA – annual testing), Edge Area (annual testing) and Low Risk Area (LRA – 4-yearly testing).<br><br>Following a 12 week consultation with industry in 2016, the Welsh Government's strengthened TB Programme committed to a regionalized approach to eradicating TB in Wales [see 'TB Area']. |
| SAM | SAM database | APHA's TB control and surveillance system, which records details of herds, TB tests, TB incidents and the details of any slaughtered (reactors, slaughterhouse cases and direct contacts) and inconclusive reactor cattle. |
| Se | Sensitivity (of a test) | The proportion of truly infected individuals in the screened population that are identified as infected by the test. |
| | Severe interpretation | Using this interpretation of the comparative intradermal tuberculin test, animals showing either i) a positive bovine reaction and negative avian reaction or ii) a positive bovine reaction more than 2mm greater than a positive avian reaction are deemed reactors. |

| Abbreviation | Detail | Definition or description |
|---|---|---|
| SICCT, tuberculin skin test, skin test | Single Intradermal Comparative Cervical Test | Also commonly referred to as the 'skin test' or 'tuberculin skin test'. The testing procedure involves the simultaneous injection of a small amount of *M. bovis* and *M. avium* tuberculins (purified protein derivative (PPD); a crude extract of bacterial cell wall antigens), into two sites of the skin of the animal's neck, followed by a comparative measurement of any swelling (delayed-type hypersensitivity reaction) which develops at the two injection sites after 72 hours. |
| SLH | Slaughter-house case | This refers to an incident (rather than an animal) that is triggered by the disclosure of an animal from an OTF herd that had lesions consistent with TB during routine post-mortem meat inspection. In order that the case becomes an OTF-W incident, *M. bovis* must be isolated on culture from samples of the lesions. Until *M. bovis* is isolated at culture, a slaughterhouse case remains suspect and does not contribute to incident figures within this report, unless any subsequent skin check test performed in the herd of origin identifies reactors. |
| | 'Smoothed' and/or '12-month moving average' | A 12-month moving average is the average of the values for the current month and the previous 11 months. Moving averages can be any length. But, in general, shorter lengths will be best at identifying turning points and longer lengths best at identifying trends. |
| Sp | Specificity (of a test) | The proportion of truly uninfected individuals in the screened population who are identified as uninfected by the test. |
| | Spoligotype | The result of one form of genomic typing of organisms of the *Mycobacterium tuberculosis* group described as Spacer Oligonucleotide typing. |
| SD | Standard deviation | The standard deviation measures the spread of the data around the mean value. It is useful in comparing sets of data which may have the same mean but a different range of raw values. |
| | Standard interpretation | Using this interpretation of the comparative intradermal tuberculin test, animals showing a positive bovine reaction more than 4mm greater than a negative or positive avian reaction are deemed reactors. |
| | Surveillance | Surveillance refers to activities to collect and record data on specific diseases in defined populations over a period of time, in order to assess the epidemiological evolution of the diseases and the ability to take targeted measures for control and eradication. |
| | TB10 form | The form issued at the end of a TB incident to lift the restrictions imposed on cattle movements onto and off the holding. |
| | TB Area | Five TB Areas (High West, High East, Intermediate North, Intermediate Mid and Low) were introduced in Wales in October 2017 based on the distribution of TB within Wales. For further details see Appendix 5. |
| | Time at risk | Time spent not under restriction since the most recent herd-level test or end of incident. |
| VetNet | VetNet database | VetNet is the predecessor of SAM, APHA's TB control and surveillance system, which records details of herds, TB tests, TB incidents and the details of any slaughtered (reactors, slaughterhouse cases and direct contacts) and inconclusive reactor cattle. VetNet data was migrated into SAM. |
| VNTR | VNTR type | The result of a form of genomic typing based on repeated sequences of genomic DNA described as Variable Number Tandem Repeat typing. |

[1] EU Commission Staff Working Document technical details on the outcome of the EU co-financed programmes for the eradication, control and monitoring of animal diseases and zoonosis over the period of 2005-2011. Brussels, 5.3.2014. SWD(2014) 55 final.

**Appendix Table 2**: Definitions of surveillance test codes used in Section 2 and Appendix Table 3

| Surveillance test type | Definition |
|---|---|
| VE-IFN_ANOM | Gamma interferon anomalous reactions procedure |
| VE-IFN_LOW_IN | Gamma interferon testing in an OTF-W herd in a low TB incidence area |
| VE-IFN_PERSI | Gamma interferon testing in an OTF-W herd with persistent infection |
| VE-IFN_SLHERD | Gamma interferon testing in whole or partial slaughter of reactor herds |
| VE-IFN_2x_IR | Gamma interferon testing of 2x IR cattle |
| VE-IFN_NSR | IFN Non-Specific Reactor Herd - Investigation and Intervention |
| VE-IFN_OTH_SP | IFN test performed due to disease in other species |
| VE-TBU | Test of a herd every 90 days in an Approved Finishing Unit (AFU – a holding that takes cattle from herds under TB restrictions) (this is the former VE-90D) |
| VE-SI (& VE-IASI) | Whole herd short interval test, used only during TB incidents (& those 2nd SI tests performed on OTF-S herds done in the 'intensive action area') |
| VE-CT | Check test of herd following slaughterhouse cases, clinical cases, evidence of TB in other non-reactors or in deer, or for any other reason at the RVL's discretion |
| VE-CT(EM) | Check test carried out outside normal testing frequency to determine the herd's disease status when there is a suspicion of infection (e.g. following back-tracing from an infected herd) |
| VE-CT(I-I) | As for CT(EM) except it will be for the 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 slaughter or post-mortem or for any other reason at the RVL's discretion |
| VE-CT-HS1, 2 | First and second tests of a herd in a recognised hotspot |
| VE-CT-RTA | Check test following the discovery of an infected road-killed badger |
| VE-CT-NH1, 2, 3 | First, second and third check tests of newly-established herds |
| VE-CT-RH1, 2, 3 | First, second and third check tests of re-formed herds |
| VE-6M (& VE-IA6) | Test six months after the end of an incident (& those done in the 'intensive action area') |
| VE-12M (& VE-IA12) | Test twelve months after the six-month (VE-6M) test (& those done in the 'intensive action area') |
| VE-CON | Test carried out on herds contiguous to OFT-W herds outside their regular test frequency (first test) |
| VE-CON6 | Test of a contiguous herd (after 6 months) |
| VE-CON12 | Test of a contiguous herd (12 months after VE-CON, or 12 months after VE-CON6, if done) |
| VE-RAD 6, 12 | Radial herd test. Eligibility will be as for contiguous herd tests. RAD6 and RAD12 conducted at 6 and 12 months post initial radial test. |
| VE-WHT | Whole herd test in a parish with a testing interval of one year |
| VE-WHT2 | Whole herd test applied to a herd in a parish with a testing interval of 2 years |
| VE-RHT | Routine herd test (only in parishes tested at intervals of 2 or more years) |
| VE-CTW1 | (Whole herd) Check test for herds previously tested at longer intervals in Health Check Wales |
| VE-CTW2 | Check test for Health Check Wales, done at the scheduled time but upgraded to a whole herd test |
| VE-IR | Inconclusive reactor re-test |

| Surveillance test type | Definition |
|---|---|
| VE-TR | Forward tracing test of bovines moved from OFT-W herds prior to service of restrictions |
| VE-SLH | A pseudo-test code applied to an incident disclosed by confirmed infection in a routinely slaughtered animal (*slaughterhouse case*) |
| VE-EX | Test on cattle to be exported from Great Britain |
| VE-PII | Post-import test performed on cattle imported from Northern Ireland and the Republic of Ireland |
| VE-PIO | Post-import test performed on other imported cattle |
| VE-AI | Test performed on cattle prior to admission to an artificial insemination centre |
| VE-PRI | Private TB test (a test approved by the AHDO, paid for by the owner and carried out by an official veterinarian) |
| VE-PRMT | Pre-movement test |
| VE-POSTMT | Post-movement test to be carried out where cattle have been moved to a holding without a required pre-movement test |
| VE-POSTMTOV | Post-movement test at 60-120 days of any animal arriving in the Low TB Area |
| VE-REST | A pseudo-test code to indicate that a herd has been put under restrictions, for example because a scheduled test is overdue. *This code is removed from VetNet when testing is performed.* |
| VE-ASG | Testing of restricted isolated groups of cattle within an incident or a non-incident herd at the RVL's discretion |

# Appendix 3 – Test type frequency

**Appendix Table 3**: Number of surveillance tests (herds not under restriction), reactors and resulting incidents and the number of disease control tests taken in herds under restriction

| | Surveillance tests[2] | | | Disease control tests[3] |
|---|---|---|---|---|
| **Test type[1]** | **No. Tests** | **Reactors** | **TB incidents** | **No. tests** |
| **Routine** | **467,655** | **377** | **161** | **1,253** |
| VE-CTW1 | 0 | 0 | 0 | 0 |
| VE-CTW2 | 0 | 0 | 0 | 0 |
| VE-WHT | 443,006 | 361 | 151 | 1,253 |
| VE-WHT2 | 29 | 0 | 0 | 0 |
| VE-IA6 | 16,464 | 13 | 9 | 0 |
| VE-IA12 | 8,156 | 3 | 1 | 0 |
| **Herd Risk** | **178,481** | **379** | **119** | **366** |
| VE-12M | 42,377 | 79 | 28 | 0 |
| VE-6M | 136,104 | 300 | 91 | 366 |
| **Area Risk** | **453,811** | **869** | **287** | **2,115** |
| VE-CON | 340,698 | 654 | 203 | 1,153 |
| VE-CON12 | 110,818 | 214 | 83 | 895 |
| VE-CON6 | 2,295 | 1 | 1 | 0 |
| VE-CT-HS1 | 0 | 0 | 0 | 67 |
| **Movement Risk** | **10,442** | **18** | **16** | **367** |
| VE-TR | 9,168 | 16 | 15 | 226 |
| VE-EX | 20 | 0 | 0 | 0 |
| VE-AI | 45 | 0 | 0 | 0 |
| VE-PII | 1,208 | 2 | 1 | 141 |
| VE-PIO | 1 | 0 | 0 | 0 |
| **Movement Risk 2** | **144,678** | **118** | **70** | **702** |
| VE-POSTMT | 8,700 | 0 | 0 | 23 |
| VE-PRI | 1,747 | 1 | 1 | 0 |
| VE-PRMT | 134,231 | 117 | 69 | 679 |
| **Inconclusive reactors** | **1,512** | **0** | **0** | **1,399** |
| VE-IR | 1,511 | 0 | 0 | 175 |
| VE_IFN_2X_IR | 1 | 0 | 0 | 1,224 |
| **Slaughterhouse** | **190,182[4]** | **0** | **75** | **45,205** |
| VE-QSLH | 0 | 0 | 0 | 0 |
| VE-SLH | 190,182 | 0 | 75 | 45,205 |

| Test type[1] | Surveillance tests[2] No. Tests | Reactors | Breakdowns | Disease control tests[3] No. tests |
|---|---|---|---|---|
| **New Herds** | **7,884** | **8** | **3** | **0** |
| VE-CT-NH1 | 7,205 | 8 | 3 | 0 |
| VE-CT-NH2 | 679 | 0 | 0 | 0 |
| VE-CT-NH3 | 0 | 0 | 0 | 0 |
| **Control** | **22,005** | **45** | **14** | **175,827** |
| VE-90D | 0 | 0 | 0 | 0 |
| VE-CT | 0 | 0 | 0 | 0 |
| VE-IFN | 0 | 0 | 0 | 0 |
| VE-IASI | 0 | 0 | 0 | 0 |
| VE-SI | 6,185 | 1 | 1 | 0 |
| VE-CT(I-I) | 11,237 | 36 | 8 | 125,965 |
| VE-CT(EM) | 2,316 | 2 | 2 | 1,446 |
| VE_IFN_ANOM | 0 | 0 | 0 | 100 |
| VE-IFN_LOW_IN | 0 | 0 | 0 | 19,089 |
| VE-IFN_NSR | 0 | 0 | 0 | 0 |
| VE-IFN_OTH_SP | 0 | 0 | 0 | 0 |
| VE-IFN_PERSI | 0 | 1 | 1 | 23,293 |
| VE-IFN_SLHERD | 0 | 0 | 0 | 4,177 |
| VE-TBU | 2,267 | 5 | 2 | 1,757 |
| **Other** | **0** | **0** | **0** | **0** |
| VE-SV | 0 | 0 | 0 | 0 |
| VE-ASG | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 |

[1] Refer to Appendix table 2 for an explanation of these codes
[2] Animal-level tests done in herds not under movement restrictions
[3] Animals-level tests done in herds under movement restrictions
[4] Figure derived from the number of animals slaughtered from herds that were not under restriction.

# Appendix 4 - Extract from European Union (1998), Council Directive 98/46/EC

A bovine herd will retain officially tuberculosis-free status if:

- the conditions detailed in 1(a) and (c) [i.e. no clinical cases, no reactors at two tests six months apart, some controls on imports] continue to apply;
- – all animals entering the holding come from herds of officially tuberculosis-free status;
- – all animals on the holding, with the exception of calves under six weeks old which were born in the holding, are subjected to routine tuberculin testing in accordance with Annex B at yearly intervals.
- However, the competent authority of a Member State may, for the Member State or part of the Member State where all the bovine herds are subject to an official programme to combat tuberculosis, alter the frequency of the routine tests as follows:
- – if the average – determined at 31 December of each year – of the annual percentages of bovine herds confirmed as infected with tuberculosis is not more than 1 % of all herds within the defined area during the two most recent annual supervisory periods, the interval between routine herd tests may be increased to two years and male animals for fattening within an isolated epidemiological unit may be exempted from tuberculin testing provided that they come from officially tuberculosis-free herds and that the competent authority guarantees that the males for fattening will not be used for breeding and will go direct for slaughter,
- – if the average – determined at 31 December of each year – of the annual percentages of bovine herds confirmed as infected with tuberculosis is not more than 0,2 % of all herds within the defined area during the two most recent biennial supervisory periods, the interval between routine tests may be increased to three years and/or the age at which animals have to undergo these tests may be increased to 24 months,
- – if the average – determined at 31 December of each year – of the annual percentages of bovine herds confirmed as infected with tuberculosis is not more than 0,1 % of all herds within the defined area during the two most recent supervisory triennial periods, the interval between routine tests may be increased to four years, or, providing the following conditions are met, the competent authority may dispense with tuberculin testing of the herds:
    - ▪ before the introduction into the herd all the bovine animals are subjected to an intradermal tuberculin test with negative results;
    - ▪ all bovine animals slaughtered are examined for lesions of tuberculosis and any such lesions are submitted to a histopathological and bacteriological examination for evidence of tuberculosis.
- The competent authority may also, in respect of the Member State or a part thereof, increase the frequency of tuberculin testing if the level of the disease has increased.

# Appendix 5 – The geographical areas used in this report

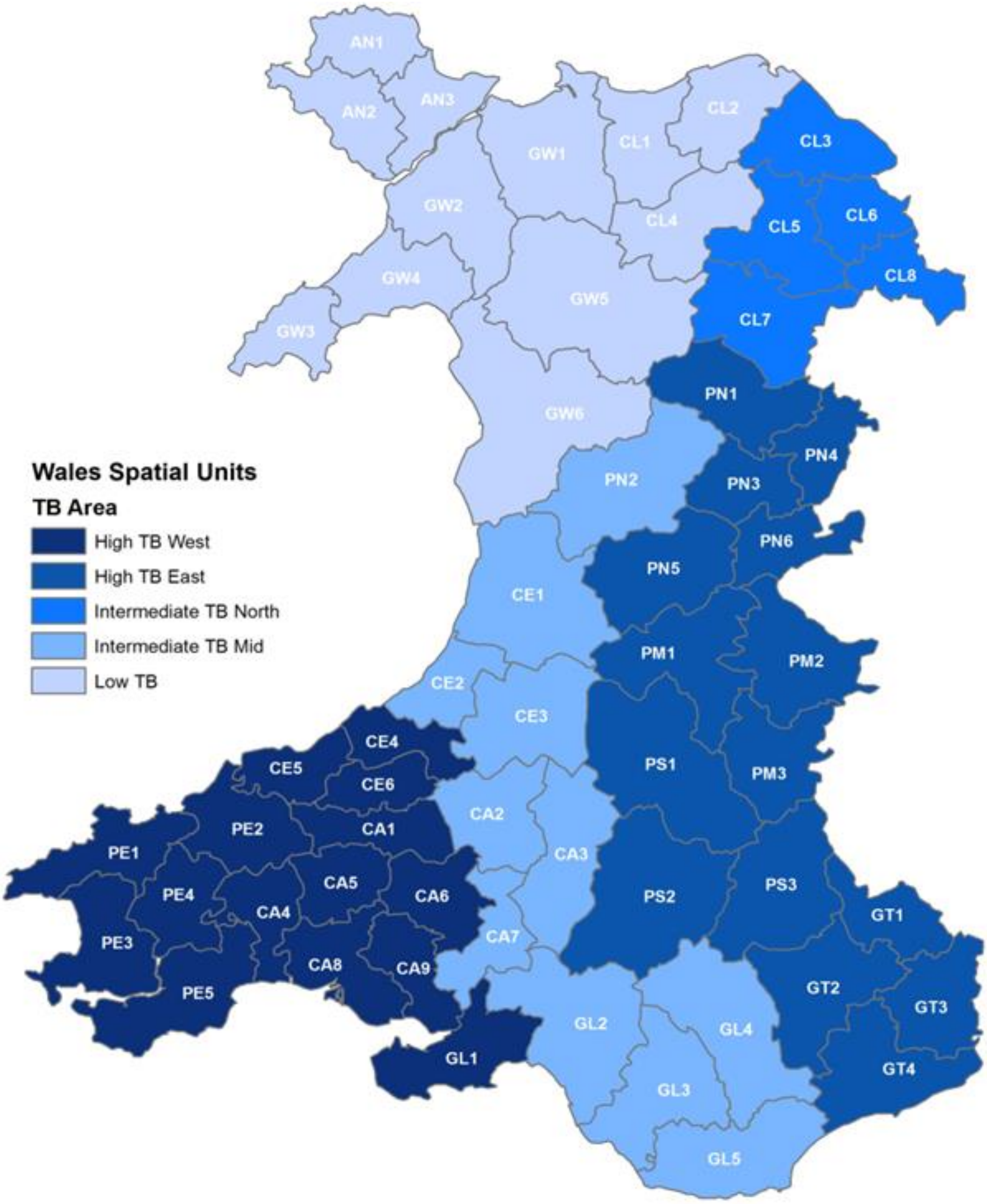
There is a need to describe the bovine TB epidemic in Wales at some geographical level above that of the 'parish' but below that of 'Wales'. Previously the data in this report were presented at a county level, derived from the 'CP' component of the County Parish Holding Herd (CPHH) identifier used for cattle herd data. This report now presents data according to the five "TB Areas" of Wales. This reflects the regionalised approach to TB eradication established through the refreshed TB Eradication Programme, launched in October 2017.

The Wales TB Areas are themselves comprised of 58 Spatial Units (Appendix Figure 1). Spatial units are compatible with the CPHH system and each contain a similar number of herds.

The splitting of Wales into a number of TB Areas reflects the need to recognise the differing disease situations. The approach to disease control in each area reflects the prevailing local circumstances and measures are developed that are best suited to make a difference to disease in those areas.

Six-year interim regional milestones have been set according to improvements in herd incidence at regional level and the transfer of Spatial Units from higher to lower incidence areas. The national eradication target emerges on the basis of the regional targets being achieved. Further information on the TB eradication targets for Wales is available on the Welsh Government website.

Office of the Chief Veterinary Officer,
Welsh Government,
September 2019




**Appendix Figure 1**: Wales TB Areas and spatial units

# Appendix 6 – The number of herds, incidents, herds under restriction and cattle slaughtered for different reasons relating to TB control between 1990 and 2018

**Appendix Table 4**: The number of herds, incidents, herds under restriction and cattle slaughtered for different reasons relating to TB control between 1990 and 2018

| Year | Number of herds | Total TB incidents | OTF-W incidents | Herds under restriction[1] | Inconclusive reactors slaughtered[2] | Reactors slaughtered[2] | Direct contacts slaughtered[2] |
|---|---|---|---|---|---|---|---|
| 1990 | 21,507 | 35 | 11 | 8 | 8 | 64 | |
| 1991 | 21,507 | 53 | 21 | 14 | 20 | 132 | 10 |
| 1992 | 21,507 | 51 | 26 | 16 | 29 | 100 | 18 |
| 1993 | 21,507 | 87 | 29 | 26 | 23 | 162 | 1 |
| 1994 | 21,507 | 99 | 63 | 40 | 43 | 361 | 27 |
| 1995 | 21,339 | 168 | 107 | 68 | 82 | 505 | 178 |
| 1996 | 20,450 | 202 | 114 | 53 | 78 | 649 | 208 |
| 1997 | 19,201 | 157 | 61 | 51 | 80 | 361 | 169 |
| 1998 | 18,657 | 209 | 91 | 84 | 119 | 729 | 236 |
| 1999 | 18,580 | 269 | 136 | 106 | 88 | 882 | 416 |
| 2000 | 18,134 | 261 | 165 | 120 | 72 | 956 | 358 |
| 2001 | 17,981 | 207 | 141 | 163 | 88 | 1,555 | 421 |
| 2002 | 17,360 | 619 | 374 | 412 | 111 | 4,393 | 520 |
| 2003 | 16,546 | 624 | 348 | 386 | 165 | 4,910 | 679 |
| 2004 | 15,881 | 653 | 351 | 425 | 163 | 4,798 | 557 |
| 2005 | 15,075 | 732 | 427 | 493 | 211 | 5,847 | 669 |
| 2006 | 14,897 | 766 | 478 | 554 | 152 | 5,253 | 700 |
| 2007 | 14,122 | 934 | 479 | 681 | 200 | 7,095 | 606 |
| 2008 | 13,766 | 1,192 | 626 | 914 | 293 | 10,462 | 1,033 |
| 2009 | 13,172 | 1,192 | 553 | 734 | 1,310 | 8,946 | 590 |
| 2010 | 12,932 | 1,036 | 507 | 710 | 940 | 6,519 | 241 |
| 2011 | 12,821 | 1,055 | 705 | 751 | 938 | 6,651 | 460 |
| 2012 | 12,729 | 1,086 | 813 | 864 | 1,064 | 8,235 | 315 |
| 2013 | 12,676 | 869 | 675 | 608 | 964 | 5,141 | 180 |
| 2014 | 12,067 | 843 | 709 | 568 | 630 | 5,387 | 491 |
| 2015 | 11,675 | 831 | 680 | 591 | 840 | 6,926 | 486 |
| 2016 | 11,651 | 706 | 624 | 566 | 862 | 8,145 | 1,144 |
| 2017 | 11,978 | 788 | 707 | 656 | 2,106 | 7,392 | 1,222 |
| 2018 | 11,955 | 744 | 665 | 679 | 2,032 | 7,843 | 808 |

[1] The number of herds under movement restrictions in the middle of December of each year. Excludes herds restricted due to an overdue test.

[2] The number of cattle slaughtered for different reasons within a year regardless of when the incident began. Data for previous years has been updated using the latest available source data, and so may differ from that presented in previous reports.