Animal & Plant Health Agency

Asiantaeth Iechyd Anifeiliaid a Phlanhigion

Epidemiology of bovine tuberculosis in Wales

Annual surveillance report

For the period: January to December 2019

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BovineTB@gov.wales

Contents

List of Tables and Figures (in order of appearance in the report)

Background

This report is presented in five 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 2019. It reports both the frequency and geographic distribution of the disease in Wales in 2019 and changes over time. It also explores the different surveillance and control measures used to control TB in cattle herds and the impact of the disease.

The intended audience for this report are those involved in the eradication of TB in cattle, both nationally and locally. This includes, but is not limited to: farmers, veterinarians, policy makers and the scientific community.

Data presented in these reports are derived from the same source as Defra's 'National Statistics' on the incidence and prevalence of TB in Great Britain, which include monthly statistical reports and other quarterly statistics on specific aspects of TB surveillance. Whilst the data source is the same, additional time has been spent by APHA removing duplication and correcting other transactional data errors before compiling the Wales TB report. As such, there may be some differences between the data presented in this report and the national statistics.

Summary

The following summary highlights the main findings described in each section. Overall, the data suggests that progress continues to be made in Wales to tackle bovine tuberculosis (TB) through the comprehensive TB eradication programme introduced in 2008. A refreshed eradication strategy was published in 2017[1] to check progress towards a TB-free Wales and focus on a regionalised approach to TB control.

The implementation of annual testing across all cattle herds in Wales since 2010 has continued to be effective in identifying infection early, with the number of new TB incidents at a ten year low. Six per cent of cattle herds had a new TB incident in 2019, while 5.5% were under movement restrictions, with around 90% of cattle herds in Wales free of TB. Where data has identified that TB incidence and prevalence are not uniformly distributed throughout Wales, the introduction of TB Risk Areas help to identify the different patterns of disease across the country.

Welsh cattle population characteristics

As in previous years, density of herds was highest in the High West TB Area. Beef herds accounted for nearly 80% of all herds in Wales, however the majority of large herds (with more than 300 animals) are dairy (74%). This is consistent with previous reporting years.

[1] https://gov.wales/sites/default/files/publications/2017-11/wales-bovine-tb-eradication-programme.pdf

Routine testing frequency has remained stable since the implementation of annual testing, and the ratio of animal tests to cattle is 2:1.

Most animal movements occur within the same TB Area, although the percentage varies, from 29% in the Intermediate North TB Area to 80% in the High West TB Area. The High West, Intermediate Mid and Intermediate North TB Areas received more animal movements from higher risk areas, and movements that occurred outside of the same TB Area.

Bovine tuberculosis surveillance in Wales

Just over two million skin tests were conducted in Wales in 2019 across all TB areas. Nearly 70% of all tests were conducted in the High TB Areas of Wales. 'Routine' and 'Herd Risk' tests detected similar numbers of herds where the officially tuberculosis free (OTF) status was withdrawn (OTF-W, 106 and 111, respectively), and more than double were detected by 'Area Risk' tests. However, as a proportion of all tests, over five times as many incidents were detected per 100 'Herd Risk' tests and over three times as many incidents per 100 'Area Risk' tests compared to 'Routine' herd tests.

Reactor and Inconclusive Reactor (IR) frequencies were greatest in the High West TB Area, reflecting the geographical distribution of TB incidents in Wales. The median number of reactors disclosed at the first whole herd test (WHT) following an incident is usually one or two in each TB Area but was higher in the High West TB Area (3).

Interferon gamma (IFN-γ) tests are used in less heavily infected areas of Wales to help prevent TB from becoming established in low incidence areas, and in areas where TB is more prevalent, the use of IFN-γ helps to clear infection from herds more quickly. In 2019, 5% of all IFN-γ tests in the High East and West TB Areas disclosed reactors. This was slightly higher in the Intermediate Mid TB Area (7%) and lower in the Intermediate North and Low TB Areas (3%).

Bovine tuberculosis incidence in Wales

In 2019, the number of new TB incidents had declined by 11% compared to 2018 and was the lowest number since 2006. A total of 661 new TB incidents were disclosed in 2019, the majority (91%) of which were OTF-W.

Where the number of new TB incidents disclosed each year has been declining over the past ten years, the TB incidence (number of newly detected infected herd per 100 active herds) and incidence rate (number of new TB incidents per 100 herd years at risk (HYR)) has also declined. Nearly 6% of herds incurred a new TB incident in 2019, and nearly 7% per 100 HYR. As expected, incidence rates were highest in the High East and West TB Areas which were above the overall average for Wales. All TB Areas apart from the Intermediate North, experienced a decline in incidence per 100 HYR in 2019. Incidence in the Intermediate North TB Area has varied over time but in recent years has been close to or above the average for Wales, as was the case in 2019.

The risk of a herd becoming infected with TB is associated with factors such as herd density, herd size, production type, TB history and location. These factors contribute to the spatial pattern of TB in cattle herds across Wales. Dairy herds had a significantly higher TB incidence rate compared to beef herds, however this effect did not remain once adjusting for herd size and location.

As well as systematic skin testing of cattle, routine slaughterhouse surveillance is also used to identify and remove infected animals. Just under 10% of new OTF-W incidents in 2019 were disclosed in the slaughterhouse, but this varied by TB Area, with the Intermediate Mid TB Area closer to 20% and the Low TB Area at 3%. Dairy herds and herds with 11 - 200 animals had significantly lower odds of incurring an OTF-W incident that was disclosed in the slaughterhouse, compared to beef herds or herds with more than 300 animals. This effect remained after controlling for other factors (herd size, herd type and TB Area). After controlling for herd size and type, the odds of an OTF-W incident being disclosed in the slaughterhouse was nearly three times higher in the Intermediate Mid TB Area, compared to the High West TB Area. This could be as a result of either, variation in the sensitivity of slaughterhouse surveillance by TB Area, or geographic clustering of Official Veterinarian (OV) surveillance test performance issues.

Sixteen per cent of herds with new TB incidents in 2019 had suffered another TB incident in the previous three years, confirming that recurrent infection remains an important driver for TB infection in Wales. The odds of a herd incurring a recurrent TB infection was twice as high in herds with TB history in the High West and Intermediate North TB Areas and over three times greater in the Intermediate Mid TB Area (compared to herds with no TB history in the previous 36 months). Beef herds with TB history were also twice as likely to have a TB incident in 2019 compared to herds with no TB history.

Some animals show reactions to the skin test that are not marked enough to be classed as a reactor. Inconclusive reactors (IRs) were found in 715 herds in Wales, and 17% of these IR-only herds (that were clear at retest), went on to have a TB incident in the subsequent 15 months, compared to 5% (482/8,946) of non-IR herds that tested clear at a routine whole herd test. Half of all IR-only animals that had tested clear at the first retest, remained clear in the subsequent 15 month follow-up.

Bovine tuberculosis prevalence in Wales

Application of movement restrictions helps to prevent infection spreading, and reduces the risk of TB persisting in cattle herds. In 2019, 6% of Welsh herds incurred a new TB incident and 5.5% of herds were under movement restrictions (in mid-December 2019, excluding herds under restriction due to an overdue test).

As expected, prevalence varied by TB Area, and with over half of TB incidents in 2019 located in the High West TB Area, prevalence was highest here too (11%). In recent years, prevalence has peaked on an approximate three-yearly basis. This could be associated with the high risk of recurrence of infection in herds and the frequency by which herds were tested in relation to TB risk before annual testing was introduced (where herds from low incidence areas were tested on a less frequent basis). The percentage of herds under movement restrictions has remained relatively stable at around 5% since annual testing was implemented in 2010.

When comparing the prevalence of TB by risk area in Wales, the percentage of herds under movement restrictions (per 100 live herds) is greater in the High East and West TB Areas compared to Wales overall. In the Intermediate North TB Area, prevalence has increased since 2016. Prevalence in the Intermediate Mid and Low TB Areas fluctuates but remains below the average for Wales.

The median duration of OTF-W incidents has remained relatively stable over the past ten years, averaging 240 days, or eight months. Persistent TB herds refer to herds that have been under movement restrictions for 550 days or more (or over 18 months). Persistent OTF-W incidents 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 the high risk area of England. There were a total of 135 persistent open incidents in 2019, with 67% located in the High West TB Area. A total of 39 TB incidents that closed in 2019 were classed as persistent.

Post mortem examination, culture and genotyping of suspected TB cases

The number of cattle slaughtered for TB control has shown an increasing trend over the past five years. The recent increase in the number of reactors disclosed is primarily attributable to increases in IFN-γ testing. A total of 12,599 cattle were slaughtered in 2019 for TB control. Of these, 68% were reactors to either the skin test, IFN-γ or antibody test 25% were IRs and 7% were Direct Contacts (DCs).

In 2019, nearly 30% of reactors disclosed in Wales through standard interpretation of the skin test were confirmed infected, through either observation of detectable lesions (DLs) or culture of *M bovis*. The percentage was higher in the High East TB Area compared to Wales overall (46%), but lower in all other TB Areas (between 23-25%). The percentage of samples with DLs that were *M. bovis* positive varied by TB Area and was highest in the High East TB Area (96%) and lowest in the Low TB Area (67%). Of the 2,115 samples from animals with no detectable lesions (NDLs) and for which culture results were available, 1.3% were *M. bovis* positive overall. The percentage positive was highest in the High East and Low TB Areas (2.3 and 3.4% respectively).

There were 377 isolates from cattle for incidents in Wales that started in 2019. All were spoligotyped and the full genotype (spoligotype plus 6 VNTR loci) was obtained for 95% of these. The most common spoligotype in Wales is spoligotype 9, which has two main clusters, one in the south-west (High West TB Area) and the other mainly located in Mid Powys (High East TB Area).

Table S1. Summary of key bovine TB parameters, by TB area, 2019

Key parameter	High East TB Area	High West TB Area	Intermediate Mid TB Area	Intermediate North TB Area	Low TB Area	Wales total
Number of herds	2,806	3,185	2,038	920	2,826	11,775
Number of new TB incidents	210	308	75	45	23	661
Number of new OTF-W incidents	196	294	59	37	18	604
New TB incidents per 100 herd years at risk	9.3	12.4	4.4	6.0	1.0	6.9
New TB incidents per 100 unrestricted herds tested	8.5	11.2	4.2	5.7	1.0	6.5
Herds under restriction per 100 live herds (mid-December)	6.3	11.0	2.5	5.6	0.6	5.5
New TB incidents per 100 live herds (mid-December)	7.5	9.7	3.7	4.9	0.8	5.6
Median duration total TB (days)	207	263	188	254	246	234
Median duration OTF-W (days)	211	271	203	270	260	244
Number of open persistent incidents	29	91	3	10	2	135
Persistent TB incidents (closing in 2019)	10	24	3	2	0	39
Number of non-bovine TB isolates genotyped	4*					43**

*Not including badger isolates

**All non-bovine isolates, including 38 badger samples, location unknown

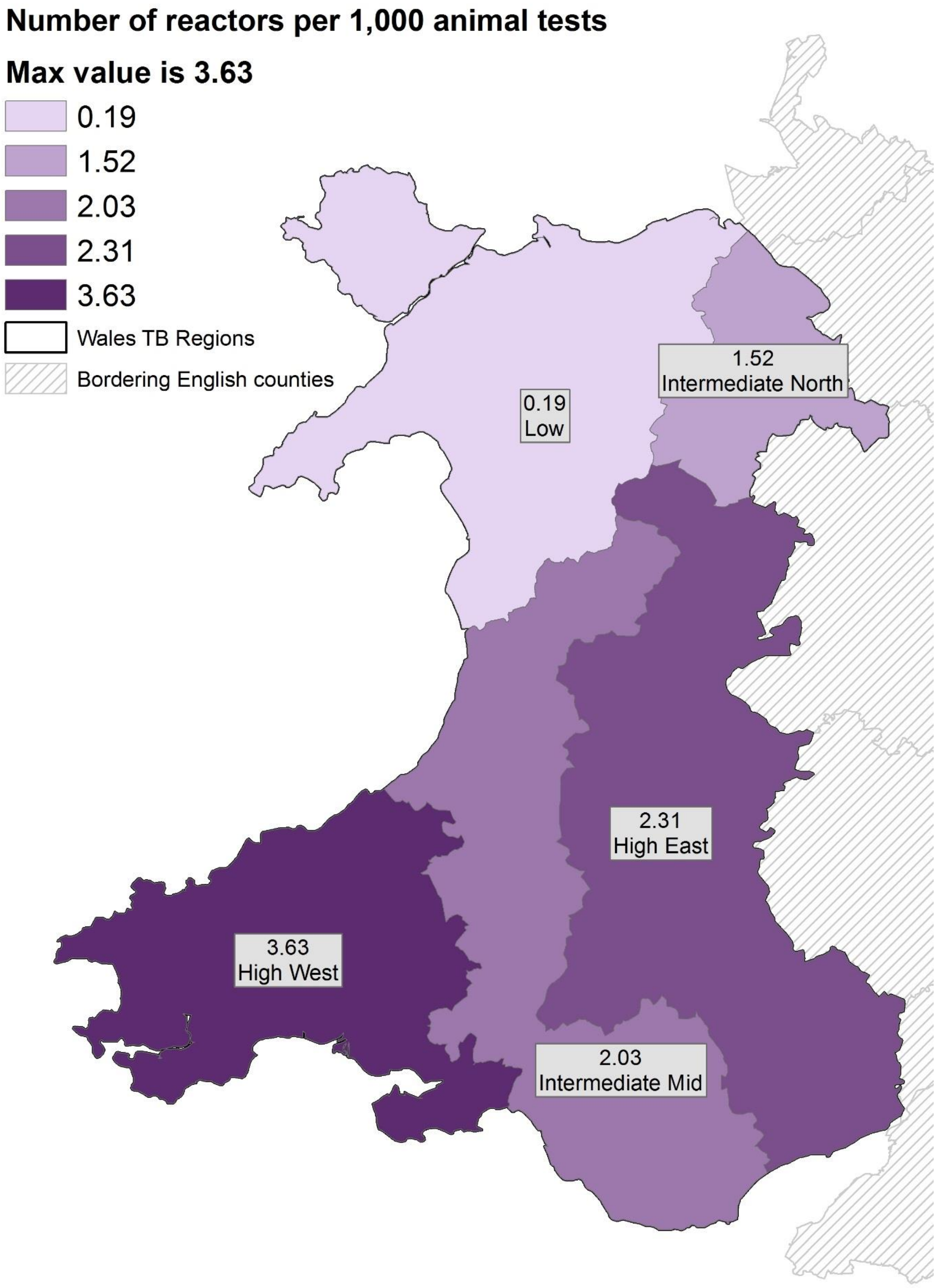


Figure S1: Reactors per 1,000 animal tests, 2019 (includes SICCT and IFN-γ tests)

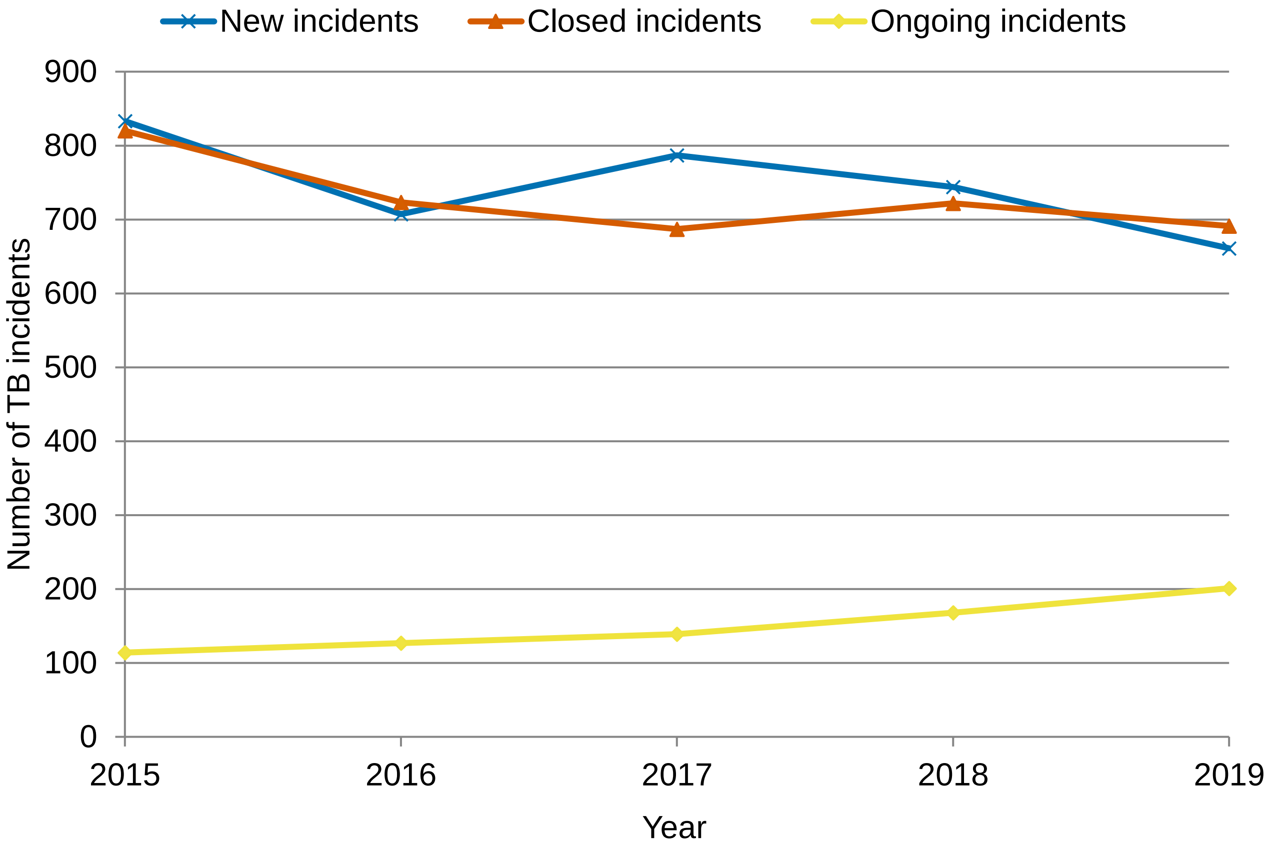


Figure S2: New, closed and ongoing TB incidents in Wales, 2015-2019

Introduction

This report is the tenth 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 2019 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

March 2021

1.0 Welsh cattle population characteristics and cattle movements

Key Points:

- As in previous years, density of herds was highest in the High West TB Area.
- The High East and Low TB Area have the same percentage of total herds in Wales, however in the Low TB Area, herds are particularly concentrated in Anglesey.
- Beef herds accounted for nearly 80% of all herds in Wales, however the majority of large herds (with more than 300 animals) are dairy (74%), which is consistent with previous reporting years.
- The number of animal tests conducted in a reporting year has remained fairly stable over the past five years, as has the ratio of animal-level tests to cattle (2:1), reflecting the stability in the routine testing frequency.
- Although most animals moved in Wales stay within the same TB Area, the percentage varies, from 29% in the Intermediate North TB Area, to 80% in the High West TB Area.
- The areas of Wales that received more animal movements from higher risk areas, and outside the same TB Area included the High West, Intermediate Mid and Intermediate North TB Areas.
- When comparing the previous three years, there is little variation in the percentage of movements from different areas into each Welsh TB risk area, however the percentages of movements from different areas differ strongly between the Welsh TB risk areas.

This section describes the population demographics of cattle in Wales, and cattle movements into each TB Area in Wales. It includes a description of factors which can affect TB infection risk such as herd size and production type. A summary of the number of TB tests performed is also provided, although further information on testing is presented in Section 2. Monitoring the movement of cattle is an important tool in TB surveillance. Movements from a high incidence area into a lower incidence area could increase the likelihood of a herd becoming infected, although the use of pre- and post-movement testing will mitigate some of this risk. The Wales TB eradication programme that launched on 1 October 2017 has a regionalised approach. This regionalised approach introduced Low, Intermediate and High TB Areas where measures have been applied in each TB Area, tailored to address the varying risks and disease drivers in each TB Area.

1.1 Welsh cattle population characteristics

The density of cattle herds registered as active on SAM on the 31st December 2019 in Wales and the bordering English counties is shown in Figure 1.1 (see Appendix 5 for description of areas).

The geographical distribution is 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 (3,185; 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 (2,806 and 2,826 respectively, both 24% of the total). This was a slight decrease on the number of herds observed in 2018. Large areas of low herd density (<0.27 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 1.1.1).

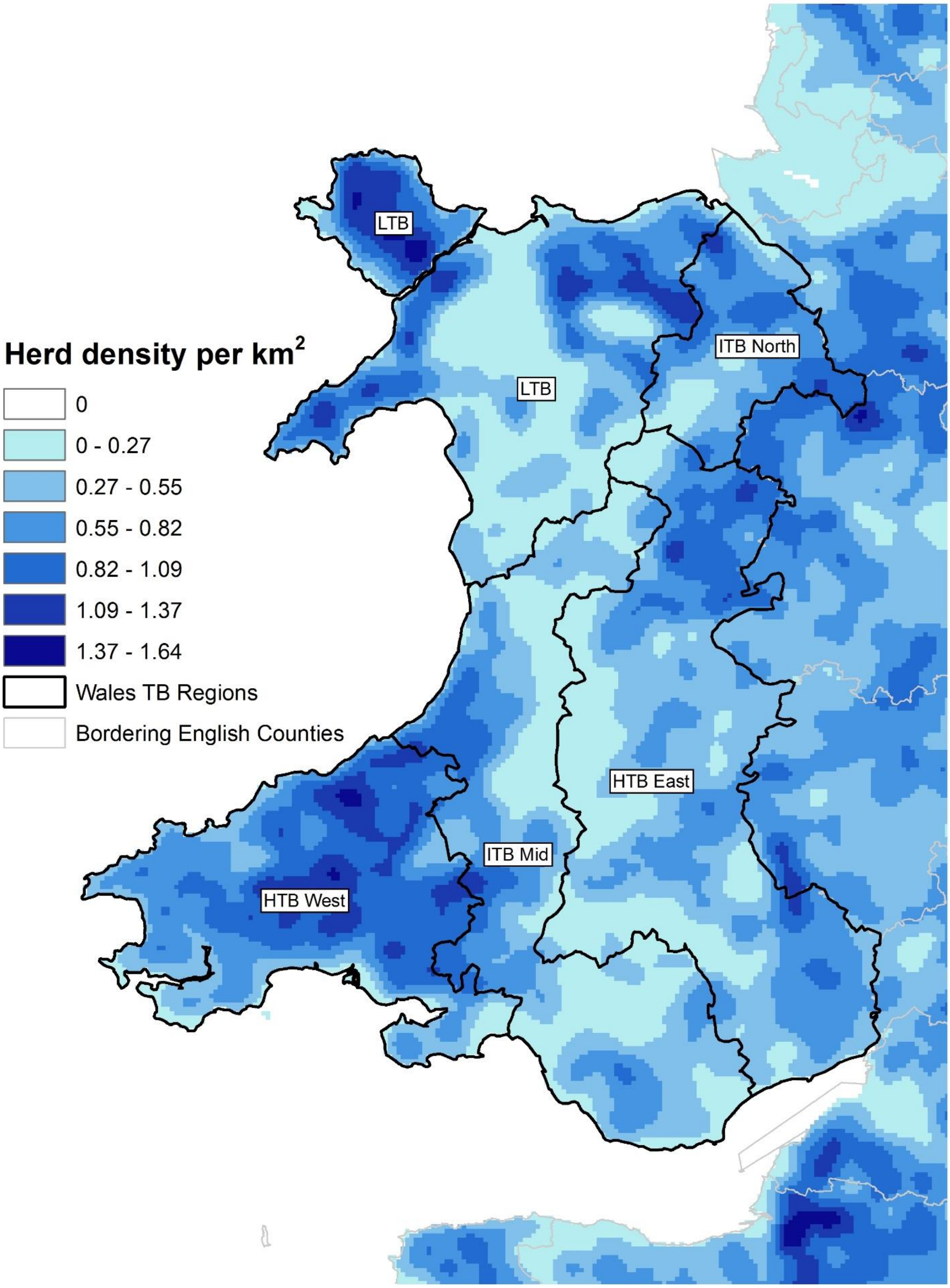


Figure 1.1.1: Density of cattle herds in Wales and English border counties, 2019

Beef herds formed the majority (77%) of cattle herds in Wales whilst dairy and mixed/other herds accounted for 20% and 3%, respectively. Variations in these percentages exist between TB Areas. The High East, Intermediate North and Low TB Areas had around 83-85% beef herds, whilst the percentage in the High West (64%) and Intermediate North (68%) were slightly lower where more dairy herds were present (34% and 28% respectively; Table 1.1.1a). In the High West TB Area, there are more than three times the number of dairy herds (1,069) compared to any other TB Area in Wales (around 300 herds in each TB Area). This reflects the large number of cattle in these dairy herds compared to other TB Areas (Table 1.1.1b). The High East and Low TB Areas have a similar number of beef herds (close to 2,400), while the High West and Intermediate Mid TB Areas have around 2,000 herds. The Intermediate Mid TB Area has just 625 beef herds, which reflects the smaller geographical area it represents across Wales.

Table 1.1.1a: Herds in Wales (active on SAM) by herd type and TB area, end-2019

TB Area	Herds	Percentage of total herds in Wales	Beef [no. herds (%)]	Dairy [no. herds (%)]	Mixed / Other [no. herds (%)]
High East	2,806	24	2,398 (85)	317 (11)	91 (3)
High West	3,185	27	2,023 (64)	1,069 (34)	93 (3)
Intermediate Mid	2,038	17	1,684 (83)	287 (14)	67 (3)
Intermediate North	920	8	625 (68)	260 (28)	35 (4)
Low	2,826	24	2,358 (83)	343 (12)	125 (4)
Total	**11,775**	**100%**	**9,088 (77)**	**2,276 (20)**	**411 (3)**

Table 1.1.1b: Number of cattle in Wales (active on SAM) by herd type and TB Area, end-2019

TB Area	Number of cattle from beef herds	Number of cattle from dairy herds	Number of cattle from mixed/ other herds
High East	166,930	66,375	3,929
High West	131,054	307,894	1,883
Intermediate Mid	86,071	64,139	907
Intermediate North	41,614	60,810	1,062
Low	165,544	79,191	3,972
Total	**591,213**	**578,409**	**7,824**

Approximately 72% of herds in Wales consisted of fewer than 100 cattle in 2019. Herds in the High West TB Area tended to be larger, with 12% having more 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 1.1.1c and d).

Table 1.1.1c: Herds in Wales (active on SAM) by size category, geographic location and herd type, end-2019

TB Area	Undetermined [no. herds][1]	1-10 [no. herds]	11-50 [no. herds]	51-100 [no. herds]	101-200 [no. herds]	201-300 [no. herds]	>300 [no. herds]	Total
High East	16	462	990	656	386	163	133	2,806
High West	12	514	946	578	533	227	375	3,185
Intermediate Mid	5	467	771	378	268	88	61	2,038
Intermediate North	2	174	257	172	161	71	83	920
Low	15	553	1,000	513	432	142	171	2,826
Herd type	**Undetermined [no. herds][1]**	**1-10 [no. herds]**	**11-50 [no. herds]**	**51-100 [no. herds]**	**101-200 [no. herds]**	**201-300 [no. herds]**	**>300 [no. herds]**	**Total**
Beef	10	1,864	3,550	1,913	1,209	333	209	9,088
Dairy	2	114	290	352	553	355	610	2,276
Other	38	192	124	32	18	3	4	411
Total in each size category	**50**	**2,170**	**3,964**	**2,297**	**1,780**	**691**	**823**	**11,775**

[1] Undetermined herd sizes arise due to no testing taking place or no cattle showing on the Cattle Tracing System (CTS). 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 are therefore not typical cattle farms.

Table 1.1.1d: Percentage of herds (active on SAM) by size category, geographic location and herd type, end-2019

TB Area	Undeter-mined	1-10	11-50	51 - 100	101 - 200	201 - 300	>300	Median herd size
High East	0.6	16.5	35.3	23.4	13.8	5.8	4.7	47
High West	0.4	16.1	29.7	18.1	16.7	7.1	11.8	58
Intermediate Mid	0.2	22.9	37.8	18.5	13.2	4.3	3.0	35
Intermediate North	0.2	18.9	27.9	18.7	17.5	7.7	9.0	57
Low	0.5	19.6	35.4	18.2	15.3	5.0	6.1	41
Herd Type	**Undeter-mined**	**1-10**	**11-50**	**51 - 100**	**101 - 200**	**201 - 300**	**>300**	**Median herd size**
Beef	0.1	20.5	39.1	21.0	13.3	3.7	2.3	37
Dairy	0.1	5.0	12.7	15.5	24.3	15.6	26.8	185
Other	9.2	46.7	30.2	7.8	4.4	0.7	1.0	10
Percentage of total herds (%)	**0.4**	**18.4**	**33.7**	**19.5**	**15.1**	**5.9**	**7.0**	

The number of herds decreased by 1.5% in 2019 (Table 1.1.2). In the same period, the total number of cattle decreased by 1.3%. In 2014, a cleansing exercise was performed on BCMS data, resulting in the removal of inactive herds, and a subsequent decline in the total number of herds recorded on the database in 2015. The increase observed in 2017 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 recorded.

The total number of tests conducted on cattle in Wales increased by only 0.1% (3,810 tests) between 2018 and 2019. In 2019, the total number of annual tests conducted on cattle in Wales included approximately 238,000 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 2015 and 2019 (Table 1.1.2). Following the results of the TB Health Check Wales in 2008, all herds in Wales have been tested annually since January 2010. However, approximately 300 herds in the Intensive Action Area (IAA) of Pembrokeshire have been tested biannually since May 2010. As well as more frequent routine testing, measures imposed to reduce infection levels include: enhanced cattle movement controls, improved biosecurity measures on farms, testing of goats and camelids and badger vaccination. This regime has continued since the refreshed TB eradication programme was launched on 1 October 2017.

Table 1.1.2: Herds (active on SAM), cattle and animal-level tests, 2015-2019

Year	Total herds	% change in herds[1]	Total cattle[2]	% change in cattle[1]	Total tests (animal level)[3]	% change in tests[1]
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
2019	11,775	↓1.5	1,119,844	↓ 1.3	2,347,770	↑0.1

[1] Arrows indicate the direction of the percentage change from the previous reporting year: ↓ = 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 Cattle movements – number of movements by TB Area

Cattle movements within and between TB risk areas, can increase the risk of herds becoming infected, especially if movements into a herd are from herds at higher risk.

Table 1.2.1 shows the total number (and percentage) of movements across all GB areas, to each TB Area in Wales. In 2019, the majority of animal moves occurred from herds located within the same TB Area, but the percentage varied.

The highest number of animal movements was in the Low TB Area, followed by the High West TB Area, although 80% of movements were from within the same TB Area. There was a higher percentage of animal movements from England’s High Risk Area (HRA) and Edge Area, into the High West TB Area (27%) and the Intermediate North TB Area (44%) compared to other TB Areas. Even in the Low TB Area, where 80% of movements occurred within the same TB Area, nearly 7% were from the HRA and Edge areas of England which accounted for over 6,000 animals. Most infection in the Low TB Area is likely to be as a result of undetected infection brought in by cattle movement. Therefore, as of 1 October 2017, all cattle moved into the Low TB Area require a post-movement test.

In herds in the High East TB Area, 44% of animal movements were from herds within the same TB Area, with a further 23% from England’s Edge area. By contrast, in the Intermediate Mid TB Area, 46% were from within the same area, and 32% from the High West TB Area. This highlights there are a significant number of animal movements into lower risk areas in Wales, from higher risk areas of both Wales and England. Herds in the Intermediate North TB Area received broadly similar percentages of cattle from a number of TB Areas (30% from within the same TB Area), with 44% of movements from England's HRA and Edge Area.

Table 1.2.1: Number and percentage of animal movements from GB areas to each Welsh TB Area, 2019

Number of animal moves in 2019	**Welsh TB Area Moved To :**				
GB TB Area Moved From:	**Wales: High East**	**Wales: High West**	**Wales: Intermediate Mid**	**Wales: Intermediate North**	**Wales: Low**
England: HRA	2,931 (4.4%)	534 (0.6%)	260 (0.6%)	10,984 (27.1%)	3,577 (3.7%)
England: Edge	15,000 (22.6%)	4,987 (5.6%)	2,999 (7.1%)	6,828 (16.9%)	2,789 (2.9%)
England: LRA	2,591 (3.9%)	697 (0.8%)	224 (0.5%)	765 (1.9%)	3,798 (3.9%)
Scotland	613 (0.9%)	27 (0.03%)	42 (0.1%)	189 (0.5%)	767 (0.8%)
Wales: High East	29,317 (44.3%)	1,907 (2.1%)	3,582 (8.5%)	1,256 (3.1%)	1,236 (1.3%)
Wales: High West	4,926 (7.4%)	70,659 (79.2%)	13,366 (31.8%)	427 (1.1%)	393 (0.4%)
Wales: Intermediate Mid	6,438 (9.7%)	9,489 (10.6%)	19,558 (46.5%)	476 (1.2%)	1,124 (1.2%)
Wales: Intermediate North	2,806 (4.2%)	469 (0.5%)	413 (1.0%)	11,623 (28.7%)	6,929 (7.1%)
Wales: Low	1,621 (2.5%)	460 (0.5%)	1,648 (3.9%)	7,967 (19.7%)	76,830 (78.9%)
Total	**66,243**	**89,229**	**42,092**	**40,515**	**97,443**

Key to table 1.2.1:

Percentage of animal movements

0-10%
11-30%
31-50%
51-70%
71-100%

Figure 1.2.1 shows the percentage of total movements from each GB Area into herds in each Welsh TB Area, from 2017 to 2019. Overall, there is not much variation in the percentage of movements from different areas into each Welsh TB risk area when comparing the last three years. However, the percentages of movements from different areas differ strongly between the Welsh TB Areas. The High East and Intermediate North TB Areas had more movements from England risk areas, likely due to their location bordering with England counties.

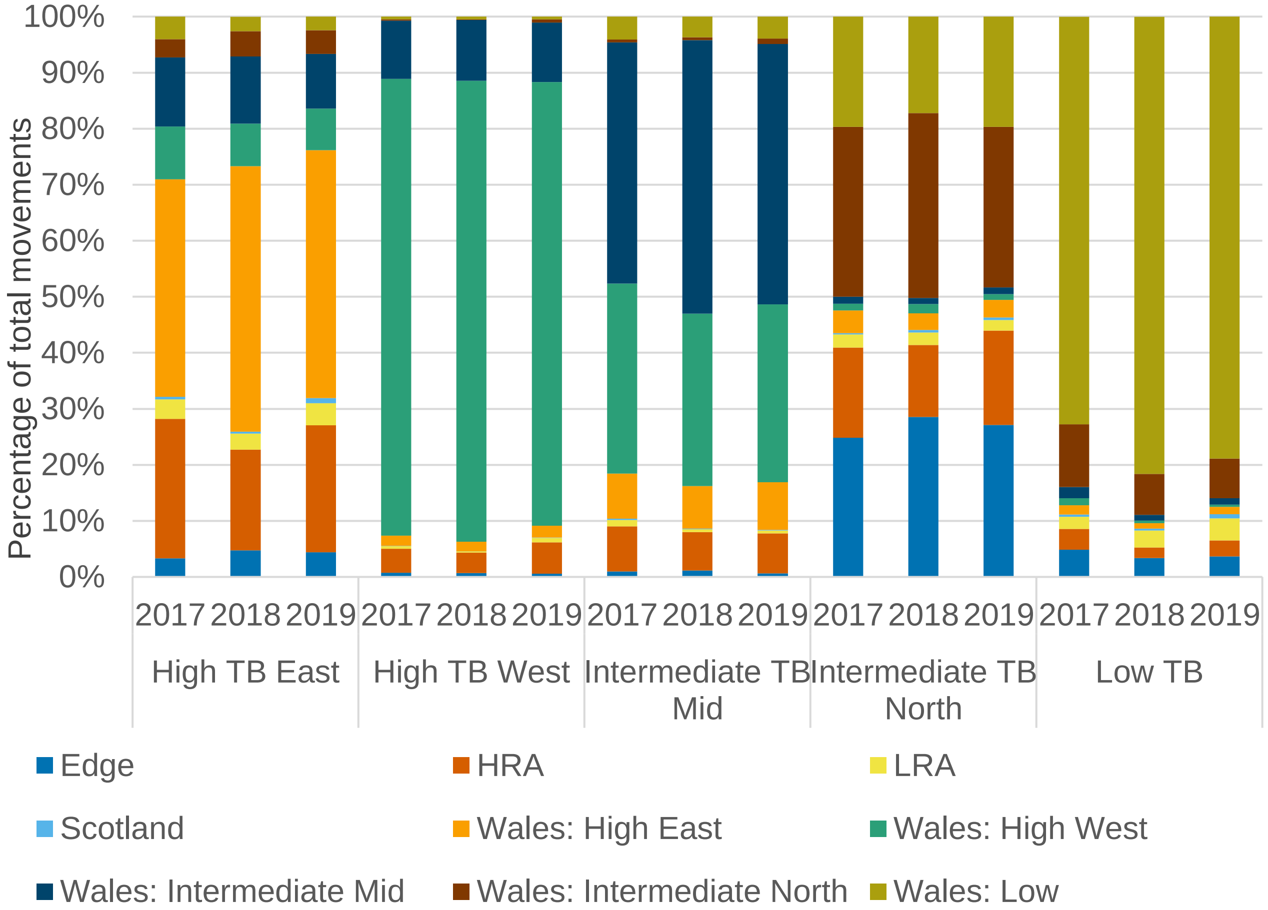


Figure 1.2.1: Percentage of animal movements into Welsh TB Areas from each GB area, 2017-2019

2.0 Bovine tuberculosis surveillance in Wales

Key Points:

- Nearly 70% of all single intradermal comparative cervical tuberculin, or skin (SICCT) tests were conducted in the High TB Areas of Wales in 2019 (East; 21%, West; 46%). At standard interpretation, 0.2% of skin tests disclosed reactors in the High East TB Area, 0.15% in the High West, 0.1% in the Intermediate North and Mid Areas and 0.01% in the Low TB Area.
- In 2019, 5% of all IFN-γ tests in the High East and West TB Areas disclosed reactors. The percentage was slightly higher in the Intermediate Mid TB Area (7%) and lower in the Intermediate North and Low TB Areas (3%).
- In 2019, there were 661 new TB incidents, of which 604 (91%) were classified as OTF-W and 57 (9%) as OTF-S.
- As a proportion of all tests, over five times as many incidents were detected per 100 'Herd Risk' tests and over three times as many incidents per 100 'Area Risk' tests compared to 'Routine' herd tests.
- Reactor and Inconclusive Reactor (IR) frequencies were greatest in the High West TB Area, reflecting the geographical distribution of TB incidents in Wales.
- The median number of reactors disclosed at the first whole herd test (WHT) following a TB incident, is usually one or two in each TB Area. In the High West TB Area, the median number of reactors from risk-based skin testing was three.
- There were a small number of incidents with unusually large numbers of reactors. In the High West TB Area, the mean number of reactors disclosed through risk-based and routine testing was 4.8 and 2.7, respectively. The mean number of reactors from incidents disclosed through slaughterhouse surveillance was highest in the Intermediate Mid TB Area (3.5).

Skin testing is a key component of TB surveillance. Additionally, enhanced testing occurs in response to specific risks, for example, herds that are contiguous to infected herds. Surveillance effort varies according to the perceived risk of infection, which can be gauged by the number of tests conducted per herd, animal or other subsets (e.g. herd size, type, farm management, and neighbouring herds).

2.1 Numbers of tests (skin, interferon gamma and antibody) and reactors over time

The vast majority of tests carried out in Wales for the surveillance of TB in cattle are skin tests. Just over two million skin and IFN-γ tests were conducted in Wales in 2019 across all TB Areas. Nearly 70% of all tests were conducted in the High TB Areas of Wales (21% in the High East and 46% in the High West). Less than 0.5% of skin tests (by standard interpretation) disclose reactors.

Table 2.1.1 shows the number of SICCT, IFN-γ and antibody tests carried out in each TB Area between 2010 and 2019, along with the number of reactors (standard and severe for SICCT), detected lesions (DL) and *Mycobacterium bovis* (*M. bovis*).

The number of skin tests increased in the High West, Intermediate Mid and Intermediate North TB Areas in 2019 compared to 2018, but showed a slight decline in the High East and Low TB Areas. The number of reactors disclosed in 2019 (by standard interpretation of the skin test) increased slightly in the Intermediate Mid and North TB Areas, and declined in the High East, High West and Low TB Areas. By severe interpretation of the skin test, the number of reactors increased in the High West and Intermediate North TB Areas, stayed the same in the Intermediate Mid TB Area and decreased in the High East and Low TB Areas.

Apart from the Low TB Area, the number of IFN-γ tests carried out in each TB Area has increased over time, with the majority being carried out in the High TB West Area (36,366 tests in 2019). The number of reactors disclosed by IFN-γ tests has mostly increased over time, although there was a slight decrease in 2019 in the High East, Intermediate Mid and Low TB Areas.

Very few antibody tests have been carried out since 2010 (most reported in the last two years), resulting in only two *M. bovis* positives from DL reactors in the High East TB Area in 2018, and one in the Low TB Area in 2019.

Table 2.1.1. The number of skin, IFN-γ and antibody (Ab) tests and accompanying data on the number of reactors, detected lesions (DL) and *M. bovis* (Mb)

Area/ Year	No. skin tests	Reactors (SICCT standard)	DL (SICCT standard)	Mb (SICCT standard)	Reactors (SICCT severe)	DL (SICCT severe)	Mb (SICCT severe)	No. IFN-γ tests	Reactors (IFN-γ)	DL (IFN-γ)	Mb (IFN-γ)	No. antibody tests	Reactors (Ab)	DL (Ab)	Mb (Ab)
High East															
2010	436,640	1,349	546	302	646	94	13	614	80	9	0	0	0	0	0
2011	442,834	1,202	466	280	689	84	32	1,011	126	29	5	0	0	0	0
2012	446,149	1,457	578	308	654	99	30	3,297	275	19	5	0	0	0	0
2013	428,213	998	385	252	352	39	15	1,031	102	10	0	0	0	0	0
2014	424,489	1,166	548	287	434	81	29	4,029	323	36	4	0	0	0	0
2015	437,338	1,012	447	216	436	72	24	5,424	336	28	1	0	0	0	0
2016	426,732	845	355	237	423	59	25	3,365	360	15	4	0	0	0	0
2017	446,561	1,097	491	266	497	68	22	5,587	328	24	6	0	0	0	0
2018	456,261	816	337	194	388	49	21	8,565	450	52	3	550	21	2	2
2019	433,610	653	297	168	339	37	20	8,353	426	17	1	633	42	0	0
High West															
2010	793,060	2,248	718	260	1,179	139	26	894	203	23	7	0	0	0	0
2011	826,834	2,135	566	224	1,438	143	25	2,396	350	21	2	0	0	0	0
2012	886,099	2,558	927	325	1,803	127	35	3,613	669	40	7	0	0	0	0
2013	890,091	1,516	504	179	888	62	22	4,172	593	21	2	10	7	0	0
2014	831,035	1,393	641	267	762	104	40	5,127	452	35	2	0	0	0	0
2015	899,761	1,827	576	239	1,454	106	33	12,077	1,114	43	5	0	0	0	0
2016	924,384	2,261	612	200	1,412	89	24	11,003	1,403	59	21	0	0	0	0
2017	914,784	1,786	486	203	1,346	62	27	13,265	1,247	28	9	0	0	0	0
2018	937,223	1,979	563	235	1,517	86	24	23,233	1,548	34	8	268	9	0	0
2019	941,822	1,730	409	191	1,684	75	25	36,366	1,913	65	12	1,757	134	0	0
Intermediate Mid															
2010	214,151	312	84	42	101	16	2	2,880	129	53	4	0	0	0	0
2011	209,837	233	48	29	89	2	1	1,066	67	11	0	0	0	0	0
2012	198,601	176	49	30	111	7	3	228	33	6	4	0	0	0	0
2013	203,008	171	37	34	63	10	7	700	13	0	0	0	0	0	0
2014	207,675	144	37	23	53	1		906	58	0	0	0	0	0	0
2015	198,815	222	72	32	122	13	5	273	21	5	0	0	0	0	0
2016	203,950	280	69	16	130	7	1	1,424	155	13	6	0	0	0	0

Area/ Year	No. skin tests	Reactors (SICCT standard)	DL (SICCT standard)	Mb (SICCT standard)	Reactors (SICCT severe)	DL (SICCT severe)	Mb (SICCT severe)	No. IFN-γ tests	Reactors (IFN-γ)	DL (IFN-γ)	Mb (IFN-γ)	No. antibody tests	Reactors (Ab)	DL (Ab)	Mb (Ab)
2017	204,746	122	29	19	92	10	2	1,456	156	3	0	0	0	0	0
2018	203,823	164	49	24	135	19	2	2,983	248	21	1	0	0	0	0
2019	217,109	196	48	26	135	12	6	2,512	180	8	3	20	0	0	0
Intermediate North															
2010	158,554	88	17	14	34	1	0	2,064	95	0	1	0	0	0	0
2011	140,338	148	46	30	47	4	4	1,850	42	0	0	0	0	0	0
2012	153,923	188	72	33	90	13	5	4,665	187	2	1	0	0	0	0
2013	154,689	90	23	20	66	17	6	4,131	130	8	4	0	0	0	0
2014	152,223	168	86	29	43	15	3	5,355	238	9	4	0	0	0	0
2015	154,279	119	42	21	59	5	1	6,281	247	5	0	0	0	0	0
2016	148,537	88	34	33	41	5	5	7,431	365	4	2	0	0	0	0
2017	171,768	127	31	26	65	4	1	11,140	447	7	1	0	0	0	0
2018	186,879	220	53	34	103	2	1	12,176	251	8	3	66	4	0	0
2019	191,573	222	52	30	163	4	2	12,853	429	10	3	840	105	0	0
Low															
2010	262,272	36	0	1	3	0	0	833	21	0	0	0	0	0	0
2011	267,401	49	2	4	12	0	0	440	29	0	0	0	0	0	0
2012	266,602	36	5	6	9	0	0	956	18	1	0	0	0	0	0
2013	268,996	45	7	7	5	1	0	1,140	21	0	0	0	0	0	0
2014	274,361	36	13	9	4	0	0	3,955	101	1	0	0	0	0	0
2015	298,395	31	9	8	4	0	0	3,354	77	2	1	0	0	0	0
2016	305,574	56	6	7	15	0	0	4,184	214	2	1	0	0	0	0
2017	278,984	20	8	7	13	0	0	1,665	38	1	0	0	0	0	0
2018	270,747	41	9	7	26	1	1	6,624	162	3	1	0	0	0	0
2019	259,982	29	8	6	19	3	1	1,977	49	1	0	132	10	0	1

The percentage of skin tests which disclosed reactors (at standard and severe interpretation) varies by TB Area; in the Low TB Area this remains around 0.01%, for the Intermediate Mid and North TB Areas; between 0.05 and 0.15%, and has declined from around 0.3 in 2010 to 0.2 in the High West and down to 0.15 in the High East TB Areas in 2019 (Figures 2.1.1 and 2.1.2).

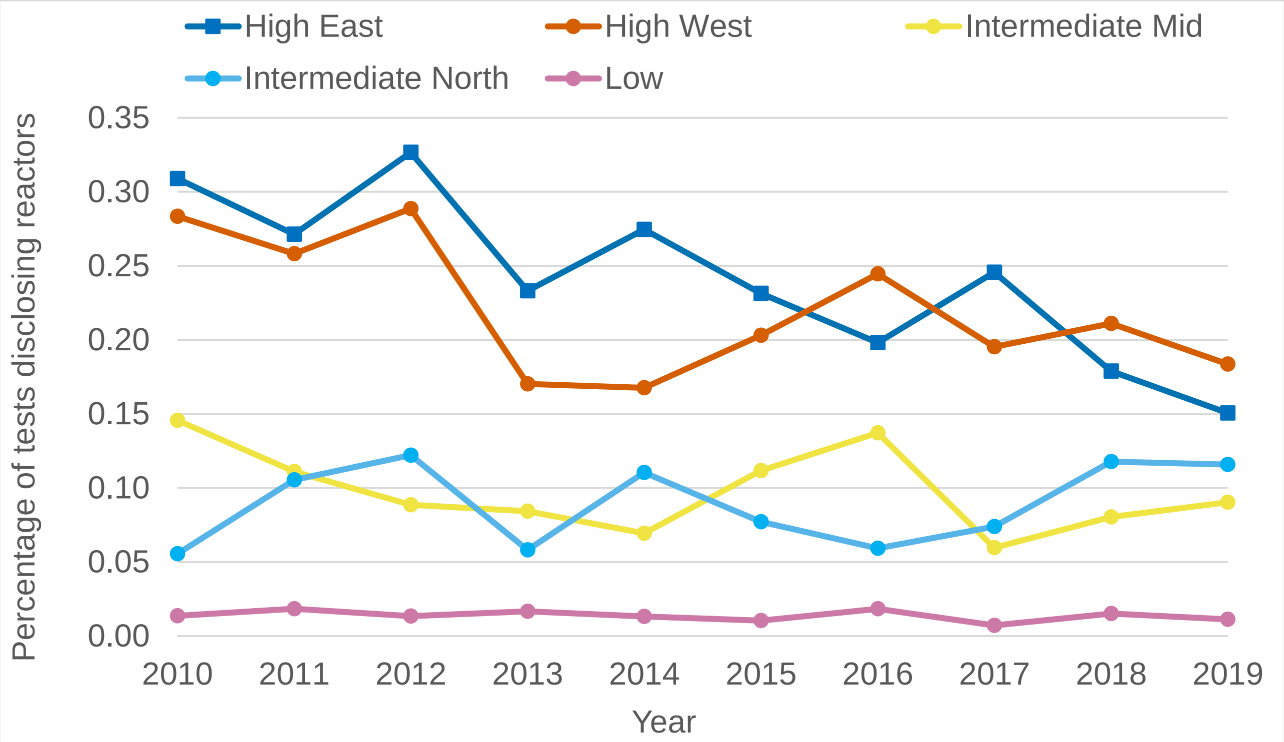


Figure 2.1.1. Percentage of SICCT tests at standard interpretation that disclosed reactors, by TB Risk Area (2010-2019)

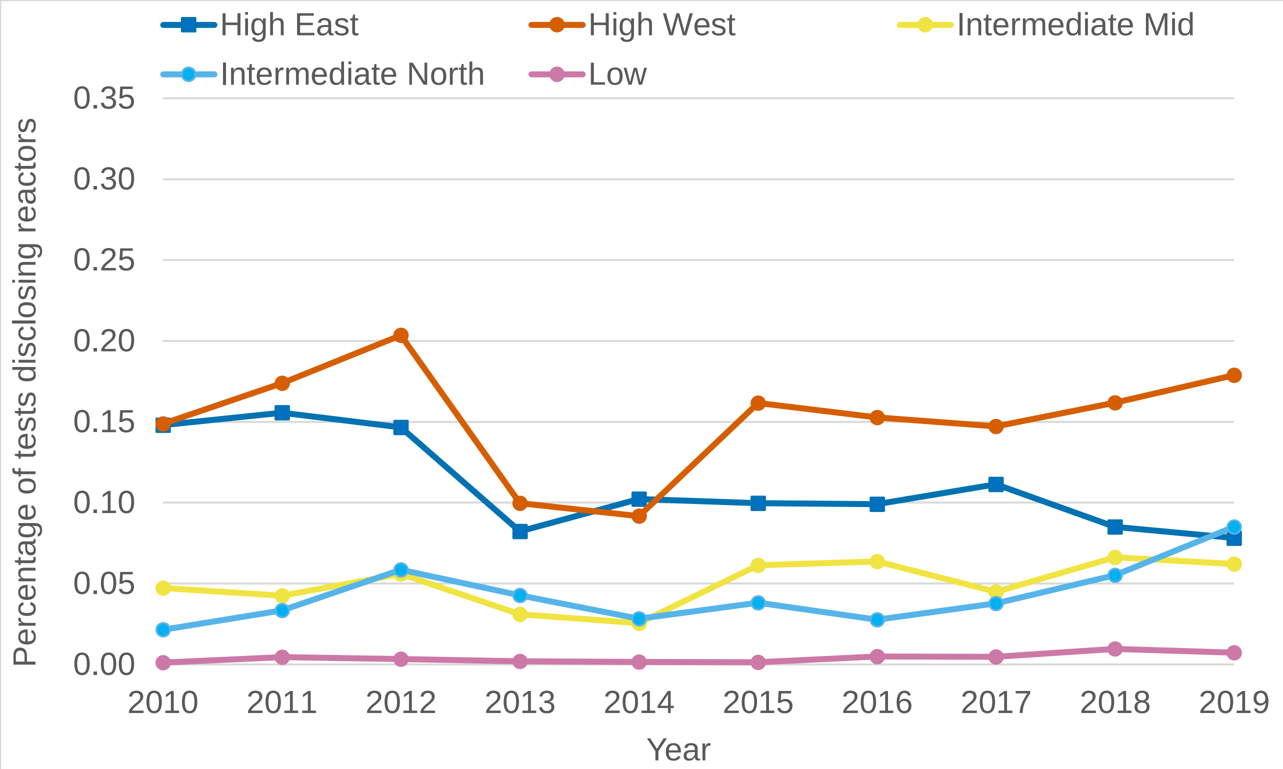


Figure 2.1.2. Percentage of SICCT tests at severe interepretation that disclosed reactors, by TB Risk Area (2010-2019)

The percentage of reactors disclosed by IFN-γ tests has for most TB Areas, declined over the past four years, although there has been less variation over time in the Intermediate North and Low TB Areas (Figure 2.1.3).

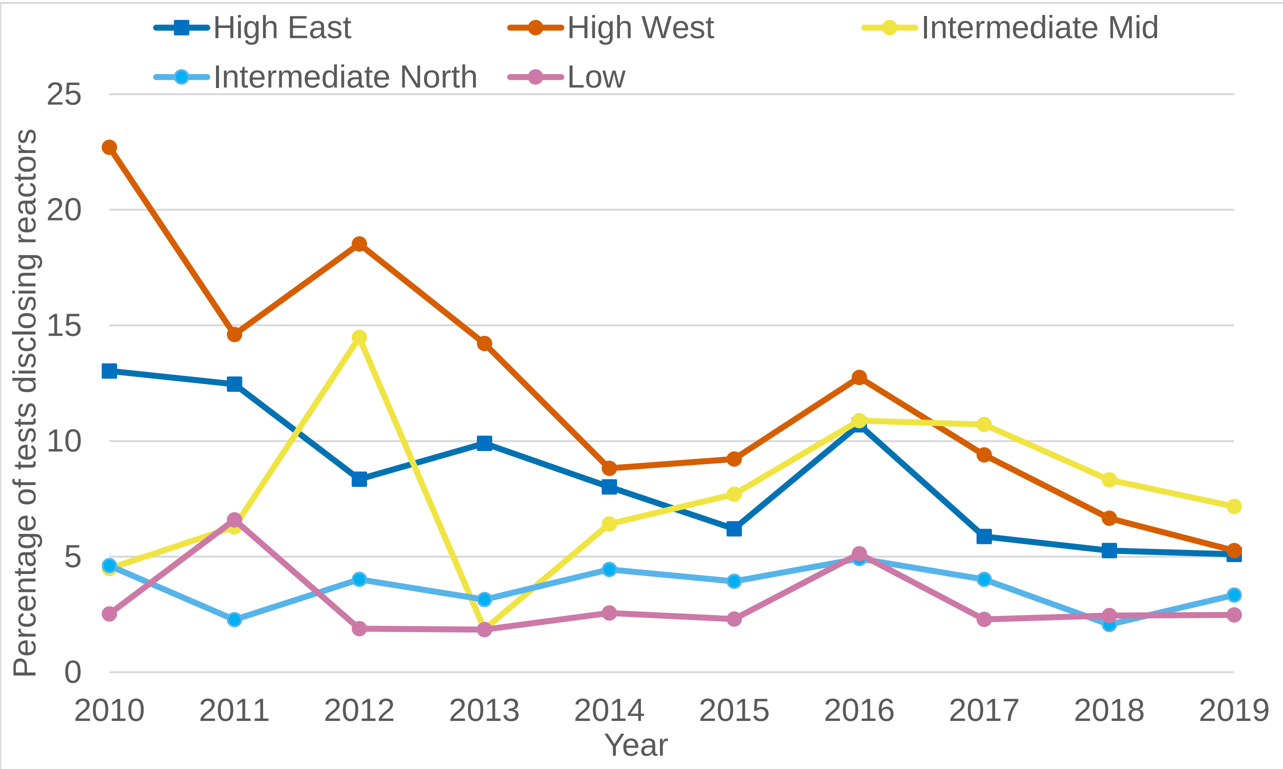


Figure 2.1.3. Percentage of IFN-γ tests that disclosed reactors, by TB Risk Area (2010-2019)

In 2019, the number of inconclusive reactors (IRs) detected for the first time and for retest varied considerably by TB Area, but was highest in the High West (7,798 in 2019, 0.8% of skin tests carried out) and the High East TB Area (1,780 in 2019, 0.4% of skin tests) (Table 2.1.2). The number of 2xIRs were highest in the High West TB Area (196). The percentage of 2xIRs with DL was highest in the Intermediate Mid TB Area, although this was based on only four DL animals (two were from slaughterhouse disclosed incidents, one from WHT and one from a contiguous test (CON12).

The number of 3xIRs[2] was highest in the High West TB Area (108). Only three 3xIRs had DLs, one each in the High West, High East and Intermediate Mid TB Areas. There were no *M. bovis* positive animals from 3xIR DLs (one in 2018 in the High West TB Area). More DCs were identified in 2019 compared to 2xIRs and 3xIRs, but few had DLs and only 13 of these were positive for *M. bovis.* None were identified in the Low TB Area.

[2] 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.

Table 2.1.2. The number of IRs for retest, number of reactors to 2xIR, 3xIR and DC, and accompanying data on the number (%) of detected lesioned (DL) animals and *M.* bovis (Mb) positives

TB Area/ Year	Total skin tests	Total 2xIR	Total DL 2xIR	% DL 2xIR	Total Mb 2xIR	Total 3xIR	Total DL 3xIR	% DL 3xIR	Total Mb 3xIR	Total DC	Total DL DC	% DL DC	Total Mb DC	Total IRs For Retest
High East														
2010	436,640	161	21	13.0	21	27	2	7.4	0	69	6	8.7	4	2,742
2011	442,834	114	18	15.8	14	16	0	0.0	0	363	17	4.7	9	2,597
2012	446,149	128	17	13.3	16	17	1	5.9	0	209	10	4.8	4	2,645
2013	428,213	96	14	14.6	14	32	0	0.0	0	96	5	5.2	3	2,212
2014	424,489	71	13	18.3	13	17	0	0.0	0	142	14	9.9	8	2,007
2015	437,338	98	17	17.3	14	24	0	0.0	0	143	12	8.4	2	2,539
2016	426,732	83	12	14.5	10	32	0	0.0	0	201	5	2.5	5	2,109
2017	446,561	82	11	13.4	7	13	0	0.0	0	491	18	3.7	2	2,274
2018	456,261	80	14	17.5	16	24	0	0.0	0	429	10	2.3	1	2,315
2019	433,610	52	6	11.5	4	28	1	3.6	0	457	17	3.7	8	1,780
High West														
2010	793,060	446	33	7.4	20	64	1	1.6	0	269	21	7.8	3	7,380
2011	826,834	436	18	4.1	10	79	0	0.0	0	250	10	4.0	4	8,366
2012	886,099	516	22	4.3	17	98	2	2.0	0	301	18	6.0	4	11,331
2013	890,091	390	14	3.6	11	129	3	2.3	0	197	9	4.6	0	8,017
2014	831,035	251	19	7.6	12	65	5	7.7	0	349	29	8.3	8	6,842
2015	899,761	308	30	9.7	23	167	4	2.4	0	514	26	5.1	5	10,993
2016	924,384	341	5	1.5	3	135	1	0.7	0	1,288	42	3.3	10	9,216
2017	914,784	245	10	4.1	7	105	0	0.0	0	1,646	35	2.1	9	8,561
2018	937,223	178	8	4.5	6	115	0	0.0	1	2,389	40	1.7	11	7,895
2019	941,822	196	15	7.7	9	108	1	0.9	0	2,558	34	1.3	4	7,798
Intermediate Mid														
2010	214,151	61	5	8.2	3	5	0	0.0	0	27	7	25.9	0	723
2011	209,837	31	3	9.7	1	3	0	0.0	0	23	1	4.3	2	807
2012	198,601	35	3	8.6	5	5	0	0.0	0	26	1	3.8	0	862
2013	203,008	25	2	8.0	0	1	0	0.0	0	21	0	0.0	0	569
2014	207,675	27	3	11.1	1	1	0	0.0	0	49	3	6.1	0	670
2015	198,815	17	2	11.8	2	0	0	0.0	0	51	4	7.8	2	610
2016	203,950	16	1	6.3	1	1	0	0.0	0	142	24	16.9	1	672

TB Area/ Year	Total skin tests	Total 2xIR	Total DL 2xIR	% DL 2xIR	Total Mb 2xIR	Total 3xIR	Total DL 3xIR	% DL 3xIR	Total Mb 3xIR	Total DC	Total DL DC	% DL DC	Total Mb DC	Total IRs For Retest
2017	204,746	31	1	3.2	1	6	0	0.0	0	26	0	0.0	0	982
2018	203,823	15	0	0.0	1	12	0	0.0	0	54	1	1.9	0	955
2019	217,109	26	4	15.4	2	12	1	8.3	0	63	3	4.8	1	1,172
Intermediate North														
2010	158,554	33	3	9.1	2	0	0	0.0	0	3	0	0.0	0	481
2011	140,338	17	1	5.9	1	4	0	0.0	0	16	0	0.0	0	438
2012	153,923	35	5	14.3	5	3	0	0.0	0	32	3	9.4	1	625
2013	154,689	40	1	2.5	2	4	0	0.0	0	26	0	0.0	0	507
2014	152,223	26	3	11.5	5	0	0	0.0	0	106	6	5.7	1	390
2015	154,279	10	0	0.0	0	8	1	12.5	0	10	1	10.0	0	504
2016	148,537	8	0	0.0	0	0	0	0.0	0	26	2	7.7	1	320
2017	171,768	19	2	10.5	1	6	0	0.0	0	72	2	2.8	0	720
2018	186,879	24	0	0.0	0	12	0	0.0	0	125	1	0.8	0	832
2019	191,573	15	1	6.7	0	15	0	0.0	0	224	5	2.2	1	686
Low														
2010	262,272	17	2	11.8	1	0	0	0.0	0	4	0	0.0	0	255
2011	267,401	24	0	0.0	0	0	0	0.0	0	6	0	0.0	0	280
2012	266,602	21	0	0.0	0	0	0	0.0	0	18	0	0.0	0	265
2013	268,996	19	1	5.3	1	0	0	0.0	0	9	0	0.0	0	218
2014	274,361	11	0	0.0	0	0	0	0.0	0	7	0	0.0	0	153
2015	298,395	11	1	9.1	2	0	0	0.0	0	5	0	0.0	0	158
2016	305,574	8	0	0.0	0	0	0	0.0	0	15	1	6.7	1	253
2017	278,984	14	1	7.1	1	0	0	0.0	0	6	0	0.0	0	227
2018	270,747	10	3	30.0	4	0	0	0.0	0	14	1	7.1	1	266
2019	259,982	4	0	0.0	0	0	0	0.0	0	68	1	1.5	0	221

2.2 New TB incidents identified by different test types

In 2019, there were 661 new TB incidents, of which 604 (91%) were classified as OTF-W and 57 (9%) 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 2.2.1), 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, over five times as many incidents were detected per 100 'Herd Risk' tests and over three times as many incidents per 100 'Area Risk' tests than through 'Routine' herd tests. The higher detection of TB incidents from 'area and herd risk' tests is expected, given that these tests are conducted in areas where herds and cattle are perceived to be at increased risk of infection.

Table 2.2.1: Tests in herds not under restriction (surveillance tests), resulting incidents and incidents per 100 herd surveillance tests, 2019

Surveillance test type[1]	No. herd tests	No. incidents Total	No. incidents OTF-W	Incidents per 100 herd tests Total	Incidents per 100 herd tests OTF-W	Restricted following VE-IR test[2] Total	Restricted following VE-IR test[2] OTF-W
Routine	7,063	140	106	1.98	1.50	49	35
Area Risk	4,047	271	259	6.70	6.40	67	61
Herd Risk	1,047	112	111	10.70	10.60	25	24
Movement Risk 2	11,271	59	52	0.52	0.46	9	6
Movement Risk 1	2,487	12	11	0.48	0.44	1	1
Control	138	6	6	4.35	4.35	0	0
New Herd	360	2	1	0.56	0.28	1	1
SLH[3]	**189,725**	**59**	**58**	**0.03**	**0.03**	**0**	**0**
Total	**216,138**	**661**	**604**	**0.31**	**0.28**	**152**	**128**

[1] See Appendix 3 for test type category details.

[2] Incidents where 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; calculated 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 through 'Routine' testing but over the last five years has reduced to around 20% (Figure 2.2.1). This is due to the falling number of incidents overall, and an increasing proportion of TB incidents being detected through 'Area Risk' tests carried out. Between 34% and 42% of annual TB incidents have been detected through 'Area Risk' tests since 2011. The number of TB incidents detected through slaughterhouse surveillance has varied over the past five years, but the proportion has increased in 2018 and 2019.

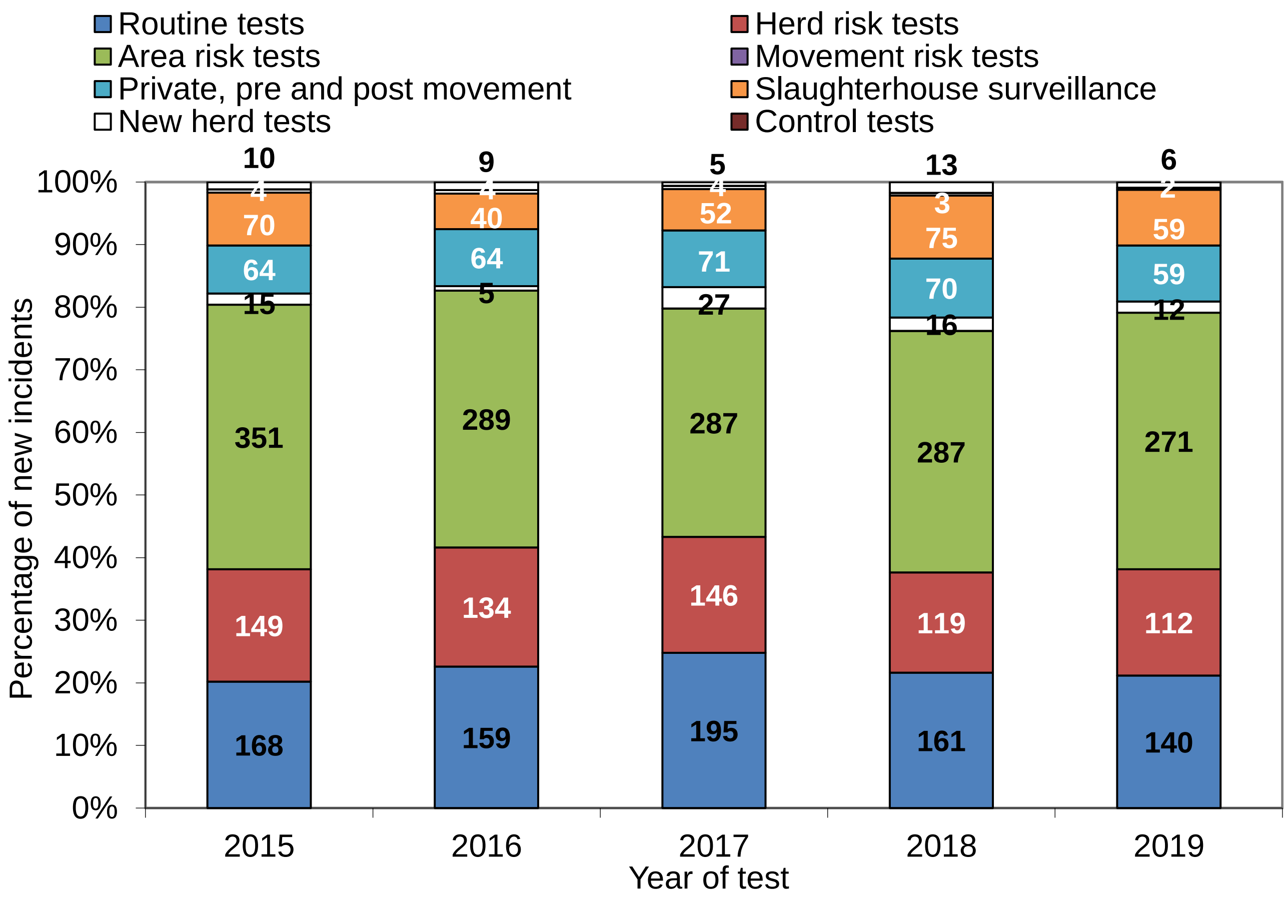


Figure 2.2.1: New TB incidents detected through different surveillance testing methods, 2015-2019

* Only one incident was detected in an “other” test type category in 2016 and is not presented here.

2.3 Animal level frequency of TB Infection

In the High East and West TB Areas where TB infection is highest, the number of tests performed is approximately double that of animals tested, reflecting the higher densities of cattle and greater burden of infection in the cattle population (Table 2.3.1). The application of short interval tests during TB incidents means that animals were tested more frequently in areas with higher levels of TB. In addition, parts of Pembrokeshire, Carmarthenshire and Ceredigion (all in the High West TB Area) were subject to six monthly testing as part of the Intensive Action Area strategy.

Table 2.3.1: Animal level frequency of reactors and inconclusive reactors in 2019

TB Area	Animals tested	Skin tests performed on animals	Animals slaughtered as reactors	% of animals disclosed as a reactor	Animals slaughtered as IRs[1]	% of animals disclosed as an IR
High East	261,512	433,610	1,000	0.4	83	0.03
High West	456,746	941,822	3,421	0.8	334	0.07
Intermediate Mid	148,406	217,109	331	0.2	39	0.03
Intermediate North	112,981	191,573	388	0.3	31	0.03
Low	224,068	259,982	49	0.02	6	0.00

[1]Includes 2 and 3 x IRs

2.4 Submission of slaughterhouse samples from animals with lesions suspicious of TB

Slaughterhouse surveillance is the *post-mortem* inspection of all cattle slaughtered commercially in abattoirs. This type of surveillance can detect some infected cattle that may be missed by active live animal surveillance. Slaughterhouse surveillance can act as an indicator for the efficacy of the live animal testing component of the surveillance system, where an increase in cases detected at slaughter may reflect infection not being picked up in active surveillance (when carried out optimally by experienced and trained official veterinarians). Equally, a decrease in slaughterhouse cases may indicate where TB infection is being detected earlier on the farm, due to enhanced surveillance and control measures. Monitoring trends in the percentage 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 (skin test) or IFN-γ 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 number of slaughterhouse samples submitted between 2015 and 2019 from cattle originating from Welsh herds and their culture results are presented in Table 2.4.1. There were sharp declines in the number of submissions made in 2016 and 2019. Any decline in slaughterhouse detection of TB-like lesions 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, or on the other hand could be due to poorer sensitivity of slaughterhouse post-mortems. The percentage of samples submitted from slaughterhouses (from cattle with TB-like lesions detected during this surveillance), which were positive for *M. bovis* was 60.4% in 2019, which is consistent with 2017 and 2018 despite some variation over the past five years. The percentage in 2016 was the lowest observed in the last five years (52%). The percentage for Great Britain as a whole in 2019 was 64.1%[3].

Table 2.4.1: Culture results[1,2] from cattle with TB-like lesions detected during slaughterhouse surveillance in Wales, 2015-2019

Year	Number of samples submitted	*M. bovis*	*M. avium*	*Actinobacillus spp.*	Negative	Percentage *M. bovis* (%)
2015	138	94	0	4	40	68.1
2016	95	49	0	11	35	51.6
2017	97	59	0	9	29	60.8
2018	138	81	0	9	47	58.7
2019	106	64	0	9	33	60.4

[1] Samples where the mycobacterium detected was 'other' than *M. bovis* are not included in the authorised culture results above.

[2] There were no unclassified mycobacterium or contaminated samples recorded over the last five years, therefore they are not displayed in the table.

The culture results of samples processed in 2019, split by TB Area are shown in Table 2.4.2. The largest percentages of *M. bovis* positive submissions came from animals originating from herds in the Intermediate Mid, High East and High West TB Areas (71%, 69% and 62% respectively). The higher percentage could indicate reduced sensitivity of skin testing in some TB Areas (see Table 3.6.1).

Table 2.4.2: Culture results[1,2] from cattle with TB-like lesions detected during slaughterhouse surveillance, by TB Area, 2019

TB Area	No. samples submitted	*M. bovis* positive	*M. bovis* negative	Percentage *M. bovis* (%)
High East	29	20	9	69.0
High West	47	29	18	61.7
Intermediate Mid	17	12	5	70.6
Intermediate North	6	1	5	16.7
Low	7	2	5	28.6
Total Wales	**106**	**64**	**42**	**60.4**

[1] Other' mycobacteria and *Actinobacillus* spp. are included in the total for *M*. *bovis* negative, hence the total negative in Table 2.4.1 is different.

[2] There were no contaminated samples recorded over the last five years, therefore they are not displayed in the table.

[3] https://www.gov.uk/government/publications/bovine-tb-epidemiology-and-surveillance-in-great-britain-2019

2.5 Reactors in herd tests following detection of slaughterhouse cases

Following the detection of new TB incidents via slaughterhouse testing, a whole herd field check test is administered. Tables 2.5.1 a-e show the median and mean number of reactors identified at the first WHT for incidents identified at slaughterhouse and via skin testing (routine and risk-based) in 2019, split by TB Area.

The merit in considering the first WHT, rather than the entire incident, is that some incidents detected in 2019 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 2019. The mean (average) number of reactors is higher than the median, 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 or undetected infection in the herd, potentially reflecting a reduction in the effectiveness of skin testing, or can be a reflection of the inspection efficacy by official veterinarians.

Overall, the median number of reactors disclosed through all surveillance (skin testing and slaughterhouse surveillance) was one for the High East, Intermediate Mid and Low TB Areas, and two for the High West and Intermediate North TB Areas. For slaughterhouse inspection, the median was zero for all TB Areas bar the Intermediate North (one). For risk-based skin testing, the median was three in the High West, two in the Intermediate Mid and North TB Areas and one in the High East and Low TB Areas. For routine skin testing, the median number of reactors disclosed for all TB was two in the High West TB Area and one for all other TB Areas, although increasing to two in the Intermediate Mid and North Areas when looking at the median of just OTF-W incidents (Table 2.5.1).

The mean number of reactors disclosed through slaughterhouse surveillance was highest in the Intermediate Mid TB Area (n=3.5; based on 11 TB incidents, all OTF-W). For routine and risk-based skin testing, the mean was highest in the High West TB Area (n=2.7 and 4.8 respectively).

Table 2.5.1 (a-e): Reactors identified at the first whole herd test following a TB incident, by TB Area (2019)

(a) High East: Disclosing test	New incidents (Total TB)	New incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	17	17	0.8	0	0	1	0.8	0	0	1
Skin testing - Risk	155	147	2.7	1	1	3	2.8	2	1	3
Skin testing - Routine	38	32	1.5	1	1	2	1.7	1	1	2
Total	**210**	**196**	**2.3**	**1**	**1**	**2**	**2.4**	**1**	**1**	**3**

(b) High West: Disclosing test	New incidents (Total TB)	New incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	27	26	1.7	0	0	2	1.7	0	0	4
Skin testing - Risk	234	227	4.8	3	1	6	4.9	3	1	6
Skin testing - Routine	47	41	2.7	2	1	3	3.0	2	1	4
Total	**308**	**294**	**4.2**	**2**	**1**	**5**	**4.4**	**2**	**1**	**6**

(c) Intermediate mid: Disclosing test	New incidents (Total TB)	New incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	11	11	3.5	0	0	2	3.5	0	0	2
Skin testing - Risk	35	30	3.7	2	1	4	4.1	2	1	4
Skin testing - Routine	29	18	2.2	1	0	2	3.2	2	1	3
Total	**75**	**59**	**3.1**	**1**	**1**	**3**	**3.7**	**2**	**1**	**3**

(d) Intermediate North: Disclosing test	New incidents (Total TB)	New incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	1	1	1.0	1	1	1	1.0	1	1	1
Skin testing - Risk	31	29	3.2	2	1	5	3.3	2	1	5
Skin testing - Routine	13	7	2.2	1	1	2	3.1	2	1	2
Total	**45**	**37**	**2.8**	**2**	**1**	**4**	**3.2**	**2**	**1**	**5**

(e) Low: Disclosing test	New incidents (Total TB)	New incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	3	3	1.3	0	0	0	1.3	0	0	0
Skin testing - Risk	7	7	1.3	1	1	1	1.3	1	1	1
Skin testing - Routine	13	8	1.1	1	1	1	1.3	1	1	1
Total	**23**	**18**	**1.2**	**1**	**1**	**1**	**1.3**	**1**	**1**	**2**

[1]Inter-quartile range

Tables 2.5.2 a - e show the **total number of reactors** identified in incidents that **closed** in 2019 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 2019. The mean number of reactors identified from total TB incidents was highest in the Intermediate Mid TB Area for slaughterhouse inspection (23.8) and highest in the High West TB Area for risk-based skin testing and slaughterhouse inspection (10.9 and 11.5, respectively).

The median number of reactors identified in closed incidents was around one or two for routine skin testing, being slightly higher for risk-based skin testing (four in the High West and six in the Intermediate North and Low TB Area). The High West TB Area had the highest median number (five) of reactors in those incidents first detected in the slaughterhouse.

Table 2.5.2 (a-e): Total number of reactors identified in incidents that closed in 2019, by TB Area

(a) High East: Disclosing test	Closed incidents (Total TB)	Closed incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	20	20	4.3	2	0	5	4.3	2	0	5
Skin testing - Risk	178	173	6.5	2	1	5	6.7	2	1	5
Skin testing - Routine	41	34	3.6	2	1	5	4.2	2	1	5
Total	**239**	**227**	**5.8**	**2**	**1**	**5**	**6.1**	**2**	**1**	**5**

(b) High West: Disclosing test	Closed incidents (Total TB)	Closed incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	31	31	11.5	5	1	7	11.5	5	1	7
Skin testing - Risk	234	222	10.9	4	1	13	11.4	5	2	13
Skin testing - Routine	50	43	8.7	2	1	6	10.0	3	1	6
Total	**90**	**296**	**10.6**	**4**	**1**	**12**	**11.2**	**4**	**2**	**12**

(c) Intermediate Mid: Disclosing test	Closed incidents (Total TB)	Closed incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	9	9	23.8	0	0	7	23.8	0	0	7
Skin testing - Risk	36	33	8.9	3	1	9	9.7	3	1	12
Skin testing - Routine	22	15	1.9	1	1	2	2.4	2	1	2
Total	**67**	**57**	**8.6**	**2**	**1**	**6**	**10.0**	**2**	**1**	**8**

(d) Intermediate North: Disclosing test	Closed incidents (Total TB)	Closed incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	1	1	3.0	3	3	3	3.0	3	3	3
Skin testing - Risk	37	33	9.9	6	2	14	11.0	7	3	14
Skin testing - Routine	8	3	2.3	1	1	1	4.3	5	1	5
Total	**46**	**37**	**8.4**	**5**	**1**	**10**	**10.2**	**7**	**3**	**14**

(e) Low: Disclosing test	Closed incidents (Total TB)	Closed incidents (OTFW)	Mean number of reactors (Total TB)	Median number of reactors (Total TB)	25th percentile (Total TB)	75th percentile (Total TB)	Mean number of reactors (OTFW)	Median number of reactors (OTFW)	25th percentile (OTFW)	75th percentile (OTFW)
Slaughterhouse inspection	4	4	3.5	4	0	4	3.5	4	0	4
Skin testing - Risk	7	7	7.0	6	3	7	7.0	6	3	7
Skin testing - Routine	13	9	7.2	2	1	10	10.0	7	2	14
Total	**24**	**20**	**6.5**	**4**	**1**	**7**	**7.7**	**6**	**2**	**8**

[1]Inter-quartile range

Temporal trends in the mean and median number of reactors disclosed at the ***first whole herd test (WHT)*** are presented in Figure 2.5.1 for Wales overall. This includes the disclosing test, but only the following first check test if the disclosing test is not a whole herd test, for example an IR retest or pre-movement test.

Generally, the trends observed in the median number of reactors mirror the trends in the mean, albeit at a lower level. In 2019, the median number of reactors identified per incident at the first herd test after slaughterhouse inspection was zero, having fluctuated between zero and one since 2010. The median number of reactors for incidents disclosed by routine skin testing had fluctuated between one and two since 2010, increasing to three in 2017 before returning down to two in 2018 and 2019. Increased use of severe interpretation may have led to this short-term increase in the median number of reactors. Severe interpretation is used in TB infected herds with lesion and/or culture positive animals and in herds with increased risk of infection, for example any in which more than one reactor has been found

Over the past ten years, trends in the mean number of reactors at the first WHT indicate that there has been little difference in the mean number of reactors found in TB incidents disclosed through slaughterhouse cases and those disclosed through skin testing. This applies when looking at Wales overall but as Tables 2.5.1 (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 disclosed per closed TB incident are presented in Figure 2.5.2. The median number of reactors per skin-test disclosed incident remained relatively constant between 2010 and 2015, typically around two, although this increased to three in 2016 and has remained at that value since. The median number disclosed in per slaughterhouse incident has fluctuated between one and two reactors between 2010 and 2018 and then increased to three in 2019. The mean number of reactors in skin-test disclosed incidents has fluctuated over time with peaks in 2013 (nearly ten per incident), 2016 and 2017 (nine per incident, respectively). A similar trend can also be seen for slaughterhouse disclosed incidents, although there is more fluctuation, in part due to the relatively small number of slaughterhouse cases.

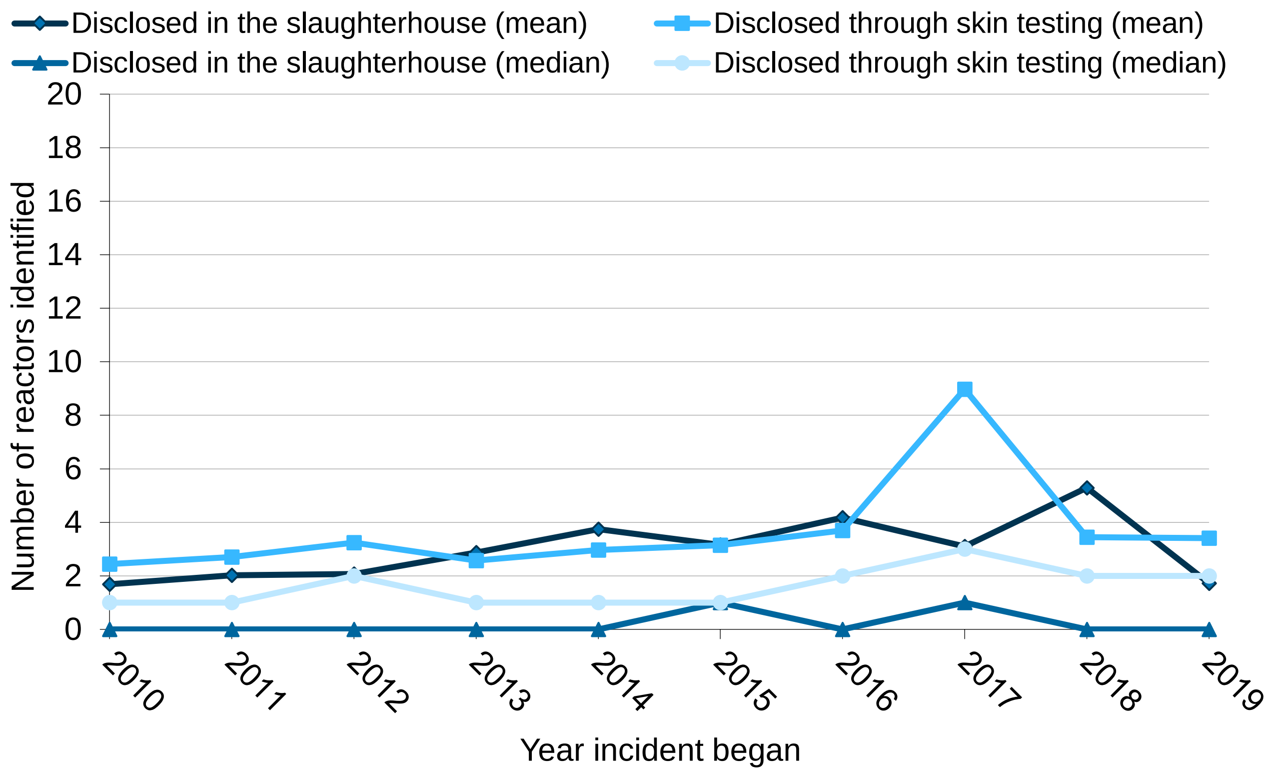


Figure 2.5.1: Reactors identified at the first WHT following disclosure of an incident, 2010 – 2019

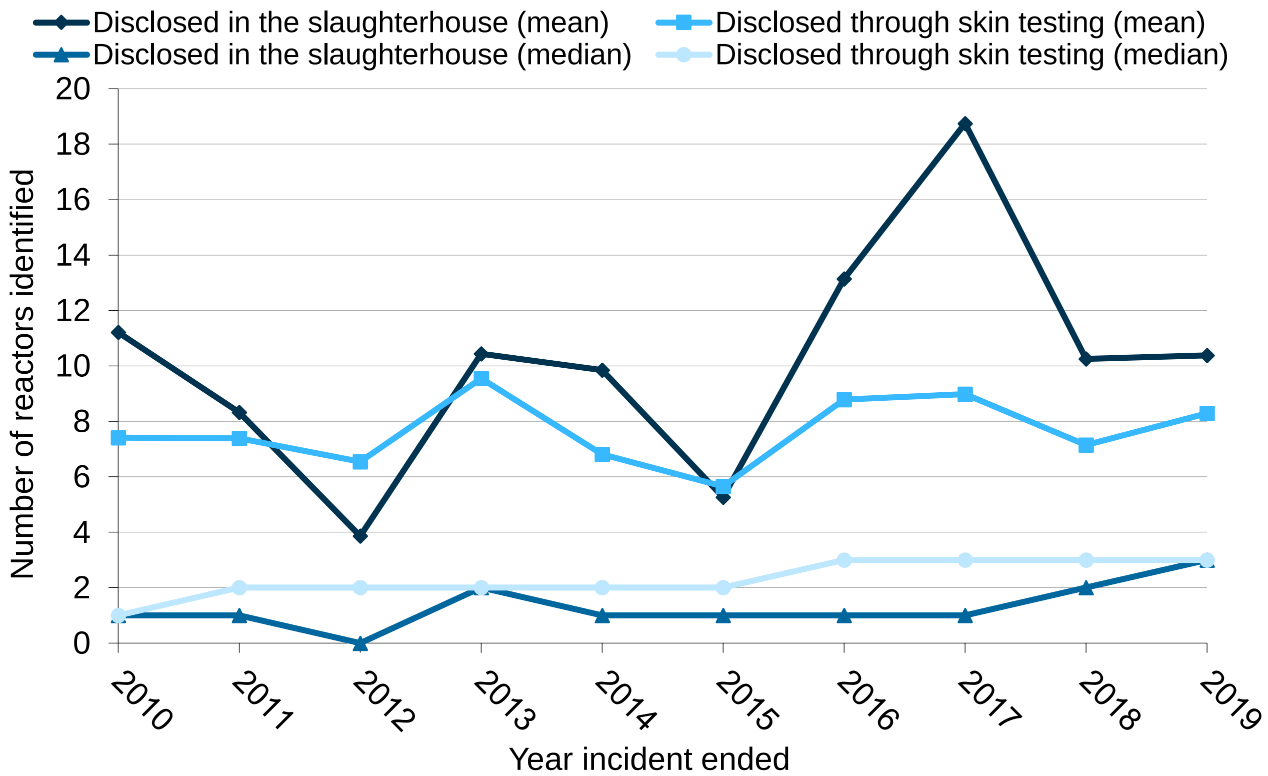


Figure 2.5.2: Reactors identified per incident that closed, 2010 – 2019

3.0 Bovine TB Incidence in Wales

Key Points:

- The number of new TB (OTF-W plus OTF-S) incidents decreased by 11% in 2019 with 661 TB incidents, compared to 744 in 2018. This number differs to Defra's official statistics due to different data cleansing processes (detailed in Appendix 1).
- Incidence rates for total TB also decreased by 11% in Wales overall, from 7.5 TB incidents per 100 herd years at risk in 2018, to 6.7 in 2019.
- There was variation by TB Area, with all apart from the Intermediate North TB Area experiencing a decline in the incidence rate in 2019.
- Dairy herds had a significantly higher TB incidence rate compared to beef herds, however this effect did not remain once adjusting for herd size and location.
- Just under 10% of new OTF-W incidents in 2019 were disclosed in the slaughterhouse.
- After controlling for the effects of herd size and location, dairy herds had significantly lower odds of an OTF-W incident being disclosed in the slaughterhouse, compared to beef herds.
- After controlling for the effects of herd type and location, herd sizes of 11 - 200 animals had reduced odds of having an OTF-W incident being disclosed in the slaughterhouse, compared to herds with more than 300 animals.
- After controlling for the effects of herd size and production type, the odds of an OTF-W incident being disclosed in the slaughterhouse was nearly three times higher in the Intermediate Mid TB Area, compared to the High West TB Area. This could be as a result of differences in the sensitivity of slaughterhouse surveillance by TB Area, or from geographic clustering of Official Veterinarian (OV) surveillance test performance issues.
- Sixteen per cent of herds (260/1,586) with a TB incident in the previous 36 months, had a new (recurrent) TB incident in 2019.
- Herds with a recurrent OTF-W incident in 2019 were significantly more likely to have been restricted due to a previous OTF-W incident, compared with herds that had a new OTF-S incident in 2019 in all TB Areas.
- Beef herds with TB history were twice as likely to have a TB incident in 2019 compared to herds with no TB history (for dairy herds, the odds ratio, or OR=1.6)
- The odds of a herd incurring a new TB incident in 2019 was twice as high in herds with TB history in the High West and Intermediate North and over three times greater in the Intermediate Mid TB Area.
- 17% (116/715) of IR-only herds that were clear at retest, went on to have a TB incident in the subsequent 15 months, compared to 5% (482/8,946) of non-IR herds that tested clear at a routine whole herd test.
- 51% (1,183/2,298) of IR-only animals that had tested clear at the first retest, remained clear in the subsequent 15 month follow-up.

3.1 Summary of new TB incidents in Wales

There were 661 new TB incidents in Wales in 2019, which represents an 11.2% decrease compared to 2018. The High West and East TB Areas had the highest number of new incidents (308 and 210 respectively), equating to nearly 80% of the total for Wales (Table 3.1.1). The number of OTF-S incidents continues to decline at a higher rate than OTF-W in Wales overall, particularly since 2011 when many OTF-S incidents were reclassified as OTF-W.

Table 3.1.1: New TB incidents by TB Area in Wales, 2019 (2018 values and percentage change shown)

TB Area	Number of TB incidents 2019 (% change from 2018)	Number of TB incidents (2018)	Number of OTF-W incidents 2019 (% change from 2018)	Number of OTF-W incidents (2018)	Number of OTF-S incidents 2019 (% change from 2018)	Number of OTF-S incidents (2018)
High East	210 (-16.3)	251	196 (-15.2)	231	14 (-30)	20
High West	308 (-7.2)	332	294 (-3.6)	305	14 (-48.1)	27
Intermediate Mid	75 (25)	60	59 (20.4)	49	16 (45.5)	11
Intermediate North	45 (-32.8)	67	37 (-36.2)	58	8 (-11.1)	9
Low	23 (-32.4)	34	18 (-18.2)	22	5 (-54.5)	11
Wales overall	661 (-11.2)	744	604 (-9.2)	665	57 (-26.9)	78

Figure 3.1.1 shows an overall decreasing trend in the total number of TB incidents since 2013, with the total number reaching its lowest level in 2019 compared to the previous ten years.

In the High East TB Area, the total number of new TB incidents has fallen from around 300 in 2013 (following the implementation of annual testing across Wales), to 210 in 2019. The High West TB Area has shown a similar decreasing trend but from around 400 in 2013 to 308 in 2019. The Intermediate Mid and North TB Areas have had similar number of TB incidents since 2012.

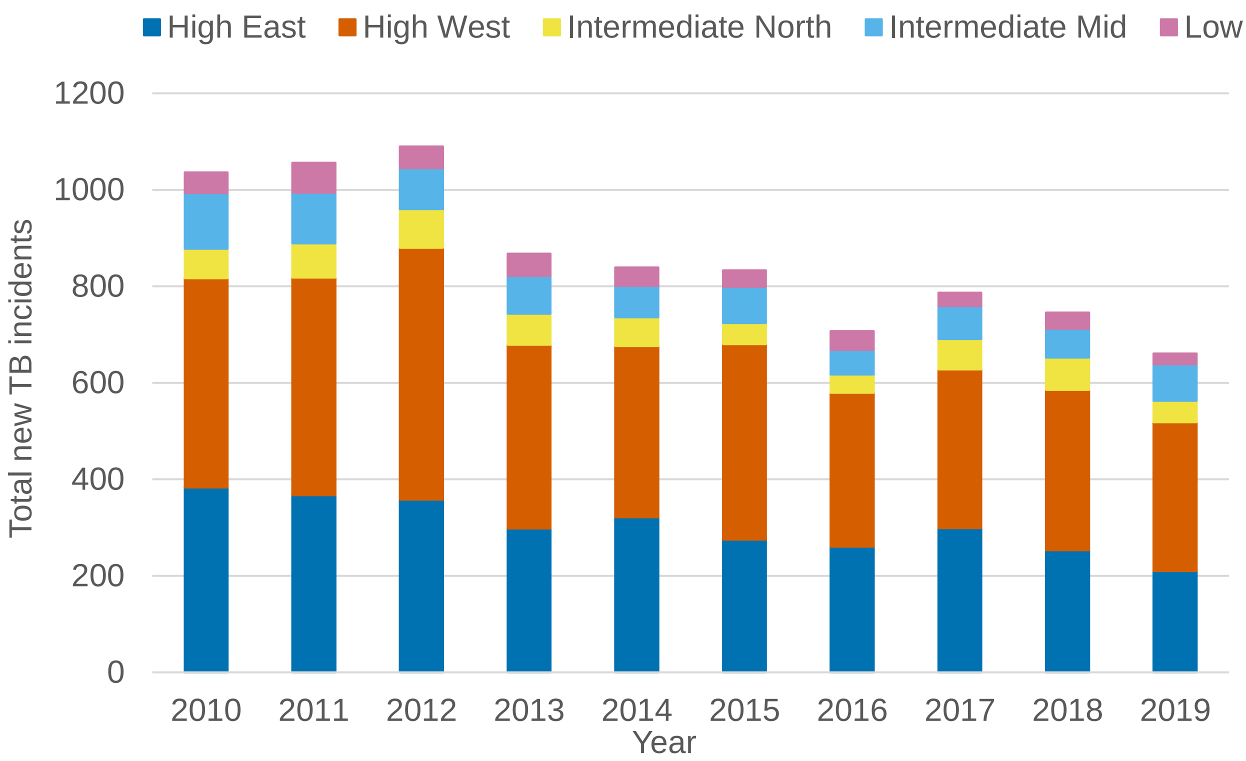


Figure 3.1.1. Annual trends in the total number of new TB incidents by TB Area, 2010-2019

Figure 3.1.2 shows the geographical distribution of new OTF-W and OTF-S incidents in 2019. There has been little change in the geographical distribution of new TB incidents over the past five years (see Figure 2.4, 2018 publication[1]). As shown in Table 3.1.1, most new TB incidents are located in the High West and East TB Areas.

New TB incidents were detected in every TB Area in Wales during 2019, 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 1.1.1).

[1] https://gov.wales/bovine-tb-annual-surveillance-report-2018

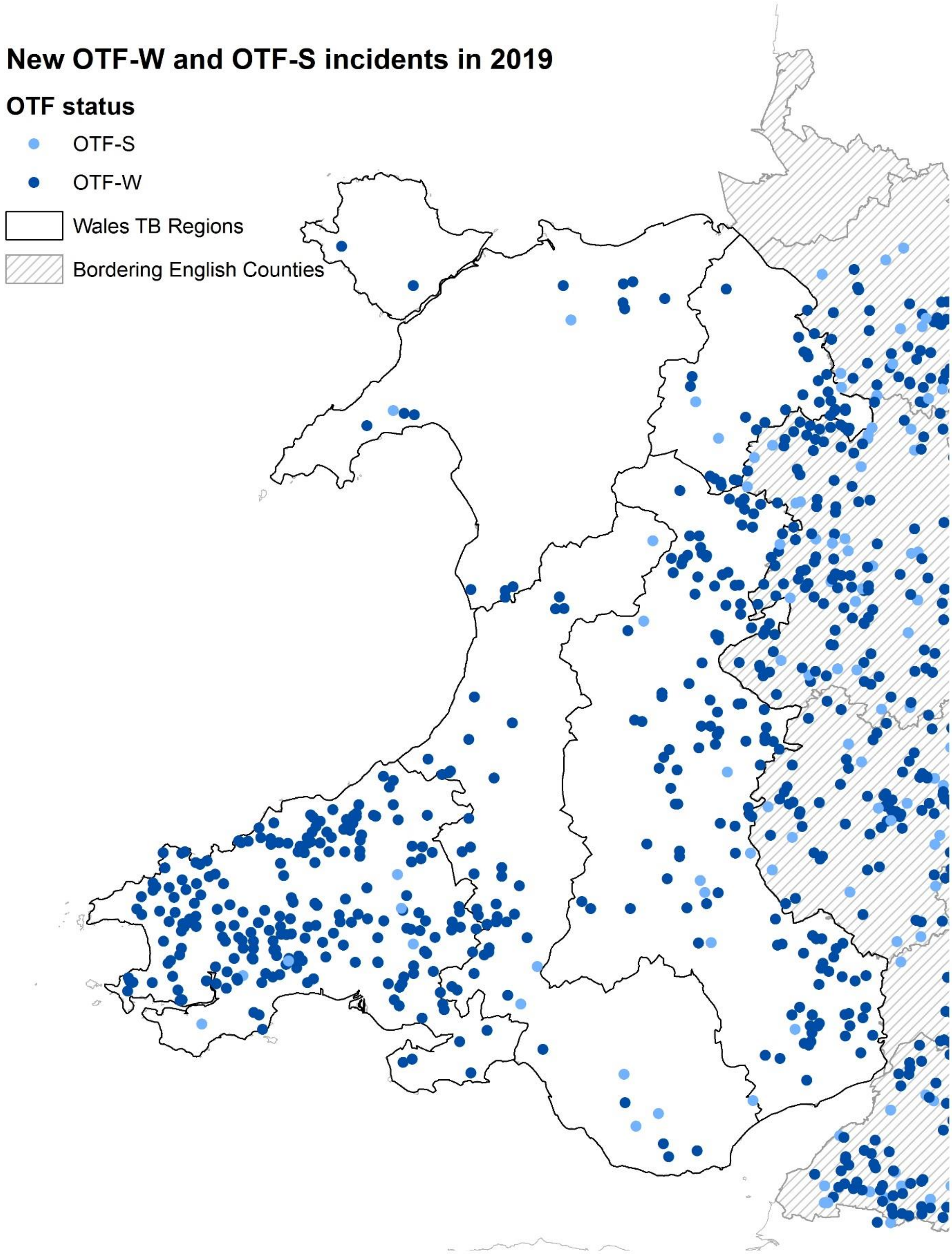


Figure 3.1.2: Geographical distribution of new OTF-W and OTF-S incidents occurring in Wales and bordering English counties, 2019

3.2 Bovine tuberculosis incidence

In this section, the scale of TB infection in Welsh herds in 2019 is compared with previous years. The variation in TB incidence between different geographical areas, herd sizes and herd types is described to facilitate the development of targeted surveillance strategies.

The methods used to determine incidence of TB in Welsh cattle herds 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 2019, 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', or HYR). 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.

In 2019, TB incidence was 5.6%, therefore nearly six herds per 100 live herds incurred a new TB incident. TB incidence varied by TB Area, being highest in the High West TB Area (9.7 TB incidents per 100 live herds) and in contrast less than one TB incident being disclosed per 100 live herds in the Low TB Area (Table 3.2.1).

The incidence rate was 6.7 new TB incidents per 100 HYR. This is equivalent to detecting 67 new incidents for every 1,000 herds that had been unrestricted for one year and is an 11% decrease compared to 2017 (7.5 per 100 HYR). As expected, incidence rates were highest in the High West and East TB Areas.

Table 3.2.1: Incidence of TB in Wales, 2019

New TB incidents per 100 live herds	Total number of TB incidents	Number of OTF-W incidents	Number of OTF-S incidents	Denominator
High East	7.5	7.0	0.5	2,806
High West	9.7	9.2	0.4	3,185
Intermediate Mid	3.7	2.9	0.8	2,038
Intermediate North	4.9	4.0	0.9	920
Low	0.8	0.6	0.2	2,826
New TB incidents per 100 unrestricted herds tested	**Total TB**	**OTF-W**	**OTF-S**	**Denominator**
High East	8.5	7.9	0.6	2,476
High West	11.2	10.7	0.5	2,748
Intermediate Mid	4.2	3.3	0.9	1,804
Intermediate North	5.7	4.7	1.0	789
Low	1.0	0.8	0.2	2,373
New TB incidents per 100 herd years at risk	**Total TB**	**OTF-W**	**OTF-S**	**Denominator**
High East	9.3	8.7	0.6	2,254[1]
High West	12.4	11.9	0.6	2,478[1]
Intermediate Mid	4.4	3.4	0.9	1,719[1]
Intermediate North	6.0	4.9	1.1	751[1]
Low	1.0	0.8	0.2	2,337[1]

[1] Number of 'herd-years at risk.'

3.3 Temporal trends in TB incidence in Wales

An overall decrease in the total number of new TB 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 2019 (Figure 3.3.1). The difference in incidence between OTF-W and total TB incidents has continually narrowed since 2011 due to the change in classification of OTF-W[1] incidents and the subsequent increase in the number of all incidents classified as OTF-W.

[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).

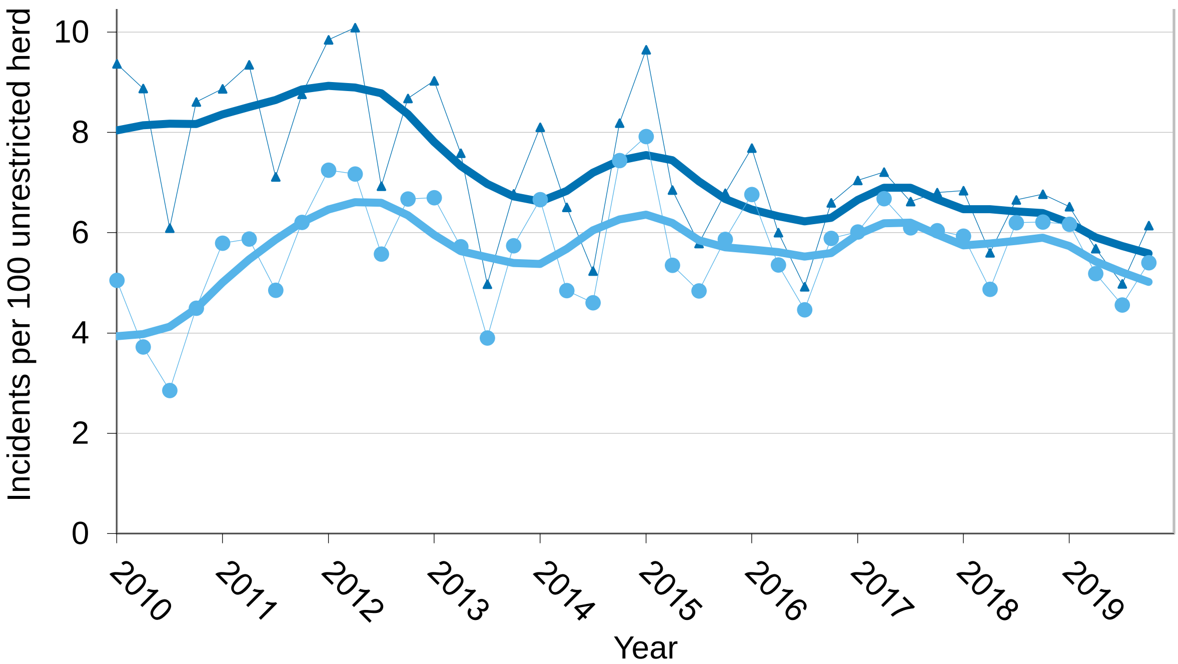


Figure 3.3.1: Quarterly number (and 12-month moving average) of total and OTF-W incidents per 100 unrestricted herds between January 2010 and December 2019

The temporal changes in the two measures used to assess the scale of the TB epidemic in Wales are compared in Figure 3.3.2a and b. Generally, the temporal trends in incidence per 100 live herds and incidence rate per 100 HYR are similar, with a general decline since 2013. 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 been subject to mandatory herd IFN-γ tests, this could lead to prolonged movement restrictions if additional reactors are disclosed. There is an increase in sensitivity of testing in persistent TB incidents, meaning more incidents may be classed as persistent, as fewer herds are coming off movement restrictions.

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

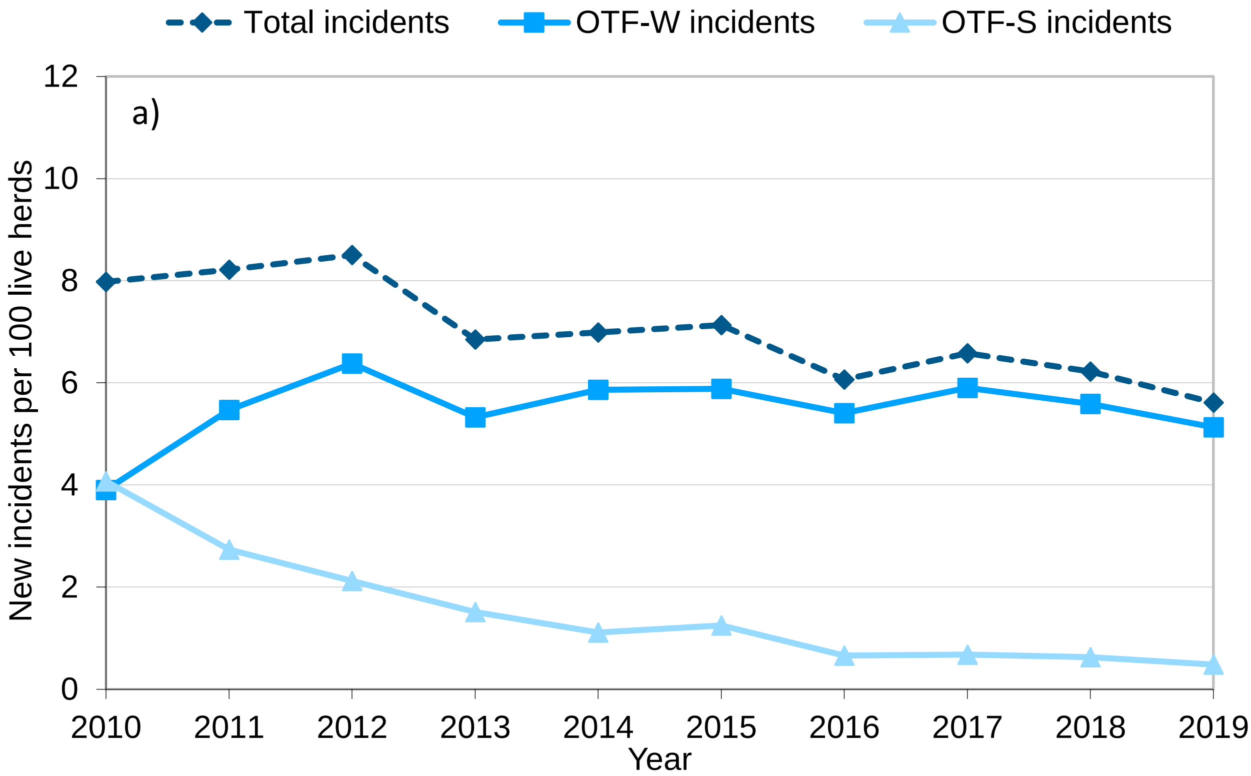


Figure 3.3.2a: Ten year trends in the total number of new incidents per 100 live herds

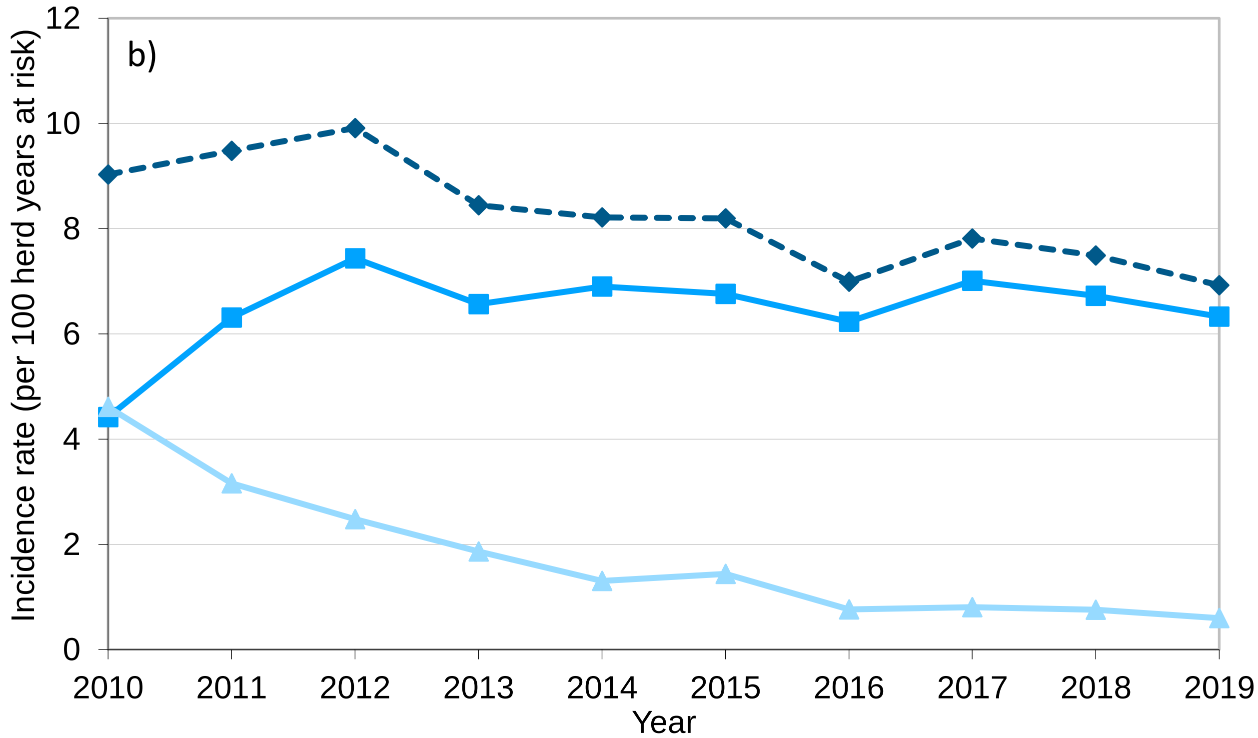


Figure 3.3.2b: Ten year trends in the total number of new incidents per 100 herd years at risk

The temporal trends in the number of new incidents per 100 unrestricted herds (Figure 3.3.3) and the incidence rates of TB per 100 HYR (Figure 3.3.4) vary by TB Area in Wales.

There is a general declining pattern in TB incidence within all TB Areas, albeit with cyclical peaks and troughs, but the trend is more evident in the High East and West TB Areas where incidence is highest. Despite a decrease through 2018 and 2019, the incidence rate in the Intermediate North TB Area increased again in the last quarter of the year, compared to all other TB Areas, where decreases in incidence rates were observed over the year.

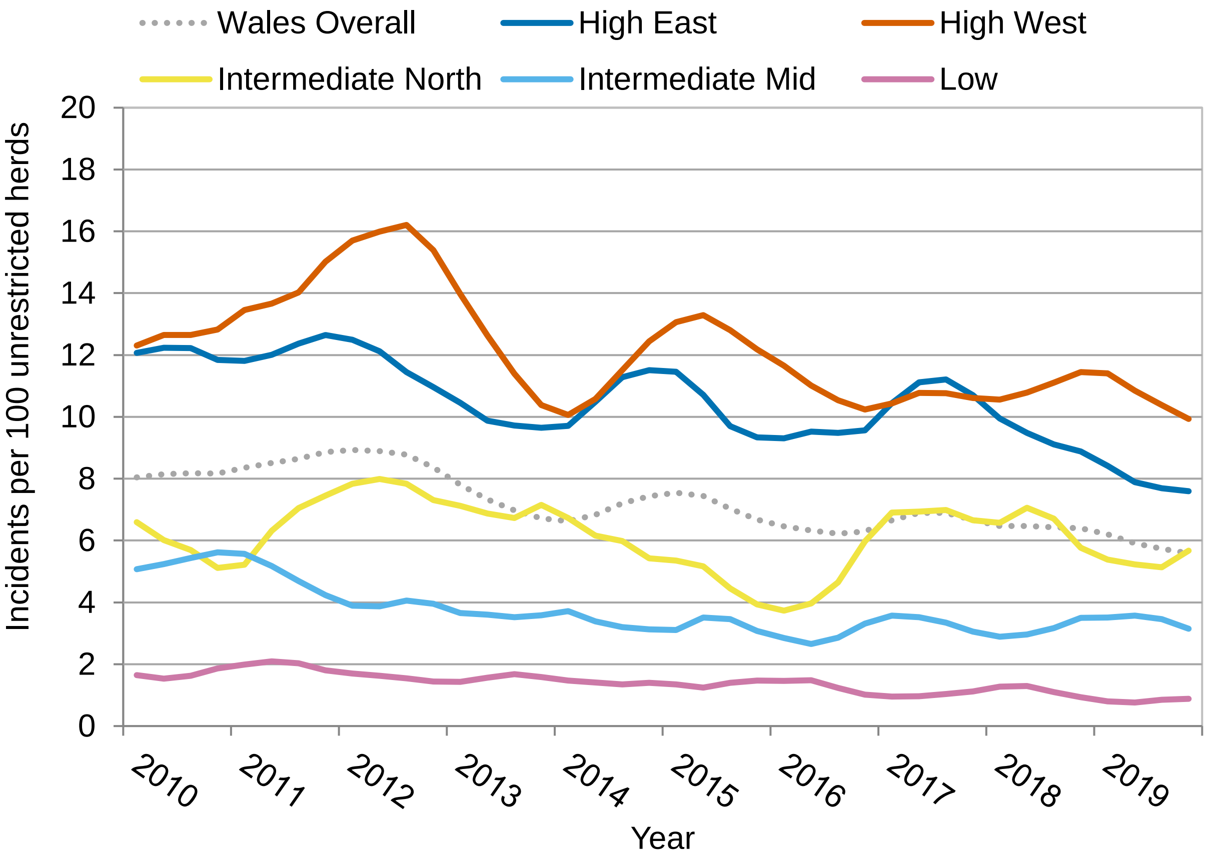


Figure 3.3.3: Trends in new incidents per 100 unrestricted herds, January 2010 – December 2019, by TB Area. The grey dotted line represents the overall trend in Wales[1,2]

[1] Quarterly (annualised), smoothed 12-month moving average

[2] New incidents per 100 unrestricted herds across the whole of Wales.

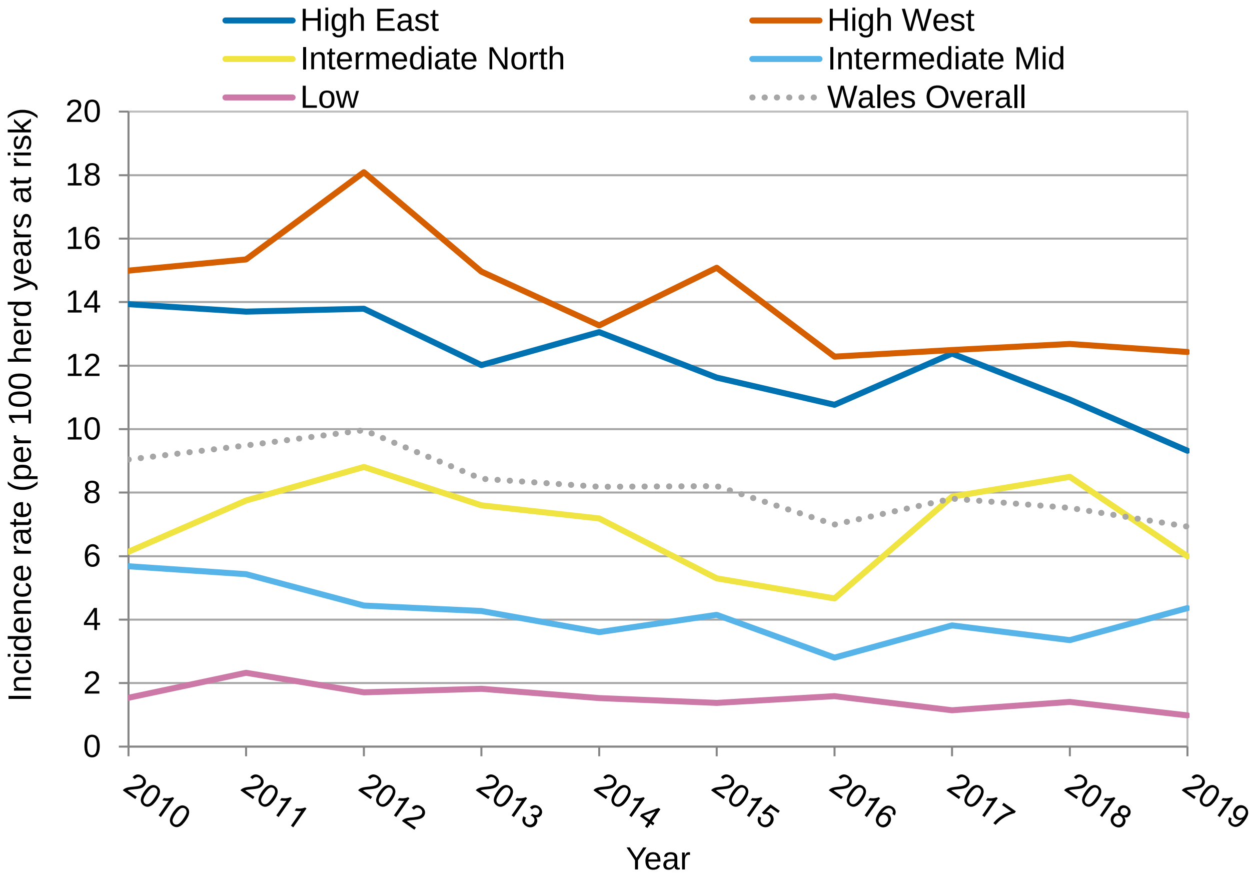


Figure 3.3.4: New incidents per 100 herd years at risk, 2010 – 2019, by TB Area. The grey dotted line represents the overall trend in Wales

3.4 Incidence of TB across Wales

A number of factors are associated with the risk of a herd becoming infected with TB, including local herd density, herd size and type, TB history and location. Herd size and the local density of herds are closely associated with the risk for herds to become infected with TB. These factors contribute to the spatial pattern of TB infection in Welsh cattle herds (Figure 3.4.1).

High cattle density and herd incidence is found in the High (West and East) and parts of the Intermediate Mid and North TB Areas. The sparsest population in terms of both cattle density (Figure 1.1.1) and herd incidence is in the Low TB Area and across the mountainous ranges of Wales (Snowdonia in the Low TB Area and the Cambrian Mountains and Brecon Beacons lying between the Intermediate Mid and High East TB Areas). Cattle demographics alone cannot explain the distribution of TB, as cattle density is high in parts of the Low TB Area, and the West of the Intermediate North TB Area, but TB incidence is low.

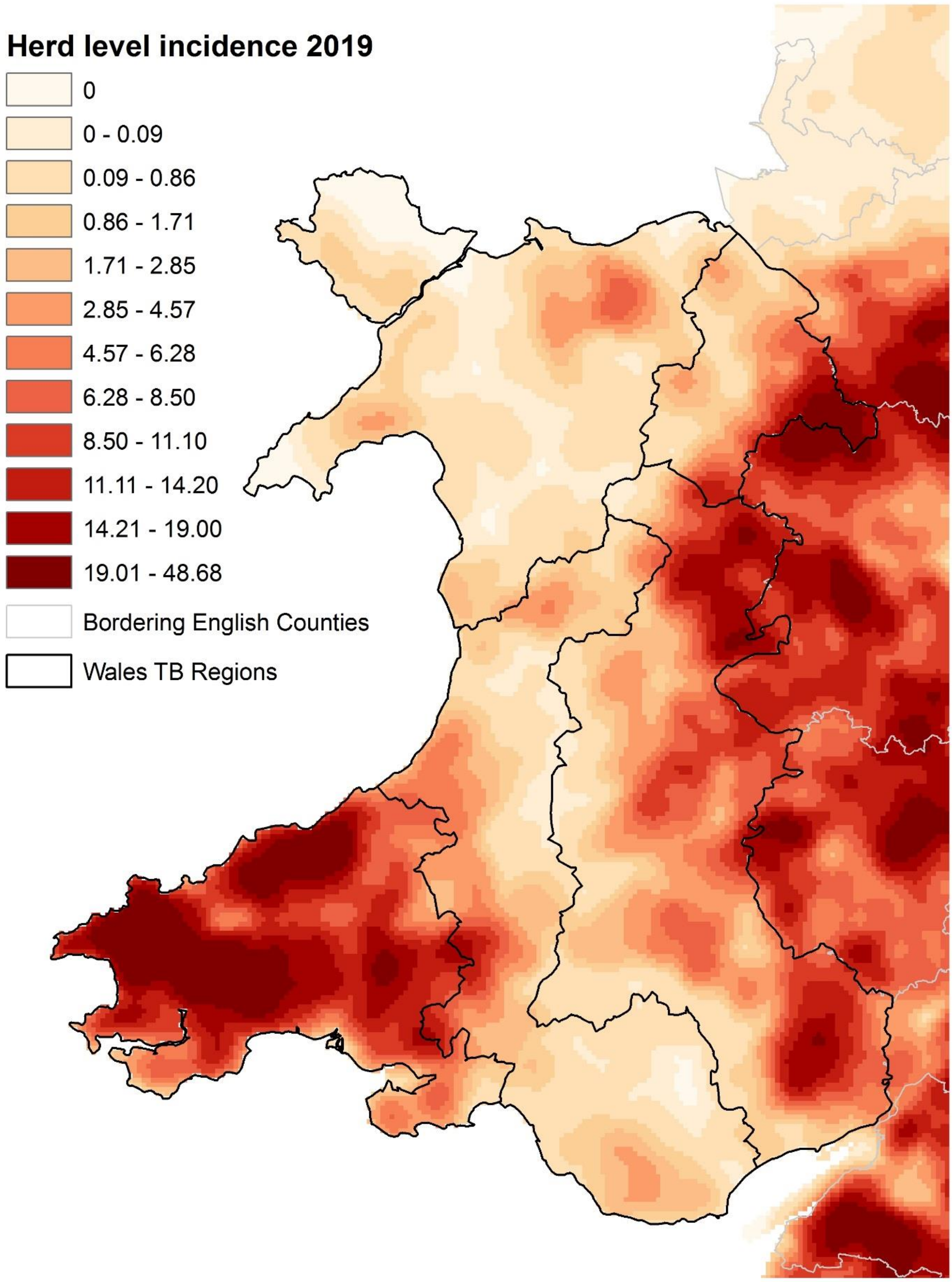


Figure 3.4.1 Herd level incidence of TB in Wales in 2019. Herd incidence is the average incidence in the 100 closest herds to each herd location which 'smooths' the effect of political boundaries

3.5 Variation in TB incidence by herd type, herd size and geographical area

Table 3.5.1 shows the results of a Poisson regression analysis (see Appendix 1 for details on methods used) of TB incidence rates by TB Area, herd type and herd size. The results from the Poisson regression indicate that TB incidence rates increase with herd size. This effect remains after adjusting for the influence of herd type and TB Area, and has been observed consistently for the past five years.

Dairy herds had a significantly higher incidence rate than beef herds (14.0 vs. 4.5 TB incidents per 100 HYR). However, this effect did not remain once adjusting the analyses for herd size and location. This result is consistent with that seen in 2014 but in subsequent years, the incidence rate ratio (IRR) was significantly higher in dairy herds even after adjusting for herd size and TB Area.

As expected, the IRR was significantly lower in the Low, Intermediate North and Mid TB Areas TB Area compared to the High West TB Area where TB incidence per 100 HYR is much lower, even after adjusting for herd size and type. This effect does not occur in the High East TB Area as it has a similarly high TB incidence rate (per 100HYR).

Table 3.5.1: 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 ratio (IRR) of all new TB incidents that started in 2019

	Time at risk (years)	Number of new TB incidents	TB incidence rate (per 100 herd years)	Unadjusted[1] IRR	Adjusted[2] IRR[3]
Herd size					
1 – 10	1,399	13	0.93	0.04***	0.04***
11 – 50	3,222	81	2.51	0.10***	0.12***
50 – 100	2,315	150	6.48	0.26***	0.29***
100 – 200	1,461	173	11.84	0.48***	0.52***
200 – 300	565	95	16.83	0.68**	0.72*
>300	599	149	24.87	*Ref*	*Ref*
Herd type					
Beef	8,654	390	4.51	*Ref*	*Ref*
Dairy	1,892	265	14.01	3.11***	1.18 ns
Other/mixed	261	6	2.30	0.51 ns	0.96 ns
TB Area					
High East	2,523	210	8.32	0.75 **	0.96 ns
High West	2,767	308	11.13	*Ref*	*Ref*
Intermediate Mid	1,925	75	3.90	0.35***	0.49***
Intermediate North	875	45	5.14	0.46***	0.47***
Low	2,717	23	0.85	0.08***	0.09***

*, **, *** 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 differences in the TB incidence rates were simultaneously adjusted for associations with herd size, herd type and/or geographical.

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

3.6 Incidents disclosed at slaughterhouse inspection

Of the 604 OTF-W incidents in Wales in 2019, 58 (9.6%) were disclosed in the slaughterhouse. This is a 15% decrease compared to 2018 but similar to 2015, when 10% were disclosed in the slaughterhouse, and slightly higher than the percentage disclosed in 2016 and 2017 (7%). The percentage varies widely by TB Area in Wales, being highest in the Intermediate Mid TB Area (19%) and lowest in the Intermediate North Area (3%) (Figure 3.6.1). In the High TB East and West Areas, the percentage of OTF-W incidents disclosed in the SLH 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 may be linked to the surveillance effort within slaughterhouses. A training exercise in 2010 was associated with an increase in the number of incidents disclosed through this type of surveillance. The lower percentages of incidents disclosed through slaughterhouse surveillance in 2003 and 2009 may have been due to the resumption of live animal testing following the 2001 FMD outbreak. Likewise, the increase in live animal testing for Health Check Wales in 2008 was associated with a decrease in the percentage of incidents disclosed through slaughterhouse surveillance. These effects were more evident in the Intermediate North, Mid and Low TB Areas.

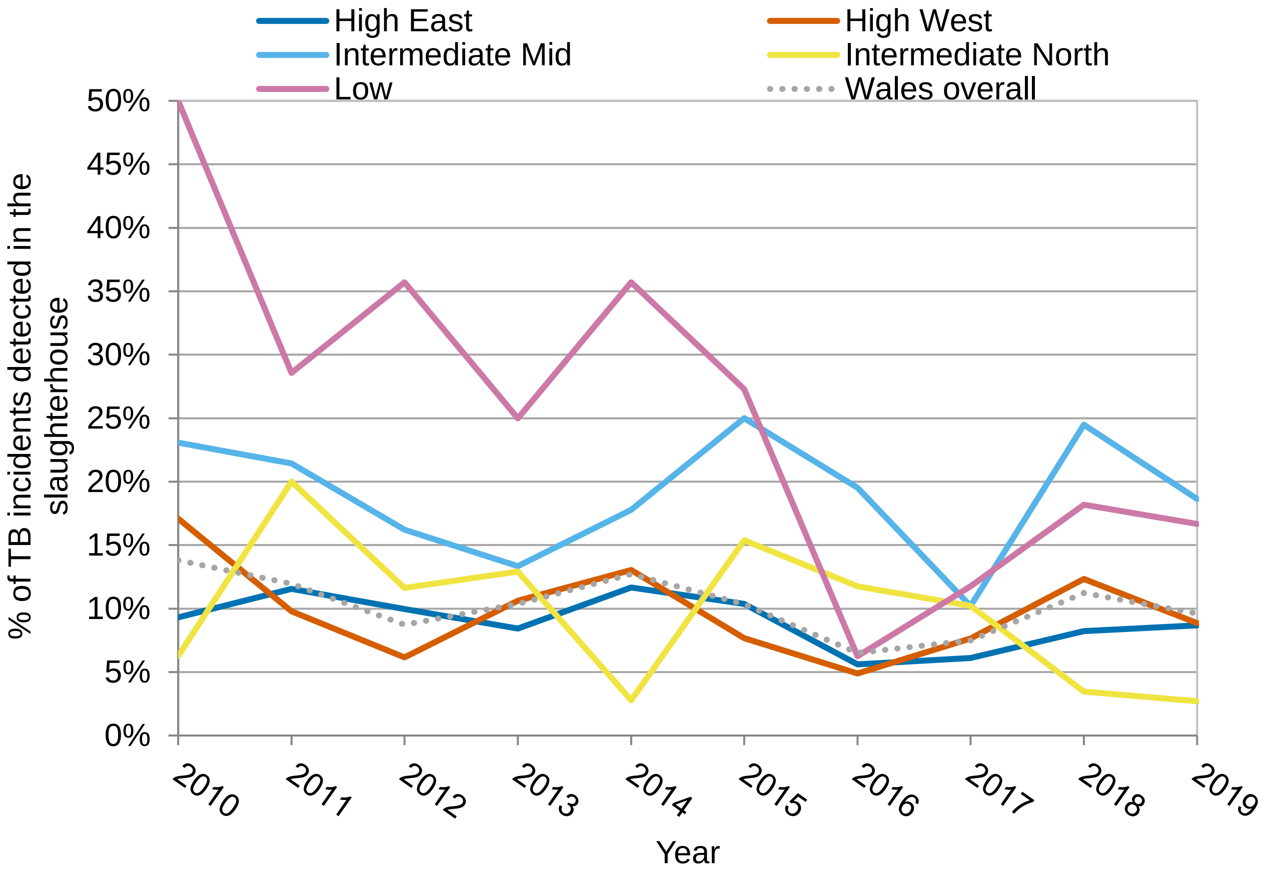


Figure 3.6.1: Percentage of OTF-W incidents disclosed in the slaughterhouse, by TB Area, 2010-2019

The geographical distribution of new slaughterhouse incidents in 2019 (Figure 3.6.2) reflects the distribution of total TB incidents (i.e. those detected by live animal testing or slaughterhouse inspection) (Figure 3.1.2). More slaughterhouse-detected incidents occur in the High West and High East TB Areas where the burden of disease and background infection is highest (27 and 16 disclosed in 2019, respectively). There were 10 TB incidents disclosed in the slaughterhouse in the Intermediate Mid TB Area, with sporadic incidents occurring in the remaining TB Areas (3 in Low, 1 in Intermediate North). This is disproportionate to the overall number of TB incidents disclosed in the Intermediate Mid TB Area. As discussed further on (Table 3.6.1), where the Intermediate Mid TB Area has much higher odds of a TB incident being disclosed in the slaughterhouse, this is likely to be related to reduced sensitivity of skin testing in this area (60% of TB incidents disclosed in the slaughterhouse occurred after clear skin tests by one practice).

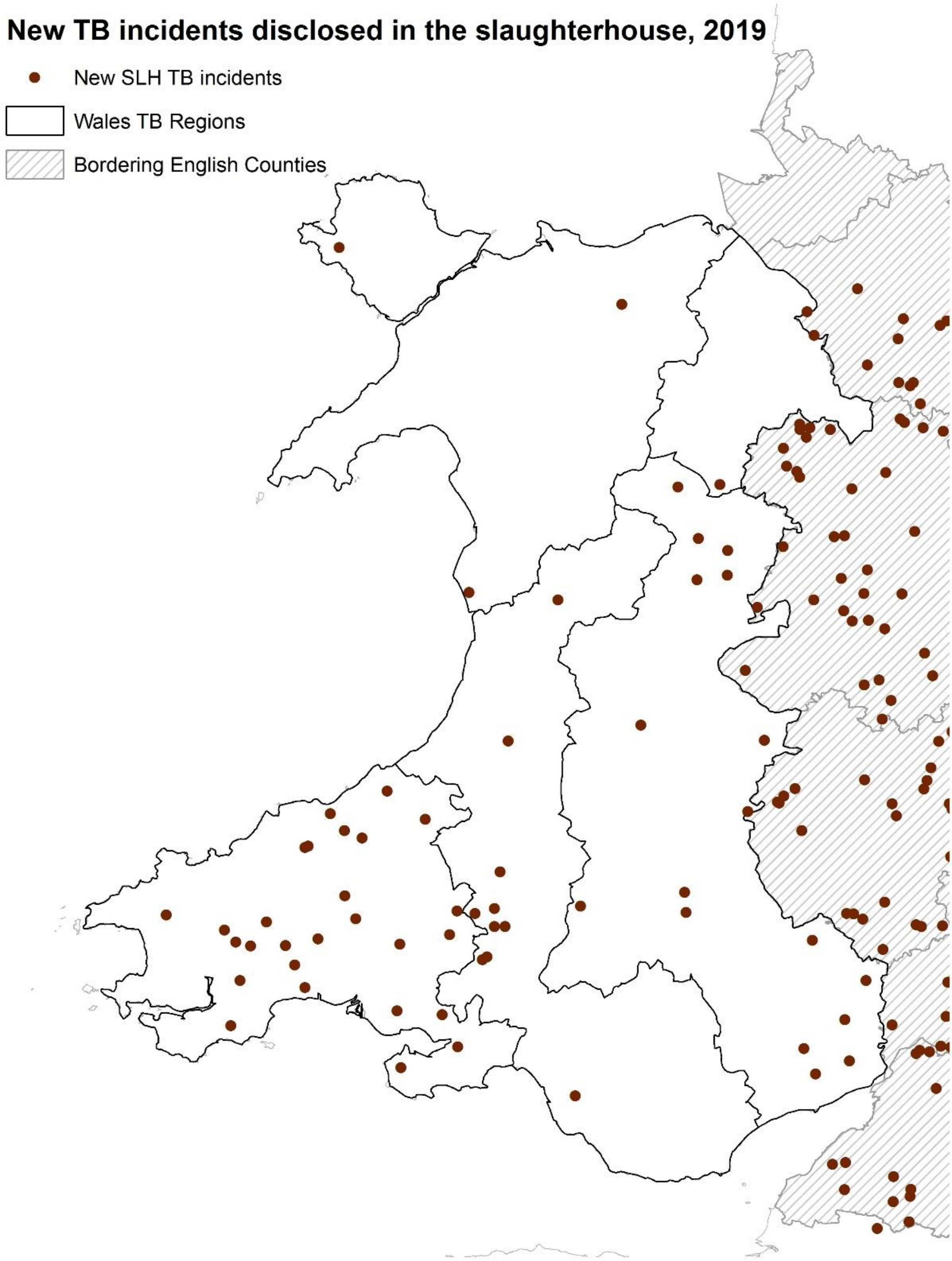


Figure 3.6.2: New TB incidents disclosed in the slaughterhouse, 2019

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 such as the stage of disease in the animal and associated pathology,
- herd characteristics e.g. size, type, or location, which may affect the prevalence of disease and hence the positive predictive value of detection or,
- intrinsic slaughterhouse processes such as management of the line, staff training.

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 (see Appendix 1 for details on odds ratios) of an OTF-W incident being disclosed in the slaughterhouse in 2019 are presented in Table 3.6.1.

After adjusting for herd size and location, dairy herds had significantly lower odds of an OTF-W incident being disclosed in the slaughterhouse, compared to beef herds. This may be as a result of high rates of detected lesions in beef cattle.

After controlling for the effects of herd type and location, herd sizes of less than 300 animals were associated with significantly lower odds of an OTF-W incident being disclosed in the slaughterhouse, relative to herds with 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 higher in the Intermediate Mid TB Area, compared to the High West TB Area. This could suggest that either the sensitivity of slaughterhouse surveillance varies by TB Area, or that there is geographic clustering of Official Veterinarian (OV) surveillance test performance issues. All other TB Areas were not significantly associated with increased or decreased odds of disclosing an OTF-W slaughterhouse incident, relative to the High West TB Area.

Table 3.6.1: 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 (SLH) in 2019

	Total OTF-W incidents	No. SLH cases (%)	No. non-SLH cases (%)	Unadjusted Odds ratio	Unadjusted 95% CI (lower)	Unadjusted 95% CI (upper)	Adjusted Odds ratio	Adjusted 95% CI (lower)	Adjusted 95% CI (upper)
Herd size									
1 - 10	11	1 (9.1)	10 (90.9)	-					
11 - 50	87	5 (5.8)	82 (94.3)	0.35*	0.13	0.98	0.14***	0.04	0.46
51 - 100	132	12 (9.1)	120 (90.9)	0.58^{ns}	0.27	1.24	0.26**	0.10	0.65
101 - 200	152	10 (6.6)	142 (93.4)	0.41*	0.18	0.91	0.21***	0.09	0.53
201 - 300	86	10 (11.6)	76 (88.4)	0.76^{ns}	0.34	1.72	0.50^{ns}	0.21	1.23
>300	136	20 (14.7)	116 (85.3)	*Ref*			*Ref*		
Herd type									
Beef	343	36 (10.5)	307 (89.5)	*Ref*			*Ref*		
Dairy	257	21 (8.2)	236 (91.8)	0.76^{ns}	0.43	1.33	0.34**	0.16	0.72
Other/mixed	4	1 (25.0)	3 (75.0)	-	-	-	-	-	-
TB Risk Area									
High East	196	17 (8.7)	179 (91.3)	0.98^{ns}	0.52	1.86	0.93^{ns}	0.46	1.88
High West	294	26 (8.8)	268 (91.2)	*Ref*	-	-	*Ref*	-	-
Intermediate Mid	59	11 (18.6)	48 (81.4)	2.36*	1.09	5.10	3.11**	1.38	6.97
Intermediate North	37	1 (2.7)	36 (97.3)	0.29^{ns}	0.04	2.17	0.31^{ns}	0.04	2.43
Low	18	3 (16. 7)	15 (83.3)	2.06^{ns}	0.56	7.59	1.96^{ns}	0.50	7.66
Total	**604**	58 (9.6)	546 (90.4)						

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

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

[2] 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] Adjusted refers to a 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

3.7 Incidents disclosed in cattle moved into a herd (out of herd, or out of home-range genotypes)

Homerange refers to the geographical area where a specific genotype is most frequently recovered. A homerange is defined as, a 5km square where there have been at least three incidents of a specific genotype on at least two holdings within a five year period. As observed in Figure 3.7.1, a 10km buffer is applied to create the homeranges of each genotype. There are four genotypes with large homeranges across Wales, although other genotypes are still recorded in Wales (see Figure 5.4.1).

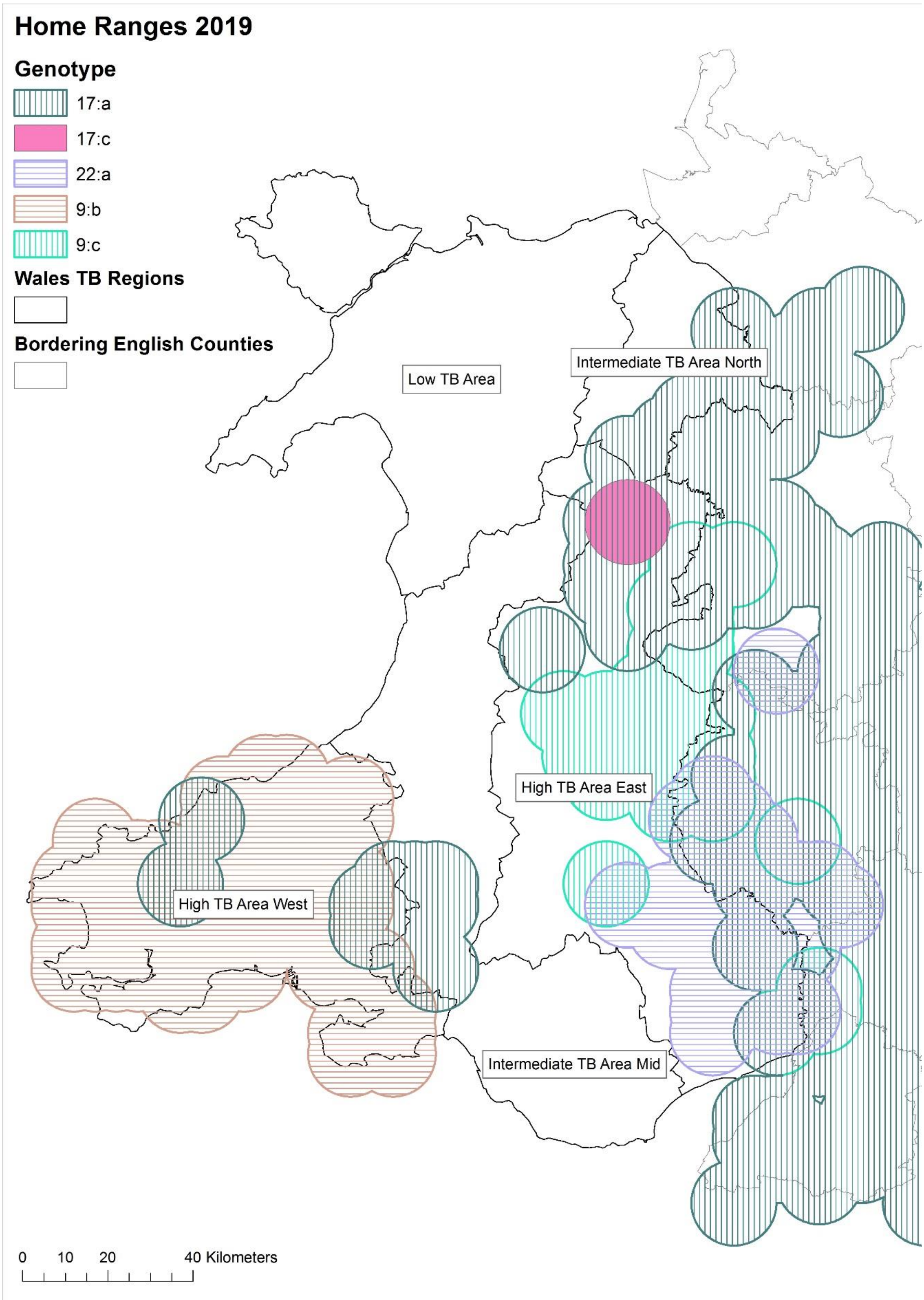


Figure 3.7.1: Homeranges for genotypes 9:b, 9:c, 17:a, 17c and 22:a using 2015-19 data

The number of TB incidents disclosed in cattle moved into a herd that are out of herd or out of home-range genotypes, is described in Table 3.7.1. In Wales overall, over 50% of OTF-W incidents had a genotype and of these, 81% of the genotypes identified were within the home-range. The percentage of TB incidents within a home-range is substantially greater in the High East, High West and Intermediate North TB Areas, compared to other TB Areas of Wales which have little or no home ranges associated with them.

Table 3.7.1. TB incidents disclosed in cattle moved into a herd (out of herd, or out of home-range[1] genotypes, 2019

TB Area	OTF-W incidents	Incidents with genotype[2]	In Home Range[2] (%)	Outside Home Range[3] (%)	Within 10km of Home Range (%)	In And Outside Home Range (%)	No Home Range Data[4] (%)
High TB East	196	133	111 (83.5)	10 (7.5)	10 (7.5)	0 (0.0)	2 (1.5)
High TB West	294	139	124 (89.2)	7 (5.0)	4 (2.9)	1 (0.7)	5 (3.6)
Intermediate TB Mid	59	30	13 (43.3)	7 (23.3)	9 (30.0)	0 (0.0)	1 (3.3)
Intermediate TB North	37	14	12 (85.7)	2 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)
Low TB	18	8	1 (12.5)	5 (62.5)	1 (12.5)	0 (0.0)	1 (12.5)
Wales overall	**604**	**324**	**261 (80.6)**	**31 (9.6)**	**24 (7.4)**	**1 (0.3)**	**9 (2.8)**

[1]The home ranges were based on data from 2013-2018.

[2]If a TB incident has >1 genotype it can count as both in, outside and within 10km of home range, and will count also in 'In And Outside Home Range' category.

[3]Outside and within 10km of Home Range are mutually exclusive.

[4]No Home Range Data counts only those incidents with a full genotype.

3.8 Incidents disclosed by trace testing, pre-movement or post-movement testing & contiguous testing

Tracing and contiguous tests are categorised under the surveillance stream for 'Area and Herd Risk', whereas pre- and post-movement testing is categorized as 'Trade and other'. Both are considered active surveillance through field testing of herds or individual cattle. They occur where there is evidence that cattle are at greater risk of being infected, or conducted for the purposes of trade. Post-incident, contiguous and tracing tests are not recorded if they are conducted at the same time as a routine surveillance test (e.g. whole-herd test).

Area risk tests are carried out on herds contiguous to OTF-W incidents, outside of their regular test frequency. Movement risk tests include tracing and pre- and post-movement tests. Tracing tests are carried out in cattle moved from OTF-W herds prior to 'service of restrictions'. Pre-movement tests are carried out prior to cattle movements and are required for herds in High and Intermediate TB Areas and higher risk herds in the Low TB Area. Post-movement tests are carried out where cattle have been moved to a holding without a required pre-movement test. They are required on holdings in the Low TB Area for cattle moved from higher risk areas in England and Wales.

Tracing tests can target higher risk herds. They are usually animal tests, where a single animal or proportion of a herd is tested, rather than the whole herd. Tracing and other trade tests are important in terms of monitoring and preventing spread, for example, through movement of higher risk herds to other herds. Source tracings also identify herds of origin not previously detected.

Close to half of all TB incidents disclosed in the High East and West TB Areas were disclosed by contiguous testing (43% and 46%, respectively), compared to 38% in the Intermediate North TB Area, 25% in the Intermediate Mid TB Area and 17% in the Low TB Area (Table 3.8.1). Tracing tests disclosed very few TB incidents (one to five TB incidents in each TB Area).

Table 3.8.1 Total number of new TB incidents disclosed in 2019, by TB Area and total and percentage of TB incidents by contiguous, tracing and movement tests

TB Area	Total new TB incidents (2019)	Total (%) TB disclosed from contiguous tests	Total (%) TB disclosed from tracing tests	Total (%) TB disclosed from pre- and post-movement tests[1]
High East	210	90 (42.9)	3 (1.4)	25 (11.9)
High West	308	141 (45.8)	5 (1.6)	24 (7.8)
Intermediate Mid	75	19 (25.3)	2 (2.7)	6 (8.0)
Intermediate North	45	17 (37.8)	1 (2.2)	4 (8.9)
Low	23	4 (17.4)	1 (4.3)	0 (0.0)

[1] Although the total is of pre- and post-movement tests, there were no TB incidents disclosed by post-movement testing in 2019.

The vast majority of TB incidents disclosed by trace, pre- and post-movement and contiguous testing were OTF-W (Table 3.8.2). The number of TB incidents disclosed per 1,000 animal tests ranged from zero to less than two. There was one exception; contiguous testing (CON-6) in the High West TB Area but this referred to only one TB incident.

Table 3.8.2. Incidents disclosed by trace, pre-movement, post-movement and contiguous testing, 2019 by TB Area

TB Area	Surveillance Stream	Test Type[1]	Number of surveillance tests (per 1,000 animals)	Total TB incidents	Incidents per 1,000 animal tests (Total TB)	Total IRs (Total TB)	OTF-W incidents	Incidents per 1,000 animal tests (OTF-W)	Total IRs (OTF-W)
High East	Area & Herd Risk	CON	73.9	58	0.8	15	56	0.8	14
	Area & Herd Risk	CON 6	0.0	0	0.0	0	0	0.0	0
	Area & Herd Risk	CON12	33.7	32	1.0	9	28	0.8	6
	Area & Herd Risk	TR	2.6	3	1.1	0	3	1.1	0
	Trade	POSTMT	0.0	0	0.0	0	0	0.0	0
	Trade	PRMT	42.0	25	0.6	5	24	0.6	4
High West	Area & Herd Risk	CON	179.4	109	0.6	22	108	0.6	22
	Area & Herd Risk	CON 6	0.1	1	7.1	1	1	7.1	1
	Area & Herd Risk	CON12	42.2	31	0.7	13	29	0.7	13
	Area & Herd Risk	TR	3.5	5	1.4	1	5	1.4	1
	Trade	POSTMT	0.1	0	0.0	0	0	0.0	0
	Trade	PRMT	42.2	24	0.6	3	21	0.5	2
Intermediate North	Area & Herd Risk	CON	16.6	6	0.4	0	6	0.4	0
	Area & Herd Risk	CON 6	33.0	9	0.3	1	9	0.3	1
	Area & Herd Risk	CON12	3.4	2	0.6	0	1	0.3	0
	Area & Herd Risk	TR	0.6	1	1.8	0	1	1.8	0
	Trade	POSTMT	0.2	0	0.0	0	0	0.0	0
	Trade	PRMT	13.6	4	0.3	0	3	0.2	0
Intermediate Mid	Area & Herd Risk	CON	23.3	12	0.5	3	12	0.5	3
	Area & Herd Risk	CON 6	0.1	0	0.0	0	0	0.0	0
	Area & Herd Risk	CON12	18.2	7	0.4	2	5	0.3	1
	Area & Herd Risk	TR	1.5	2	1.3	0	2	1.3	0
	Trade	POSTMT	0.1	0	0.0	0	0	0.0	0
	Trade	PRMT	25.4	6	0.2	1	4	0.2	0
Low	Area & Herd Risk	CON	13.0	3	0.2	0	3	0.2	0
	Area & Herd Risk	CON6	0.0	0	0.0	0	0	0.0	0
	Area & Herd Risk	CON12	22.4	1	0.0	0	1	0.0	0
	Area & Herd Risk	TR	1.0	0	0.0	0	0	0.0	0

TB Area	Surveillance Stream	Test Type[1]	Number of surveillance tests (per 1,000 animals)	Total TB incidents	Incidents per 1,000 animal tests (Total TB)	Total IRs (Total TB)	OTF-W incidents	Incidents per 1,000 animal tests (OTF-W)	Total IRs (OTF-W)
	Trade	POSTMT	10.3	0	0.0	0	0	0.0	0
	Trade	PRMT	5.2	0	0.0	0	0	0.0	0

[1] A description of each test type is found in Appendix Table 2

3.9 Recurrent incidents

Recurrence of TB in a herd may be due to persistence of infection from a previous TB incident, or the result of newly introduced infection. This section looks at the percentage 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 (2019) 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[6]. Further details are provided in Appendix 1.

Of all herds that had a history of TB consistent with the definition outlined above, 16% (260/1,586) had a new TB incident in 2019, similar to the percentages observed in preceding years. Eighty-six per cent of herds (9,754/11,340) did not have any TB incidents in either the Current or History period; a similar percentage to that observed in previous years.

Herds that had a new TB incident in 2019 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 in all TB Areas ($p<0.01$, Fisher's Exact test) apart from in the Low TB Area ($p>0.05$, Fishers Exact test).

Herds with a new TB incident in 2019 that had their OTF status withdrawn in the previous three years (history period), would be classed as OTF-W by definition. Therefore, herds with a new OTF-W incident in 2019 were significantly more likely to have been restricted due to an OTF-W incident during the History period compared with herds that had a new OTF-S incident in 2019 ($p<0.05$ by Fisher's Exact test), in all TB Areas. Tables 3.9.1 (a-e) detail the number and percentage of herds according to their TB status in 2019, and the history period of the previous 36 months, broken down by TB Area.

[6] The recurrence analyses included all herds active at the end of the Current Period (2019). 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 3.9.1 (a-e): Incident and non-incident herds by TB history and TB Area, 2019

a) High TB East

TB status in current period	No previous incidents **(a)**	Any incident **Number (b)**	Any incident **% (b/(a+b) x100)**	≥ 1 OTF-W incidents Number **(c)**	≥ 1 OTF-W incidents **% (c/(a+b)x100)**	OTF-S incidents only **Number (d)**	OTF-S incidents only **% (d/(a+b)x 100)**
OTF herds[1]	1,979	508	20	466	19	42	2
Any new TB incident	128	78	38	75	36	3	1
OTF-W herds	114	78	41	75	39	3	2
OTF-S herds	14	0	0	0	0	0	0
Total herds	2,107	586	22	541	20	45	2

b) High TB West

TB status in current period	No previous incidents **(a)**	Any incident **Number (b)**	Any incident **% (b/(a+b))**	≥ 1 OTF-W incidents Number **(c)**	≥ 1 OTF-W incidents **% (c/(a+b))**	OTF-S incidents only **Number (d)**	OTF-S incidents only **% (d/(a+b))**
OTF herds[1]	2,112	527	20	484	18	43	2
Any new TB incident	151	144	49	141	48	3	1
OTF-W herds	138	144	51	141	50	3	1
OTF-S herds	13	0	0	0	0	0	0
Total herds	2,263	671	23	625	21	46	2

c) Intermediate Mid

TB status in current period	No previous incidents **(a)**	Any incident **Number (b)**	Any incident **% (b/(a+b))**	≥ 1 OTF-W incidents **Number (c)**	≥ 1 OTF-W incidents **% (c/(a+b))**	OTF-S incidents only **Number (d)**	OTF-S incidents only **% (d/(a+b))**
OTF herds[1]	1,818	125	6	90	5	35	2
Any new TB incident	50	22	31	21	29	1	1
OTF-W herds	35	21	38	21	38	0	0
OTF-S herds	15	1	6	0	0	1	6
Total herds	1,868	147	7	111	6	36	2

d) Intermediate North

TB status in current period	No previous incidents **(a)**	Any incident **Number (b)**	Any incident **% (b/(a+b))**	≥ 1 OTF-W incidents **Number (c)**	≥ 1 OTF-W incidents **% (c/(a+b))**	OTF-S incidents only **Number (d)**	OTF-S incidents only **% (d/(a+b))**
OTF herds[1]	744	94	11	72	9	22	3
Any new TB incident	29	13	31	13	31	0	0
OTF-W herds	21	13	38	13	38	0	0
OTF-S herds	8	0	0	0	0	0	0
Total herds	773	107	12	85	10	22	3

e) Low TB

TB status in current period	No previous incidents **(a)**	Any incident **Number (b)**	Any incident **% (b/(a+b))**	≥ 1 OTF-W incidents **Number (c)**	≥ 1 OTF-W incidents **% (c/(a+b))**	OTF-S incidents only **Number (d)**	OTF-S incidents only **% (d/(a+b))**
OTF herds[1]	2,723	72	3	39	1	33	1
Any new TB incident	20	3	13	3	13	0	0
OTF-W herds	15	3	17	3	17	0	0
OTF-S herds	5	0	0	0	0	0	0
Total herds	2,743	75	3	42	1	33	1

[1] Whether a herd was active in the History Period was not checked

[2] A herd was classified as OTF in 2019 if it did not suffer a new TB incident in 2019 or was under movement restrictions due to a previous TB incident for less than four months of 2019, and thus had the potential to have a recurrent incident later in the Current period. Herds under restriction for four or more months of 2019 due to an incident that started before 2019, were excluded from analyses (n=435).

Apart from a decline in the percentage of OTF herds with TB history in 2015 and 2016, the percentage of herds with an incident in all TB Areas has since remained stable, at around 20% in the High East and West TB Areas, 10% in the Intermediate North, around 6% in the Intermediate Mid and around 3% in the Low TB Areas (Figure 3.9.1a).

Figure 3.9.1b shows the percentage of recurrent TB herds with a TB incident in 2019. This does not split TB incidents by OTF-W and OTF-S as there are very few OTF-S 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. Apart from the Intermediate Mid TB Area that had 6% of OTF-S incidents with TB history, all other TB Areas had none.

The percentage of recurrent TB herds with a TB incident in 2019 increased in all TB Areas apart from the High East TB Area (Figure 3.9.1b), but this percentage has varied over the previous five years. The High East TB Area has shown a decreasing trend since 2016 from over 50% to 40%. In the High West TB Area, the percentage of recurrent herds with an OTF-W incident in the reporting year decreased between 2015 and 2017 but increased again in 2019 to nearly 50%. In the Intermediate Mid and North TB Areas, the percentage of recurrent

TB herds with OTF-W incidents has increased from around 25% in 2018 to nearly 40% in 2019. The percentage of OTF-W incidents with TB history in the Low TB Area has varied year on year, likely due to the much lower numbers of TB incidents disclosed in the area. In 2019, the percentage was around 15% (based on three OTF-W incidents).

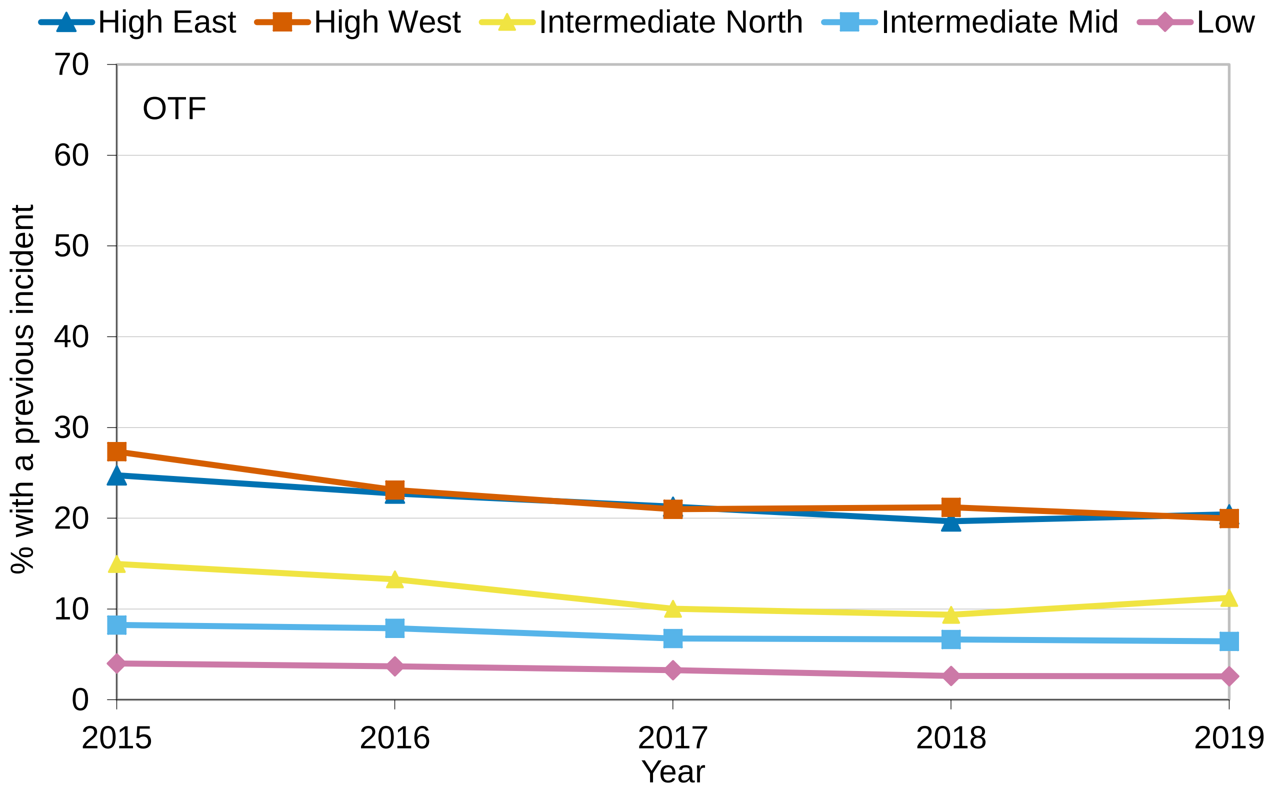


Figure 3.9.1a: Percentage of OTF herds in Current Period with any TB incident in the History Period, by TB Area, 2015 – 2019

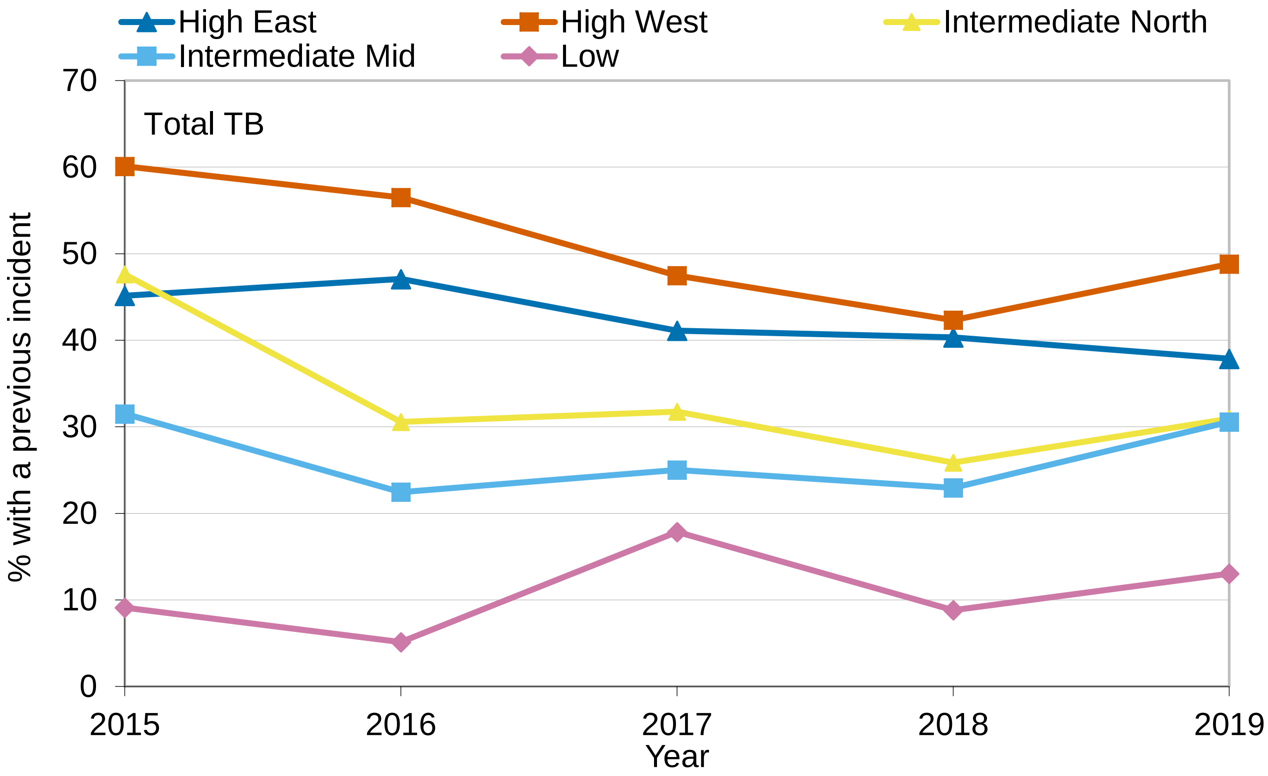


Figure 3.9.1b: Percentage of herds with any TB incident in the Current Period with any TB incident in the History Period, by TB Area, 2015 – 2019

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 (Table 3.9.2). 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 410 herds defined as 'Other/ Mixed' herd type were removed from the logistic regression analysis because the model would not converge with them included. There were no herds in 2019 (categorised as 'Other' with a TB incident).

The odds of a new incident occurring in herds with TB history were consistently greater than for those with no TB history. Herds with over 10 animals had significantly greater odds of having a recurrent TB incident. However the odds ratio for the remaining herd size categories was very similar, ranging from 1.6 to 2.0 with the confidence intervals overlapping, therefore it is not possible to discern true differences in these categories.

Beef herds with TB history were twice as likely to have a TB incident in 2019 compared to herds with no TB history (Dairy herds were 1.6 times more likely to have a TB incident, where herds had history of TB, compared to no TB history). The odds of a herd incurring a new TB incident in 2019 was twice as high in herds with TB history in the High West and Intermediate North, but 3.3 times greater in the Intermediate Mid TB Area. In the High East and Low TB Areas, the increase in the odds ratio was not statistically significant.

Of the 260 recurrent TB incidents included in the analyses, the time elapsed between the most recent TB incident in the history period and the start date of the first TB incident in the current period (2019) ranged from 13 days to around 36 months (Appendix Table 5). The median time elapsed was nearly 8 months for OTF-S incidents in 2019, and around 29 months for any incident type with an OTF-W incident in the history period. For total TB and OTF-W incidents disclosed in 2019 with a recurrent TB incident, the time between incidents tended to be longer where the incident (in the History Period) was classified as OTF-W.

Table 3.9.2: Logistic regression to determine the odds of a herd having a recurrent TB incident in 2019 according to their TB history, by herd size, type and TB Area

	TB incident[1] Herds	**TB incident[1]** Incident in 2019 (%)	**No TB incident[1]** Herds	**No TB incident[1]** Incident in 2019 (%)	**Odds ratio (adjusted)[2]**	**95% CI for odds ratio**	**95% CI for odds ratio**
Herd Size							
0 - 10	49	1 (2)	2,163	15 (0.7)	2.1[ns]	0.3	16.3
11 - 50	332	20 (6)	3,589	80 (2.2)	2.0**	1.2	3.3
51 - 100	362	42 (11.6)	1,886	104 (5.5)	1.6*	1.1	2.3
101 - 200	378	70 (18.5)	1,322	91 (6.9)	2.0***	1.4	2.8
201 - 300	193	47 (24.4)	414	40 (9.7)	1.9**	1.2	3.1
>300	272	80 (29.4)	380	48 (12.6)	1.8**	1.2	2.7
Undetermined	0	0 (0)	0	0 (0)	-	-	-
Herd type[3]							
Beef	987	127 (12.9)	7,945	252 (3.2)	2.0***	1.6	2.6
Dairy	595	133 (22.4)	1,403	120 (8.6)	1.6**	1.2	2.1
TB Area							
High East	586	78 (13.3)	2,107	128 (6.1)	1.4[ns]	1.0	1.8
High West	671	144 (21.5)	2,263	151 (6.7)	1.9***	1.5	2.5
Intermediate Mid	147	22 (15)	1,868	50 (2.7)	3.3***	1.9	5.8
Intermediate North	107	13 (12.1)	773	29 (3.8)	2.0*	1.0	4.1
Low	75	3 (4)	2,743	20 (0.7)	2.7[ns]	0.8	9.5
Total	1,586	260 (16.4)	9,754	378 (3.9)			

*, **, *** 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] Herds under restriction any time in the history period, unless the restriction lasted for more than four months into 2019; 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.

[3] A total of 410 herds defined as Other/ Mixed herd type were dropped from the logistic regression analysis since the model would not converge with them included. Within the 410 herds, there were

four with a TB incident in the history period, none of which had a TB incident in 2019, and of the 406 herds with no TB history, six had a TB incident in 2019.

The distribution of recurrent TB incidents has been similar over the last five years (Figure 3.9.2). Although there has been a decline in the High East and West TB Areas in recent years, the majority of recurrent TB incidents are concentrated in these areas (in the High East TB Area, they are concentrated closest to the bordering English counties). The majority of recurrent herds in 2019 had experienced just one previous OTF-W incident in the history period, only three herds' experienced three incidents in 2019. There were no TB incidents in 2019 that had had four OTF-W incidents in the last 3 years, and this has been observed in Wales for over five years.

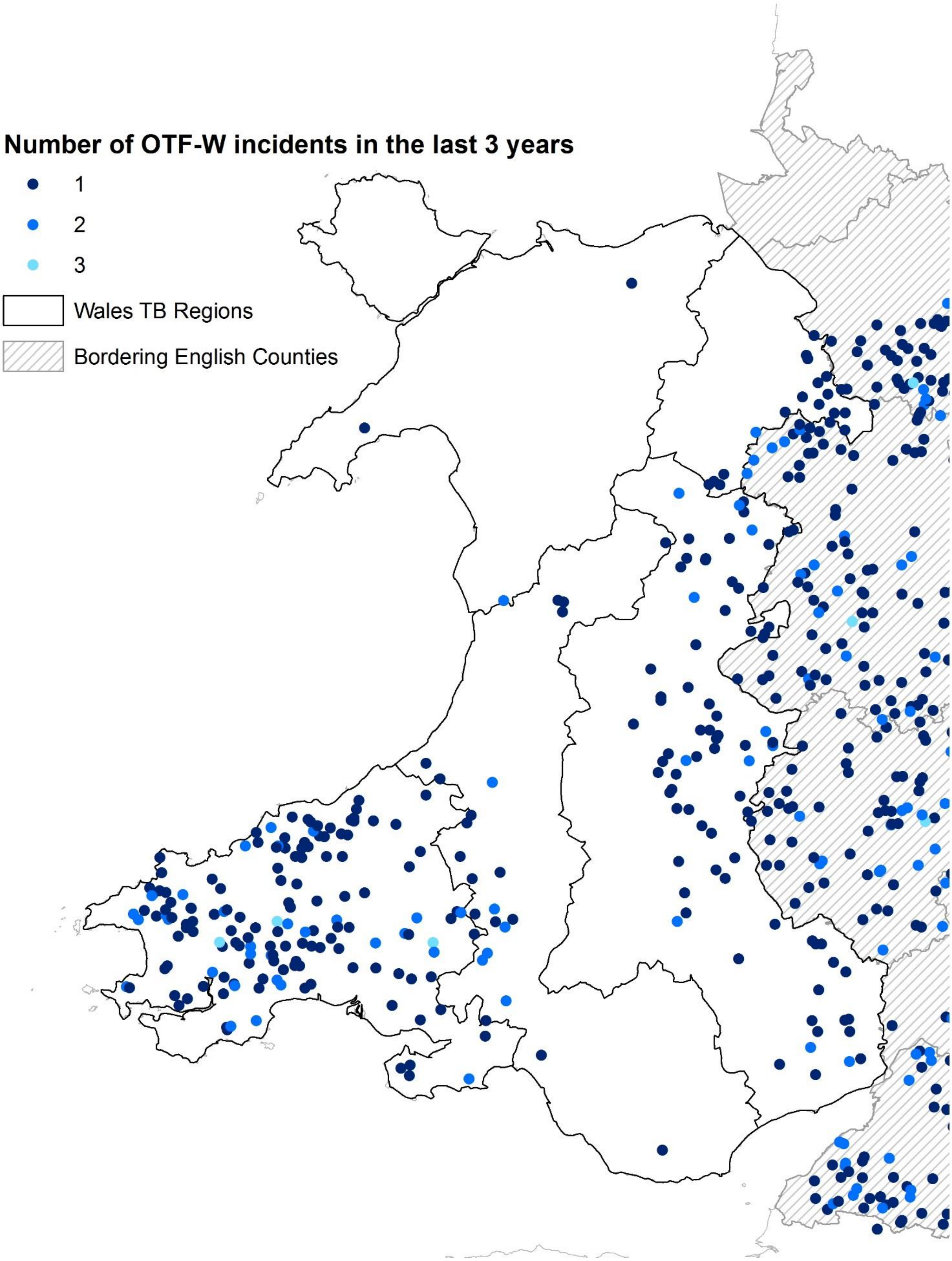


Figure 3.9.2: Herds with new bovine TB incidents in 2019 that had had between one and three OTF-W incidents in the previous 36 months (recurrent incident herds)

3.10 TB incidents up to and including the 6M test where reactors had been IRs in previous TB incidents

Inconclusive reactors (IRs) are cattle which have a reaction to bovine tuberculin from the SICCT test, but not large enough to be classified as a reactor (result is neither clear nor positive). IRs are placed under movement restrictions and can be retested 60 days after the date of the last test. At the next test, if an animal is clear (or negative), they can re-join the herd and move off restrictions (resolved IRs). If the animal is not clear (either 2xIR or now a reactor), they are classed as a reactor. The herd is placed under movement restrictions, reactors are removed and cattle are tested in short-interval (SI) tests until such time that all tests are negative and the herd is classified as clear from infection (see Appendix Table 1 for further information on the definition of standard and severe interpretation of the test). Severe interpretation is used in TB incidents with lesion and/or culture positive animals that meet certain criteria and indicate they are at increased risk of infection, for example where more than one reactor has been found. Severe interpretation is applied to the first SI test and also to the second if any IRs were found at the first test.

IRs can be an important predictor for the presence of TB infection in a herd. Table 3.10.1 shows the number of TB incidents with reactors (or 2/3xIRs) that had been an IR in a preceding TB incident, which ended within nine months of the current (2019) TB incident.

The percentage of TB incidents (where reactors had previously been IRs) was similar for the High West and Intermediate North TB Areas (6.5 and 6.7%, respectively). The High East TB Area also had the largest number of total reactors (n=60), although the maximum number of reactors per incident was actually highest in the Intermediate Mid TB Area (n=11). The percentage was lowest in the High East TB Area (2.4%).

Table 3.10.1. Number of TB incidents up to and including the six monthly test, where reactors had previously been IRs.

TB Area	Number of TB incidents where reactors had previously been IRs	% of total new TB incidents where reactors had previously been IRs	Total Reactors (where reactors has previously been an IR)	Max Reactors*	Mean Reactors	Total new TB incidents (2019)
High East	5	2.4	7	2	1.4	210
High West	20	6.5	60	6	3	308
Intermediate Mid	4	5.3	16	11	4	75
Intermediate North	3	6.7	3	1	1	45
Low	1	4.3	1	1	1	23

*Max Reactors: the highest number taken in any single TB incident in each TB Area

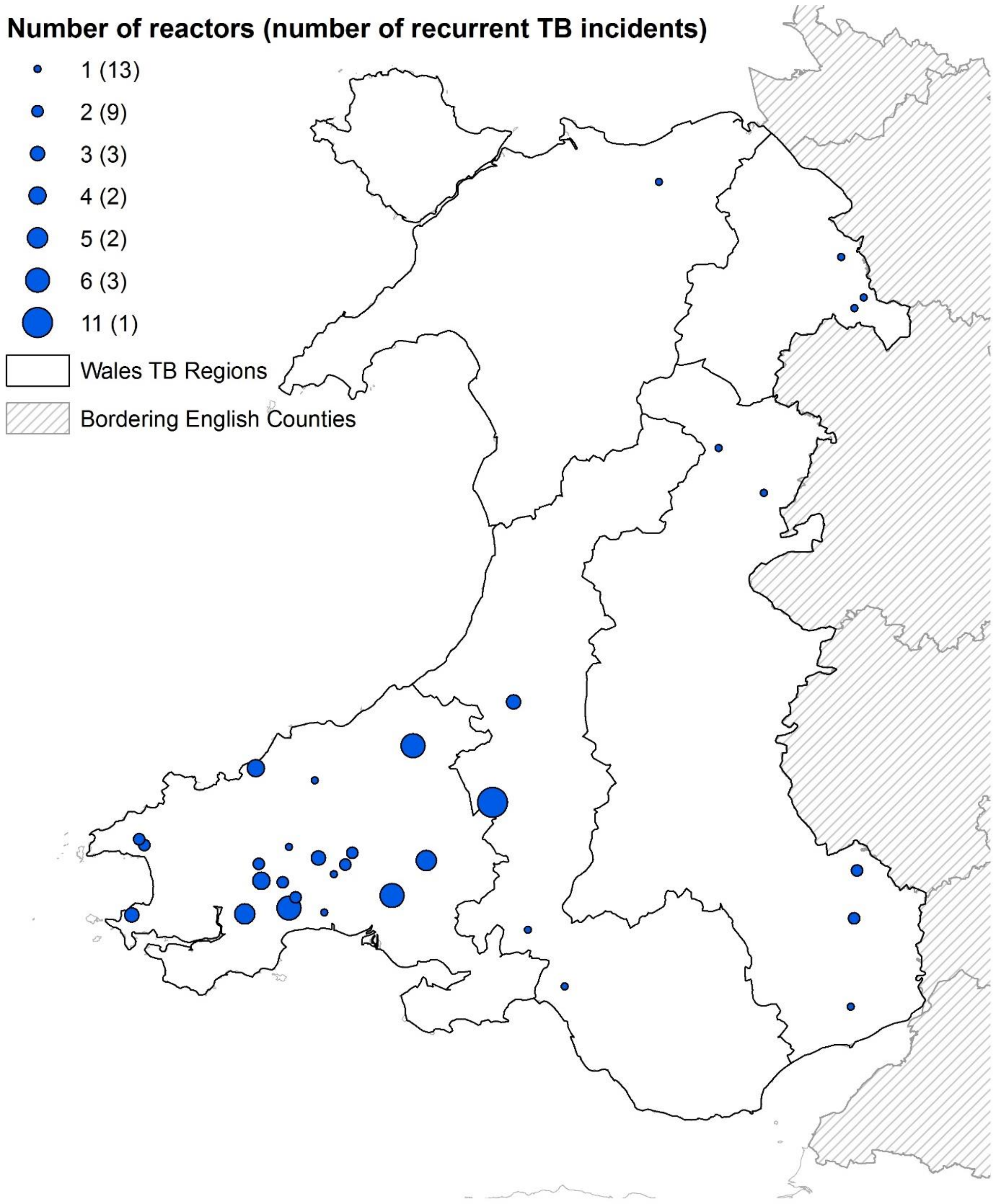


Figure 3.10.1. Number of TB incidents up to and including the six monthly test, where reactors had been IRs in previous TB incidents, 2019.

3.11 Inconclusive reactor herds that subsequently suffered an incident

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, 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[7].

There were 863 IR-only herds that had IR-retests in Wales in 2019, of which 126 (15%) had an OTF-W incident at the IR-retest and 22 (3%) had an OTF-S incident. The remaining 715 (83%) were clear at the IR-retest. Therefore a new TB incident was detected at the IR-retest in 148 (17%) herds with IR-only tests in 2019.

Of the 715 herds that tested clear at an IR retest, 698 subsequently had a whole herd test (WHT) within the 15-month follow up period. Significantly more IR-only herds (17%, n=116) went on to have a TB incident at the next WHT, compared to non-IR herds in 2019 (5%; 482/8,946) ($p<0.001$ Fishers Exact test). The percentages observed in 2019 were similar to those observed in recent years.

Figures 3.11.1 and 3.11.2 show the 10 year trends in the percentage of IR-only herds with a new TB incident at the IR retest or subsequent whole herd test since 2010, where there has been a sustained drop in the herd-level failure rate at IR retest. The percentage of IR-only herds with a subsequent OTF-S incident has decreased considerably since 2010, to 3% in 2018 and 2019, related to the change in the way incidents were classified from 2011 (Figure 3.11.1). The percentage 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

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

would be expected as more herds were classified as OTF-W from 2011 onwards (See Appendix 1 for details on classification of TB incidents). Since then, the percentage of IRs preceding an OTF-W incident has remained relatively stable since 2013, between 15% and 17%. The percentage of herds that had a new TB incident following a clear IR-retest is similar to the percentage of IR-only herds with a new TB incident at the IR-retest, suggesting that the IR retest is not predictive of new TB incidents (Figure 3.11.2).

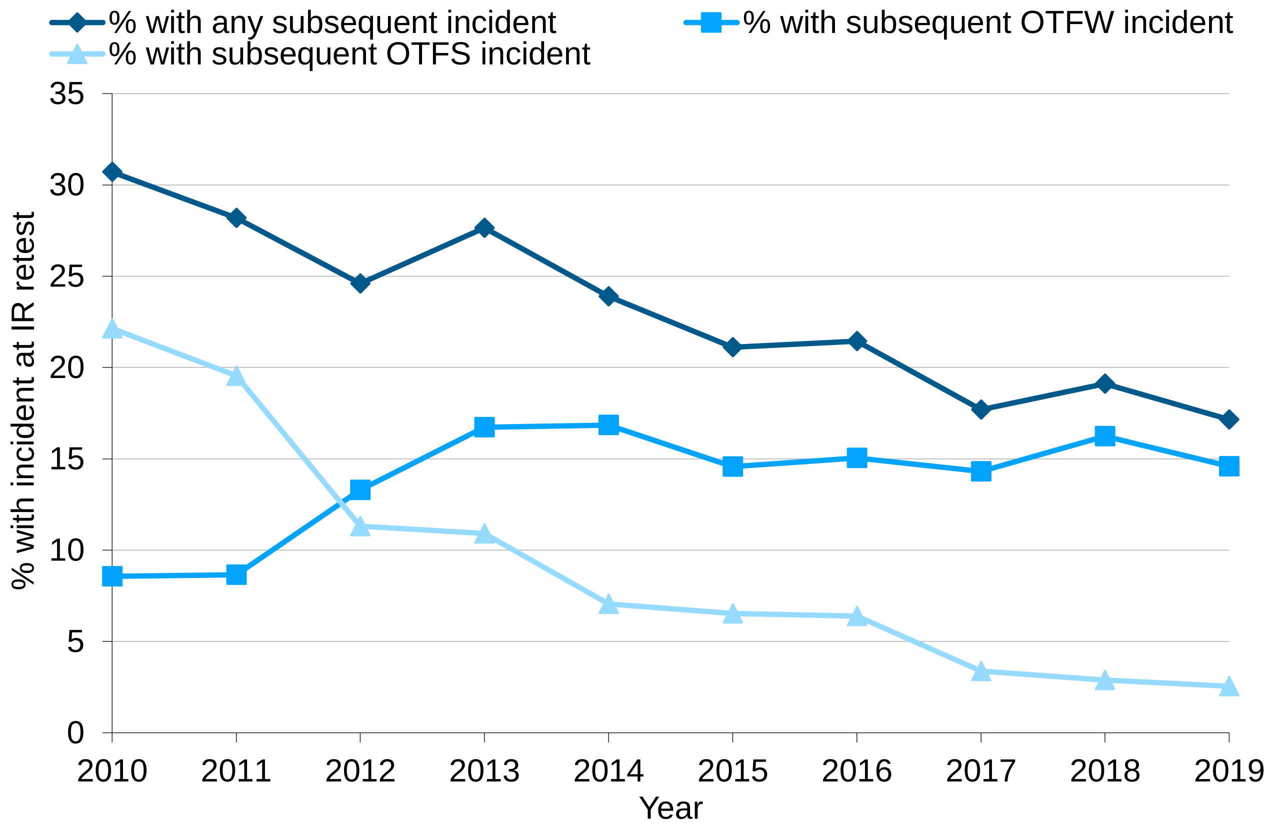


Figure 3.11.1: Percentage of IR-only herds with a new TB incident at the IR-retest

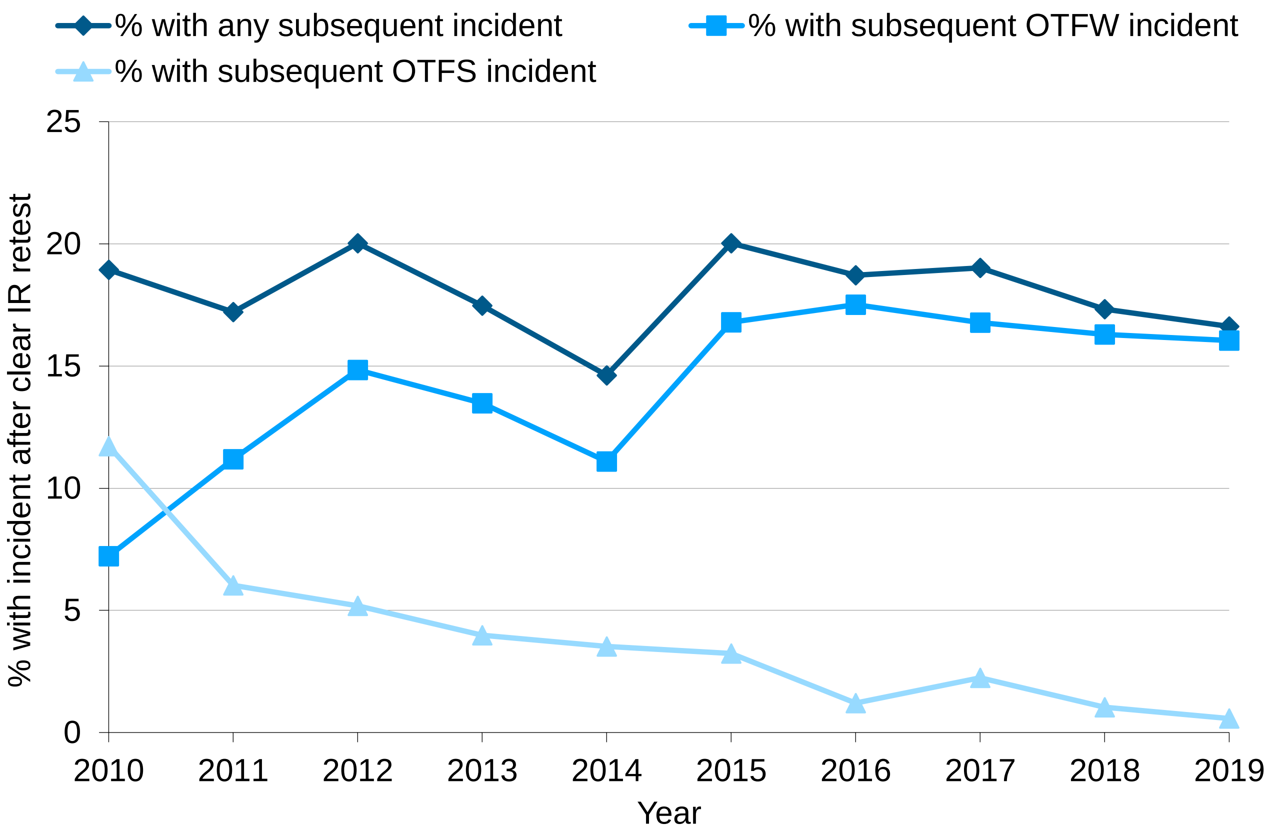


Figure 3.11.2: Percentage of herds that had a new TB incident following a clear IR-retest[1]

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

The percentage of IR-only herds that had a new incident at the IR retest varies by herd size, herd type, and TB Area (Table 3.11.1). The percentage of IR-only herds with an OTF-W incident at retest was fairly similar across herd size categories with more than 10 animals, the highest being 18.3% in the 201-300 herd size category. Excluding the 'Other' herd type category which had two of five IR-only herds having an OTF-W incident at retest, the percentage of beef herds was higher than dairy (15.6% and 13%, respectively). When comparing TB Areas, the High East had the highest percentage of OTF-W incidents disclosed at the retest (23.8%), followed by the High West (14.8%).

Demographic and geographical factors which are associated with higher rates of TB are also associated with higher levels of IR-only herds going on to have a subsequent incident. Similarly to the IR-only herds, the percentage of clear herds that had a new TB incident at a subsequent WHT in the 15 month period also varied by herd size and was highest in herds with >300 cattle (33%). By herd type, more dairy had a new TB incident at a subsequent WHT compared to beef (23% vs 12%). By TB Area, the percentage was highest in the Intermediate Mid (23%) and High West TB Areas (22%). 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.

Table 3.11.1: TB incidents in the fifteen months subsequent to tests in which only inconclusive reactors were found, and TB incidents in the fifteen months following a clear whole herd test, 2019

	IR-only herds with retest[1]	Total TB incidents retest (%)	OTF-W incidents retest (%)	Herds clear at retest with subsequent WHT	Total TB incidents at subsequent WHT (%)	OTF-W incidents at subsequent WHT (%)	Clear herds with a subsequent test[1]	Total TB incidents at subsequent test (%)	OTF-W incidents at subsequent test (%)
Herd size									
1-10	25	2 (8)	1 (4.0)	22	0 (0)	0 (0)	1,357	7 (0.5)	3 (0.2)
11-50	160	32 (20)	25 (15.6)	122	9 (7.4)	8 (6.6)	3,204	89 (2.8)	76 (2.4)
51-100	206	37 (18)	30 (14.6)	163	20 (12.3)	18 (11)	1,922	114 (5.9)	99 (5.2)
101-200	228	32 (14)	27 (11.8)	193	34 (17.6)	33 (17.1)	1,466	118 (8)	108 (7.4)
201-300	115	21 (18.3)	21 (18.3)	94	19 (20.2)	19 (20.2)	496	64 (12.9)	60 (12.1)
>300	129	24 (18.6)	22 (17.1)	104	34 (32.7)	34 (32.7)	501	90 (18)	88 (17.6)
Type									
Beef	481	90 (18.7)	75 (15.6)	379	44 (11.6)	41 (10.8)	7,238	309 (4.3)	273 (3.8)
Dairy	377	56 (14.9)	49 (13)	316	72 (22.8)	71 (22.5)	1,519	170 (11.2)	160 (10.5)
Other/mixed	5	2 (40)	2 (40)	3	0 (0)	0 (0)	189	3 (1.6)	1 (0.5)
TB Area									
High East	210	53 (25.2)	50 (23.8)	154	23 (14.9)	21 (13.6)	2,115	164 (7.8)	154 (7.3)
High West	386	64 (16.6)	57 (14.8)	316	68 (21.5)	67 (21.2)	2,224	206 (9.3)	195 (8.8)
Intermediate Mid	130	12 (9.2)	7 (5.4)	57	13 (22.8)	12 (21.1)	1,614	53 (3.3)	42 (2.6)
Intermediate North	69	12 (17.4)	9 (13)	112	11 (9.8)	11 (9.8)	692	34 (4.9)	25 (3.6)
Low	68	7 (10.3)	3 (4.4)	59	1 (1.7)	1 (1.7)	2,301	25 (1.1)	18 (0.8)
Total	**863**	**148 (17.1)**	**126 (14.6)**	**698**	**116 (16.6)**	**112 (16)**	**8,946**	**482 (5.4)**	**434 (4.9)**

[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

Figures 3.11.3 a-c show five-year trends in the percentage of IR-only herds with subsequent incidents varying across TB Areas for a) IR-only herds with no subsequent TB incident, b) IR-only herds with a new TB incident at retest and c) IR-only herds with a new TB incident at the test subsequent to a clear IR retest within fifteen months.

In Wales overall, 70% of IR-only herds had no subsequent TB incident. When comparing TB Area, the percentage was highest in the Intermediate Mid and Low TB Areas, at just over 80% and close to 90%, respectively. The percentage of other TB Areas was lower than Wales overall, at around 63-65% (Figure 3.11.3a).

The percentage of IR-only herds with a new TB incident at retest was 17% for Wales overall in 2019, but higher in the High East TB Area and the Intermediate North TB Area (Figure 3.11.3b). All other TB Areas were lower than Wales overall.

The percentage of IR-only herds with a new TB incident at the test subsequent to a clear IR retest within fifteen months was 17% for Wales overall in 2019, being higher in the High West and Intermediate North TB Areas (21.5% and 19.3%, respectively). The percentage for other TB Areas was lower than Wales overall and varied from 1.7% in the Low TB Area, to 15% in the High East TB Area (Figure 3.11.3c).

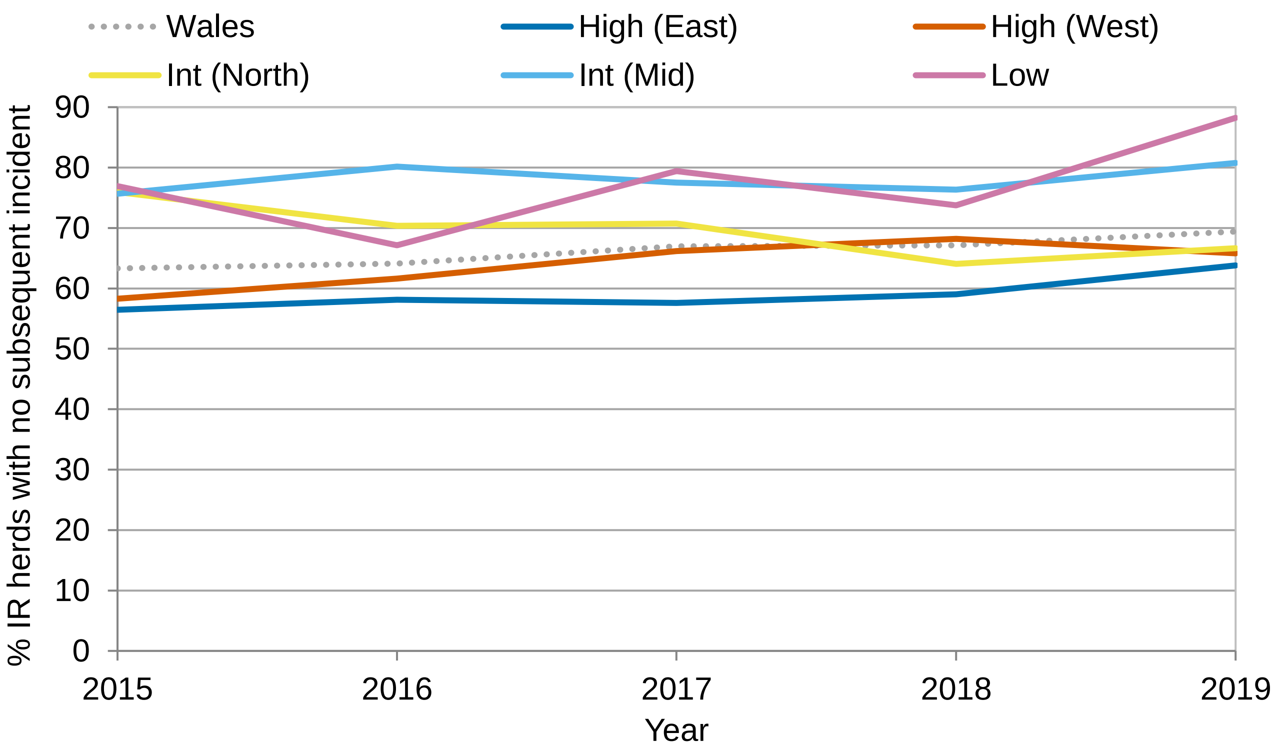


Figure 3.11.3a: IR-only herds with no subsequent TB incident within 15 months, by TB Area from 2015 to 2019.

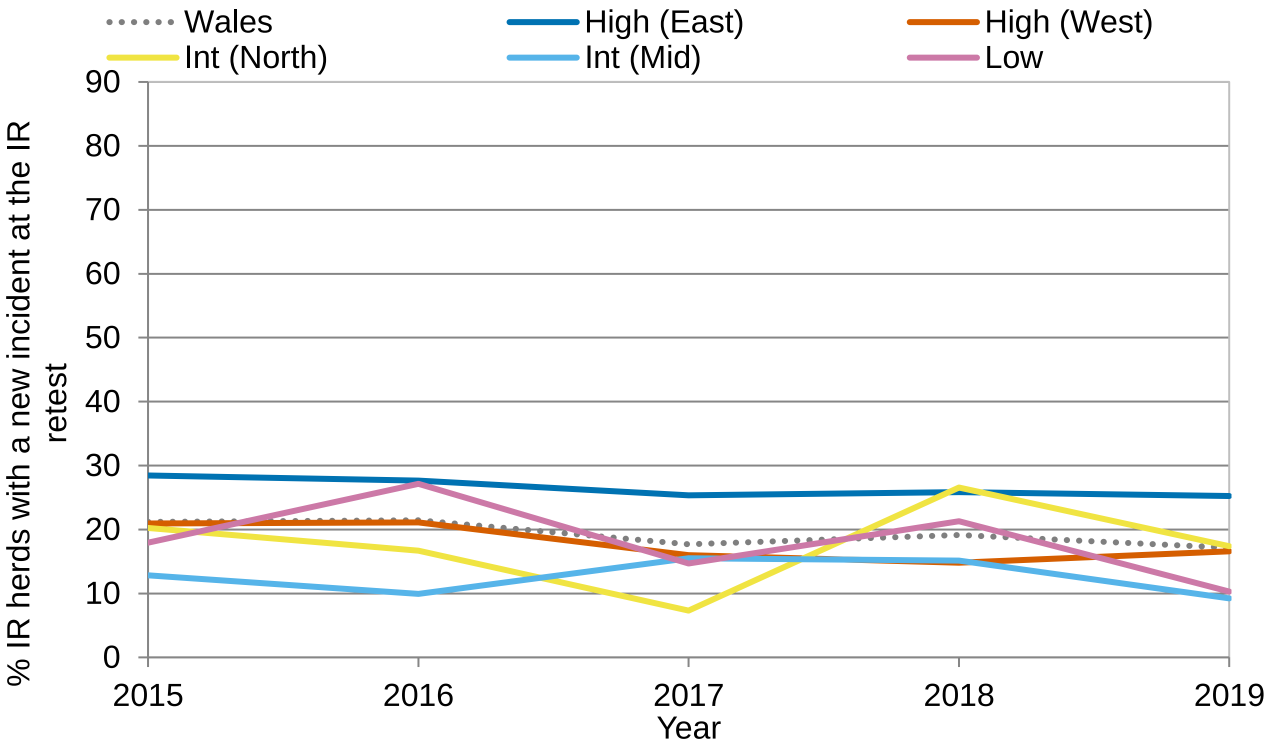


Figure 3.11.3b: IR-only herds with a new TB incident at the IR retest, by TB Area from 2015 to 2019.

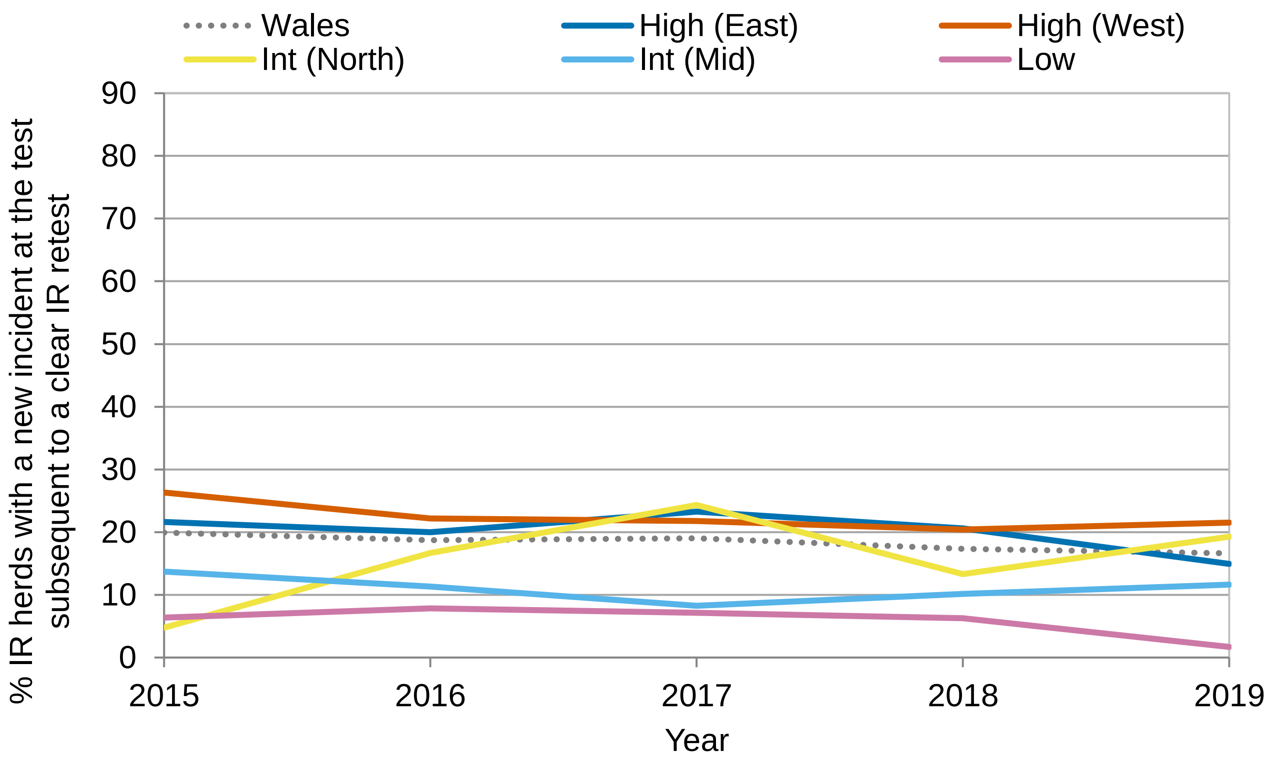


Figure 3.11.3c: IR herds with a new TB incident at the test subsequent to a clear IR retest within fifteen months, by TB Area from 2015 to 2019.

The grey dotted line represents the trends in Wales overall

Figure 3.11.4 shows the number of inconclusive reactors per 1,000 animals tested, by TB Area, while Figure 3.11.5 shows the density of inconclusive reactors in 2019 (for herds with at least one IR per km^2). As expected, the number of IRs per 1,000 animal tests was highest in the High West TB Area, where the density is highest. There are areas of increased IR density in parts of the Intermediate North and Mid, High East and even Low TB Areas, although in areas of low density, a 'hotspot' could be representative of just one OTF-W incident at retest or post-retest.

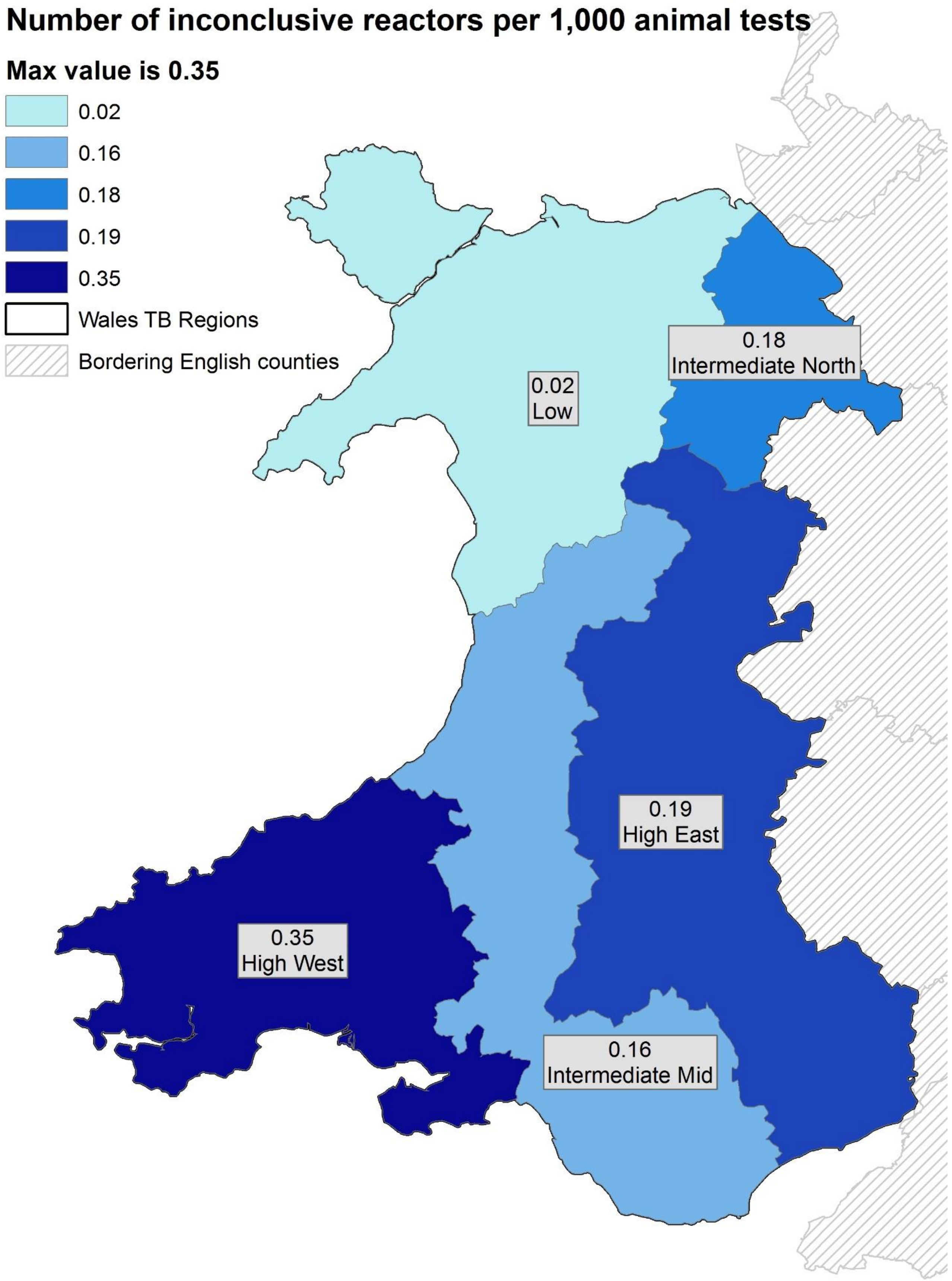


Figure 3.11.4: Number of inconclusive reactors per 1,000 animals tested in 2019, by TB Area

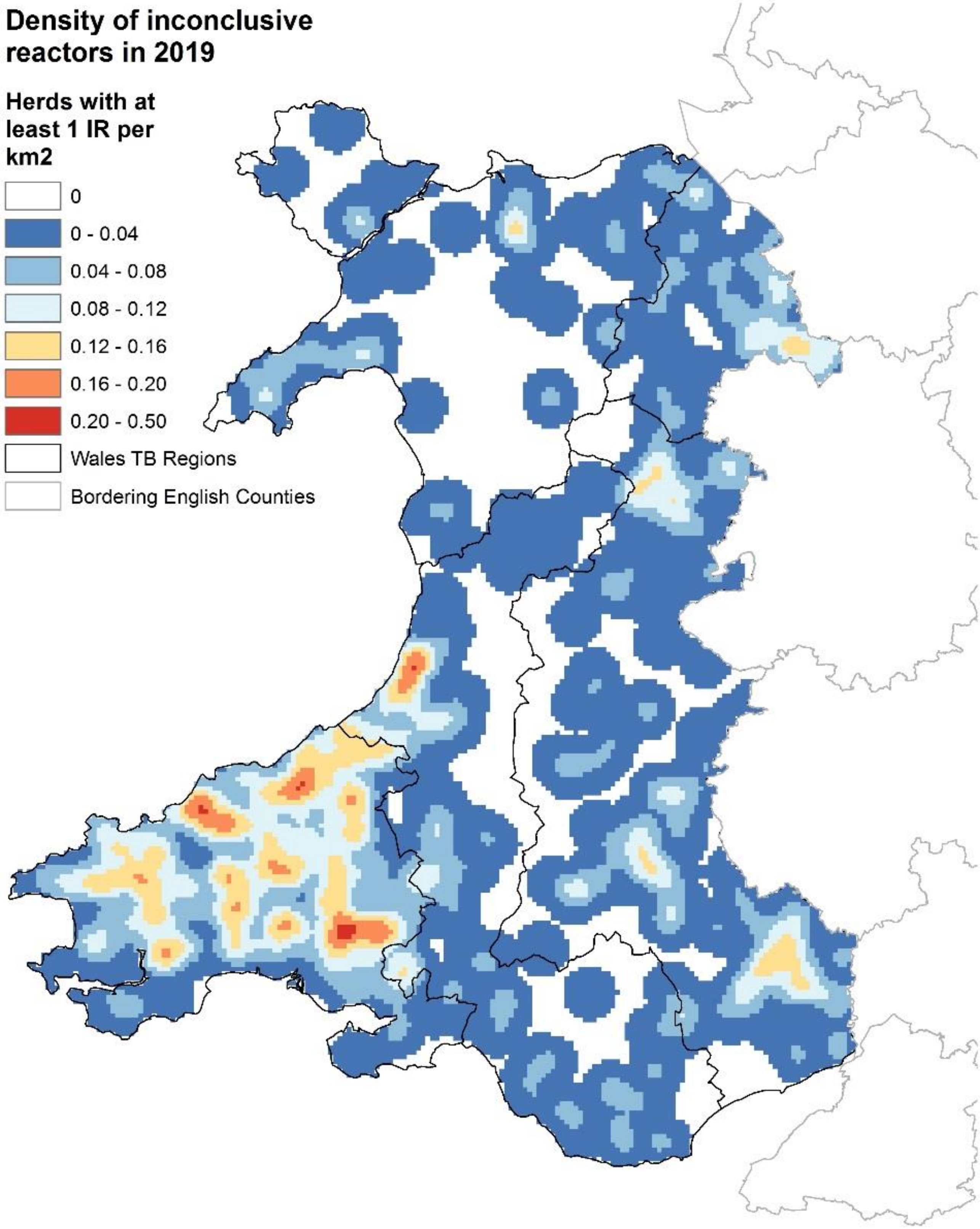


Figure 3.11.5: Density of inconclusive reactors per km², 2019

Figure 3.11.6 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 2019. The data has been split by OTF-S and OTF-W (at retest and at the subsequent test, approximately 15 months following the retest).

A total of 599 IR herds had no TB incident in the following 15 months (at IR retest or subsequent test). Twenty-two herds had an OTF-S incident at retest, four with an OTF-S incident at the subsequent test (post retest). There were 126 herds with an OTF-W incident at the retest and 112 herds OTF-W at the subsequent test (post retest).

IRs are tested either on their own or in a herd where reactors were identified, with the rest of the herd. It is important to identify IR-only herds that suffer from subsequent TB incidents, as the cattle in these herds may already have been infected at the IR-only test. Retests of IRs is usually around 60 days, with a subsequent test 12 months later (to allow for a 15 month follow-up period).

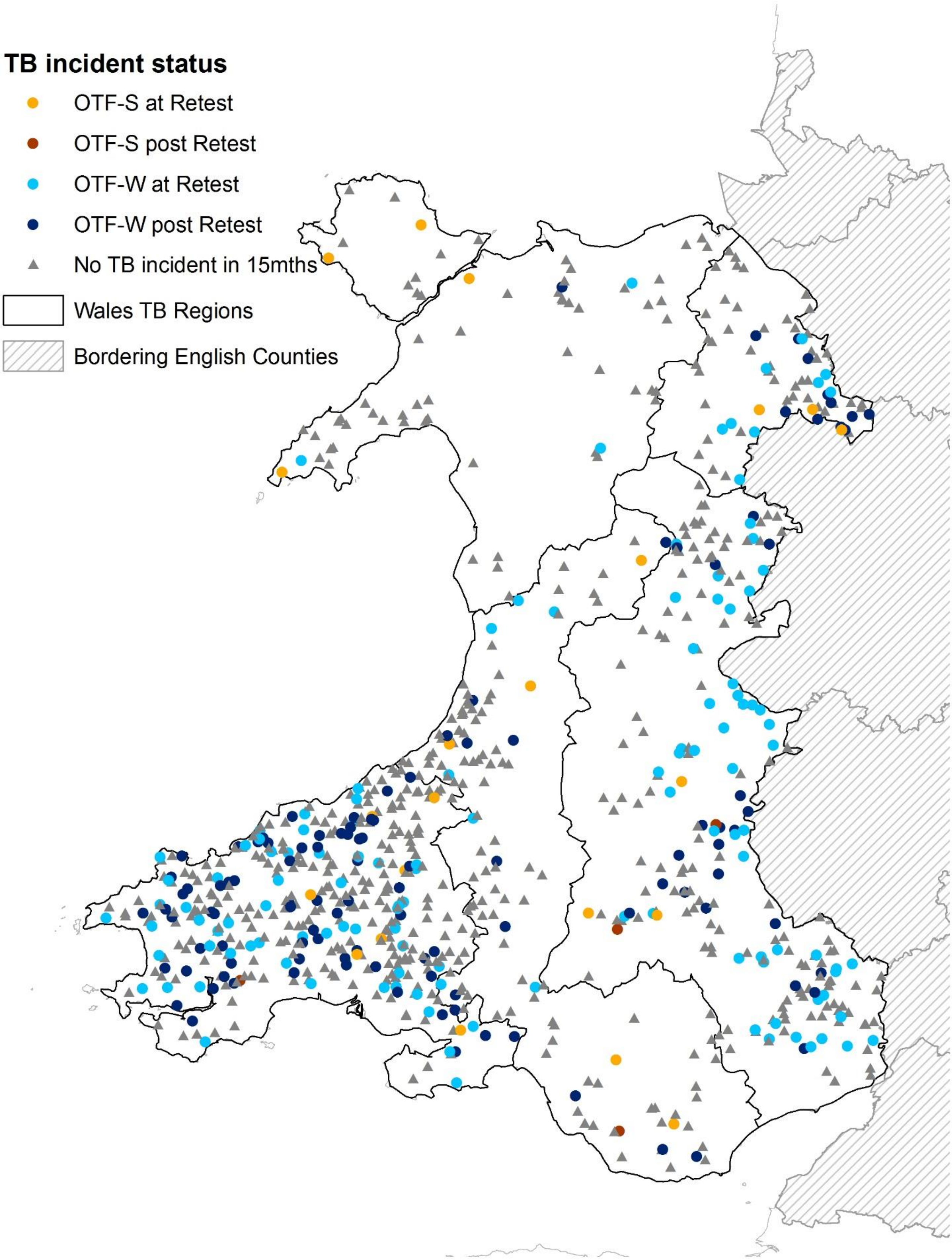


Figure 3.11.6: IR herds with no subsequent TB incident; a new OTF-W or OTF-S incident at the IR retest or at the test subsequent to a clear IR retest within fifteen months, 2019

3.12 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 3.12.1).

The cohort of animals that were followed were those with an inconclusive reaction at the initial test outside of an incident in 2018, and these animals were followed for 15 months after the initial test. Figure 3.12.1 is split into two sections. The initial IR sequence (above the grey line) follows animals through to testing clear or becoming a 2xIR, 3xIR[8], 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 (and was a standard IR on both occasions), it is removed for slaughter. If it becomes a 2xIR using the severe interpretation of the test (at least once), it has a second retest using the IFN-γ test. Passing that triggers another skin test and if the animal becomes a 3xIR, it is removed for slaughter as a reactor.

Of the 2,726 IR-only animals that had an inconclusive reaction to the skin test in 2018, 2,163 (79%) tested clear at the first retest, and over half (1,172; 54%) of these remained clear during the follow up period. A further 515 were routinely slaughtered and 513 screened negative in the slaughterhouse. Of the 1,172 animals that tested clear during the follow-up period, 35 (3%) tested clear again but the herd went on to become a reactor within three months of the test and 81 animals (7%) within 12 months (data not shown).

In this same period there were 148,654 clear tests at the initial IR test, of which 113,953 (77%) remained clear. The remaining 23% were made up of those animals not tested again (20%), IRs not slaughtered (2%), standard reactors (0.3%) and severe reactors, DCs and slaughtered IRs (0.4%). The remaining animals (less than 0.02%) were either missing a clear test from a negative slaughterhouse case (n=13), or were slaughterhouse cases (n=12).

Of the 2,163 IR-only animals which tested clear at the first retest, 161 (7%) became a reactor or an IR within the original incident, and a further 88 (4%) became a reactor or an IR at a test subsequent to the original incident. Two animals from this cohort went on to be slaughterhouse cases within the 15 months following their initial 1xIR result.

Of a total of 12 animals which were neither subjected to an IFN-γ test nor slaughtered despite a 2xIR result, 10 tested clear at their second retest. There were 120 animals cleared by IFN-γ 2xIR that also tested clear at their third retest. Seventeen of these animals went on to become reactors (both at severe interpretation) during the 15 month follow-up period and three became an IR again, all during the original incident. Eighteen animals which tested

[8] 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.

clear at the third retest tested clear again and none of these experienced a TB incident within 12 months.

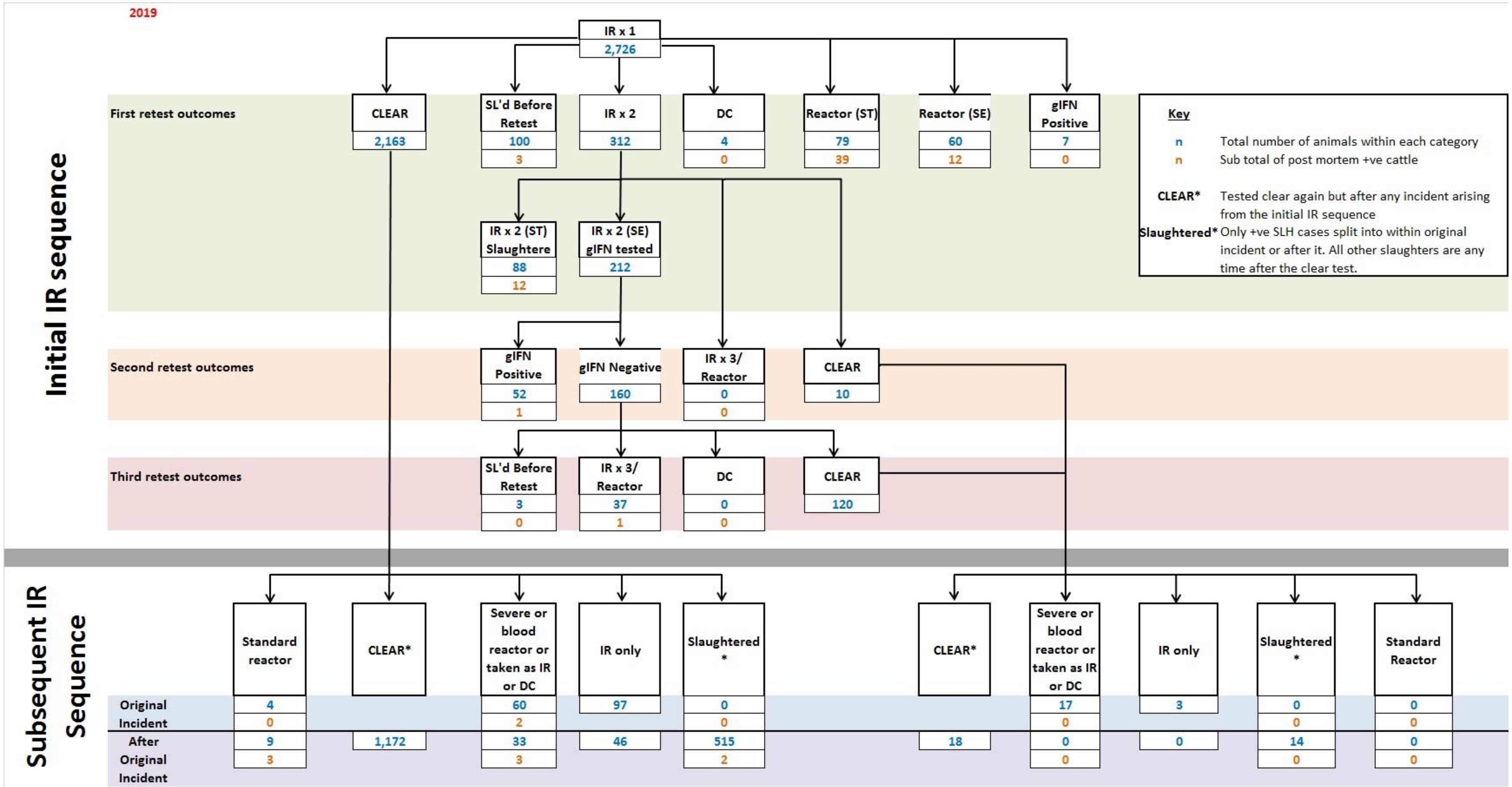


Figure 3.12.1: Flow diagram illustrating the fate of animals which had an inconclusive reaction to the SICCT test in 2019

4.0 Bovine tuberculosis prevalence in Wales

Key Points:

- A total of 477 TB incidents in Wales closed during 2019, having begun prior to 2019, with 81% located in the High East and West TB Areas.
- In 2019, there were 201 ongoing TB incidents, most (99%) of which were OTF-W and over half were located in the High West TB Area (63%).
- Six per cent of Welsh herds incurred a new TB incident in 2019 and 5.5% of herds were under movement restrictions in mid-December 2019.
- Since the implementation of annual testing in 2013, the percentage of herds under restriction has remained relatively stable at around 5 to 5.5%.
- The median duration of OTF-W incidents has remained relatively stable over the past ten years, averaging 240 days.
- 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.
- There were a total of 135 persistent (duration over 18 months) open TB incidents in 2019, with 67% located in the High West TB Area.
- A total of 39 TB incidents that closed in 2019 were classed as persistent, all of which were OTF-W. The majority (87%) were located in the High West and East TB Areas (24 and 10, respectively), followed by The Intermediate Mid and North TB Areas (three and two, respectively) with none located in the Low TB Area.

4.1 Summary of closed and ongoing incidents in Wales

A total of 477 TB incidents in Wales closed during 2019, having begun prior to 2019. Similarly to all new TB incidents disclosed in 2019, most (81%) were located in the High West and East TB Areas (Table 4.1.1).

There were a total of 201 ongoing TB incidents (started prior to 2019) in Wales, 199 (99%) of which were OTF-W incidents (Table 4.1.1). The number of ongoing incidents has nearly doubled in the past five years (Figure S2 in Summary). The majority of ongoing TB incidents were located in the High West TB Area (127, 63%), with a further 23% (47) in the High East TB Area. There were very few ongoing TB incidents in the remainder of Wales.

Table 4.1.1: The number of closed and ongoing TB incidents by TB Area in Wales, 2019

TB Area		Total incidents	OTF-W	OTF-S
High East	Closed[1] incidents in 2019	161	156	5
	Ongoing[2] incidents in 2019	47	47	0
High West	Closed[1] incidents in 2019	225	214	11
	Ongoing[2] incidents in 2019	127	126	1
Intermediate Mid	Closed[1] incidents in 2019	38	37	1
	Ongoing[2] incidents in 2019	6	5	1
Intermediate North	Closed[1] incidents in 2019	35	32	3
	Ongoing[2] incidents in 2019	19	19	0
Low	Closed[1] incidents in 2019	18	17	1
	Ongoing[2] incidents in 2019	2	2	0
Wales overall	Closed[1] incidents in 2019	477	456	21
	Ongoing[2] incidents in 2019	201	199	2

[1] Closed incidents begun prior to 2019 but ended during 2019
[2] Ongoing incidents began prior to 2019 and were still ongoing at the end of 2019

4.2 Bovine tuberculosis prevalence

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. Chapter 3 described incidence in Welsh herds in 2019 and over time. This chapter focuses on prevalence of TB (considering the percentage of cattle herds under TB restriction for TB at certain point in time or over a period). It also reports how long any restrictions to herds are in place (duration of TB). Prevalence of TB relates to the number of infected cattle in a population at a particular time and can vary across Welsh TB Areas and over time. Spatial and temporal patterns of TB prevalence may vary according to the dynamics of the disease, considering environmental conditions and demographics of the cattle population.

The method used to determine prevalence of TB in Welsh cattle herds is described in detail in Appendix 1. For the purposes of this report, prevalence of TB is calculated as the proportion of herds that are under movement restrictions on a given date due to a TB incident (mid-December), per 100 live (or active) herds (excluding herds restricted due to an overdue test).

Six per cent of Welsh herds incurred a TB incident in 2019 and 5.5% of herds were under movement restrictions in mid-December 2019 (excluding herds under restriction due to an overdue test). As expected, prevalence varied by TB Area, and with over half of TB incidents in 2019 located in the High West TB Area, prevalence was highest here too (11%, Table 4.2.1a and b).

Table 4.2.1a: Herds under restriction (mid-December), 2019

TB Area	Total incidents	OTF-W	OTF-S
High East	176	169	7
High West	350	341	9
Intermediate Mid	52	44	8
Intermediate North	52	50	2
Low	17	15	2

Table 4.2.1b: Prevalence of TB in Wales, 2019

TB Area	Total incidents per 100 live herds	OTF-W incidents per 100 live herds	OTF-S incidents per 100 live herds	Total number of herds[2]
High East	6.3	6.0	0.2	2,813
High West	11.0	10.7	0.3	3,188
Intermediate Mid	2.5	2.2	0.4	2,041
Intermediate North	5.6	5.4	0.2	922
Low	0.6	0.5	0.1	2,828

[2] This is the number of 'live' herds in mid-December 2019 so differs from the herd number given in Chapter 1.

4.3 Temporal trends in TB prevalence in Wales

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%) and at January 2019 (5.9%) (Figure 4.3.1). 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 (or frequency) by which herds were tested in relation to TB risk before annual testing was introduced (where herds from low incidence areas were tested on a less frequent basis).

Following a peak in July 2012, the percentage of herds under restriction declined to around 5%, and has since remained relatively stable where annual testing has been in place since 2013.

Since 2010, the number of active (or live) herds has decreased from around 13,000 to 11,500 in 2016. The number of herds has since fluctuated between 11,500 and 12,000, due to the creation of additional CPHs in 2018. During the same period of time, the number of TB incidents increased up to 2012, followed by a sharp decrease through 2013 and 2014. Since then, the number of herds under movement restrictions has remained relatively stable, fluctuating between 600 and 700 each year.

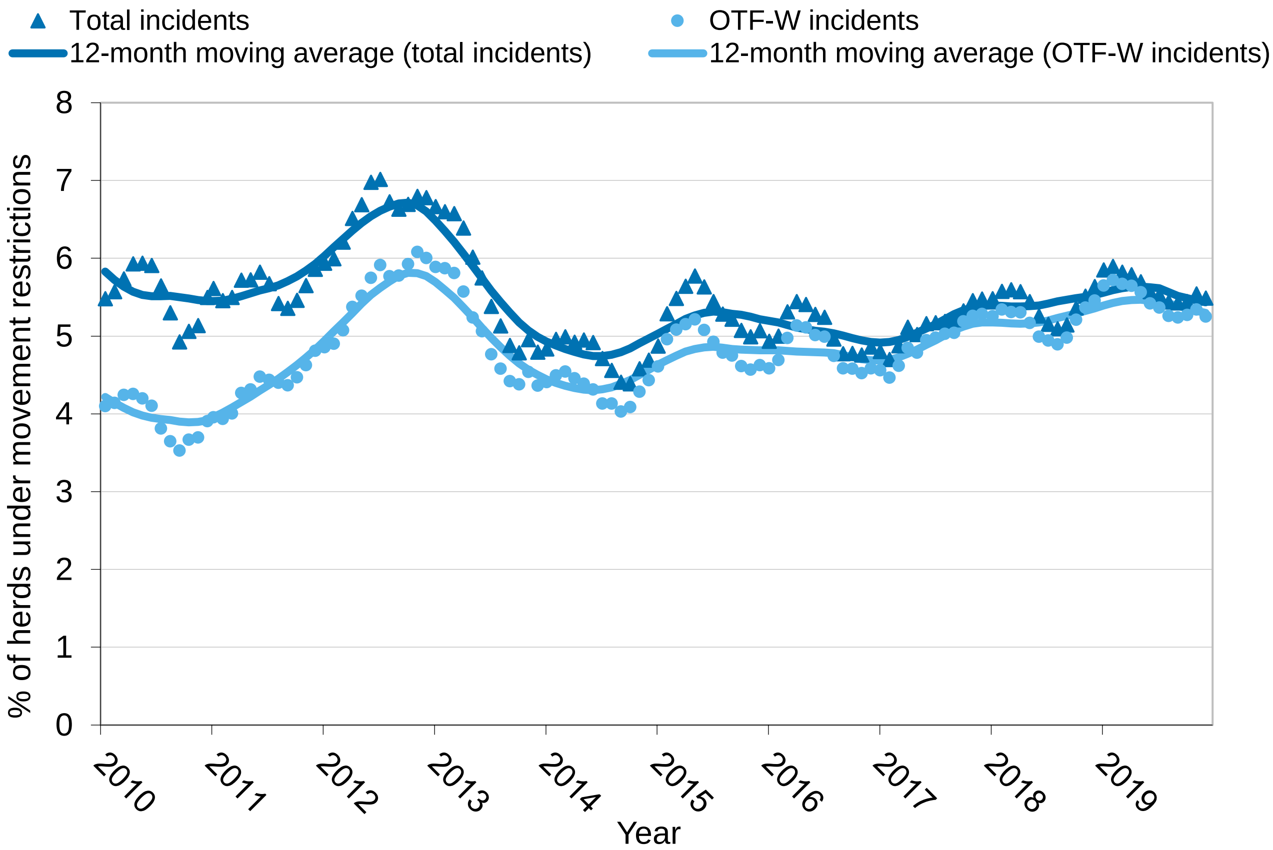


Figure 4.3.1: Percentage of herds that were under movement restrictions between January 2010 and December 2019 (12-month moving average)

Figure 4.3.2 shows the temporal trend of TB prevalence over the last ten years which along with incidence measures (as described in Chapter 3, Incidence of TB), is used to assess the scale of the TB epidemic in Wales. This shows similar data to Figure 4.3.1, but is the point prevalence for each year (rather than a 12-month moving average), and splits the data by total TB, OTF-W and OTF-S incidents.

Since a peak in 2012 followed by a sharp decrease in 2013, the prevalence of total TB and OTF-W incidents remained relatively stable at around 4.5 to 5.5 herds restricted per 100 live herds.

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 are subject to mandatory herd IFN-γ 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, probably as an artefact of OTF-S incidents being reclassified as OTF-W.

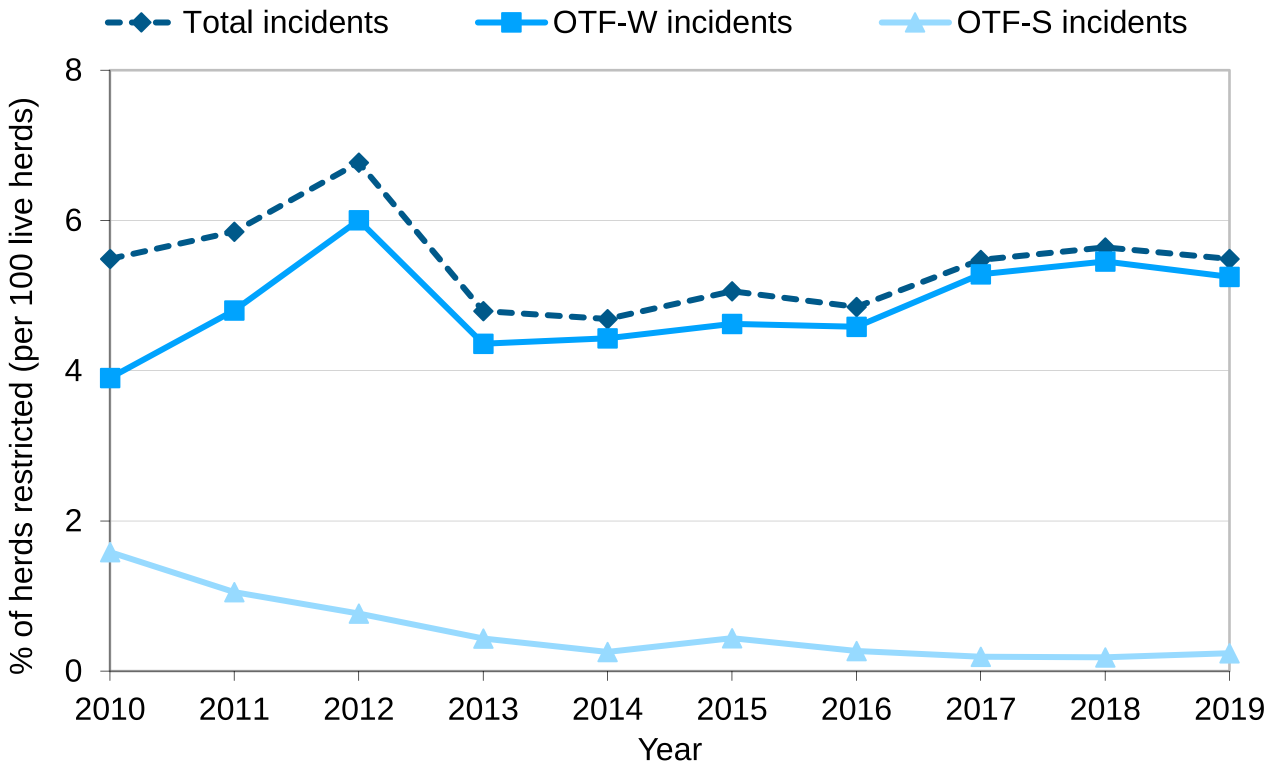


Figure 4.3.2: Point prevalence of herds under movement restrictions in each TB Area of Wales, December of each year (2010-2019)

4.4 Prevalence of TB across Wales

When comparing the prevalence of TB by risk area in Wales, the percentage of herds under movement restrictions (per 100 live herds) is greater in the High East and West TB Areas compared to Wales overall (Figure 4.4.1). Generally prevalence in other TB Areas of Wales is lower than the country average, but in the Intermediate North, prevalence has increased since 2016.

Prevalence of TB remains highest in the High West TB Area, at around 11% for 2019. Since the end of 2017, prevalence in the High East TB Area has decreased to around 6% which is only just higher than for Wales overall and the Intermediate North TB Area. Prevalence in the Intermediate North TB Area increased sharply in 2016 and 2017, but has since remained relatively stable through 2018 and 2019. For seven years, prevalence in the Intermediate

Mid TB Area has been around 2% and for more than ten years has been less than 1% in the Low TB Area.

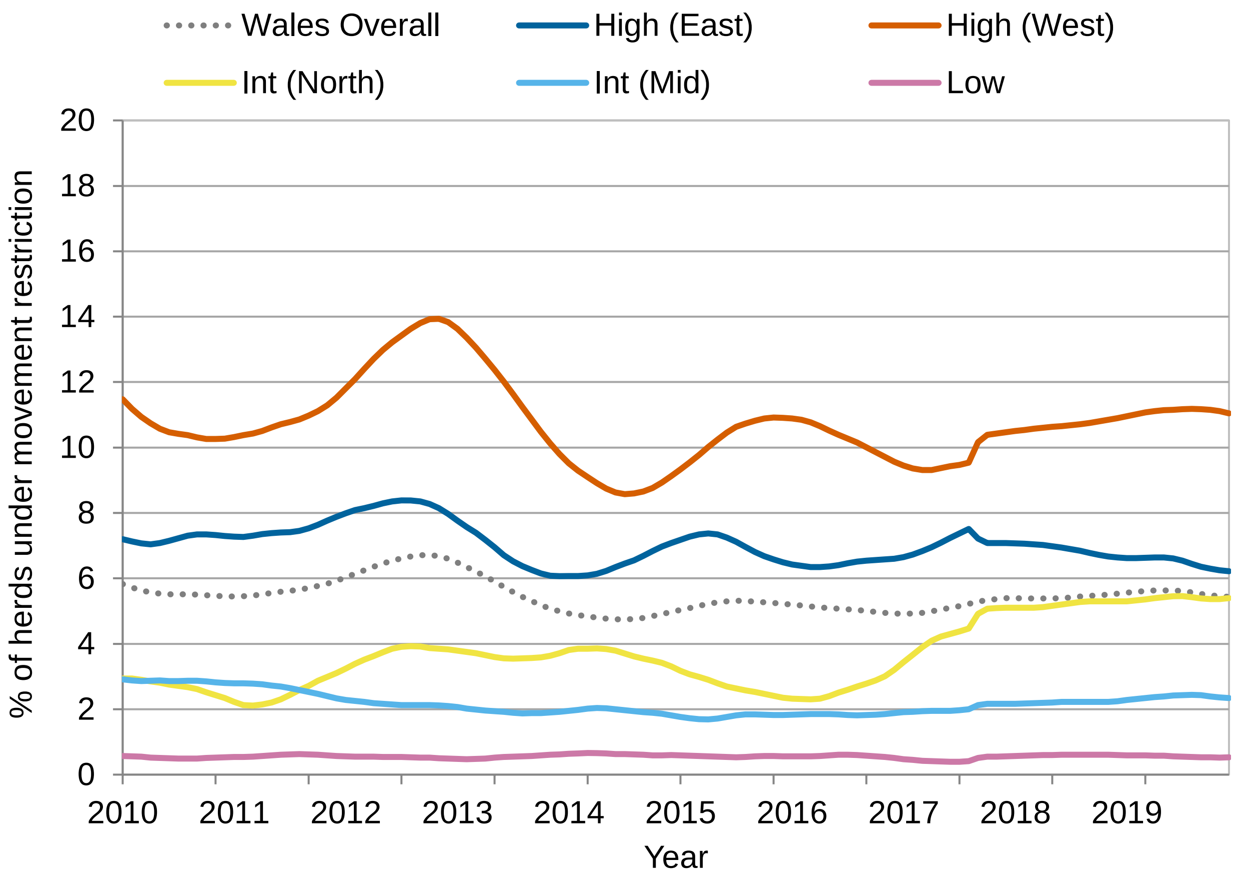


Figure 4.4.1: Trends in herds under movement restrictions, January 2010 – December 2019, by TB Area. The grey dotted line represents the overall trend in Wales[1]

[1] Quarterly (annualised), smoothed 12-month moving average

4.5 Bovine TB incident duration and the annual trend in median duration

The management of cattle herds is affected by the extent and duration of movement restrictions imposed as a consequence of a TB incident. Herds under restriction for longer periods, 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 (discussed in Chapter 3). Restrictions are maintained until there is sufficient evidence from negative tests to believe that infection has been removed from the herd. Factors that could increase the duration of movement restrictions 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).

The duration of incidents closing in 2019 varies according to TB Area (Table 4.5.1). 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 duration of movement restrictions of OTF-S incidents in all TB Areas was significantly shorter than those of OTF-W incidents ($P<0.001$, $p<0.01$ for Low TB Area), where 70 to 100% of OTF-S incidents closed within 150 days, compared to 0% to 12% OTF-W incidents, depending on TB Area.

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 a second clear test (with a minimum of 60 days from the first clear test) before movement restrictions can be lifted. Higher-sensitivity severe interpretation of the skin test is also used in OTF-W incidents and they are also likely to take longer to clear.

Table 4.5.1: Duration of movement restrictions for TB incidents that closed in 2019 (and number of persistent incidents open in 2019)

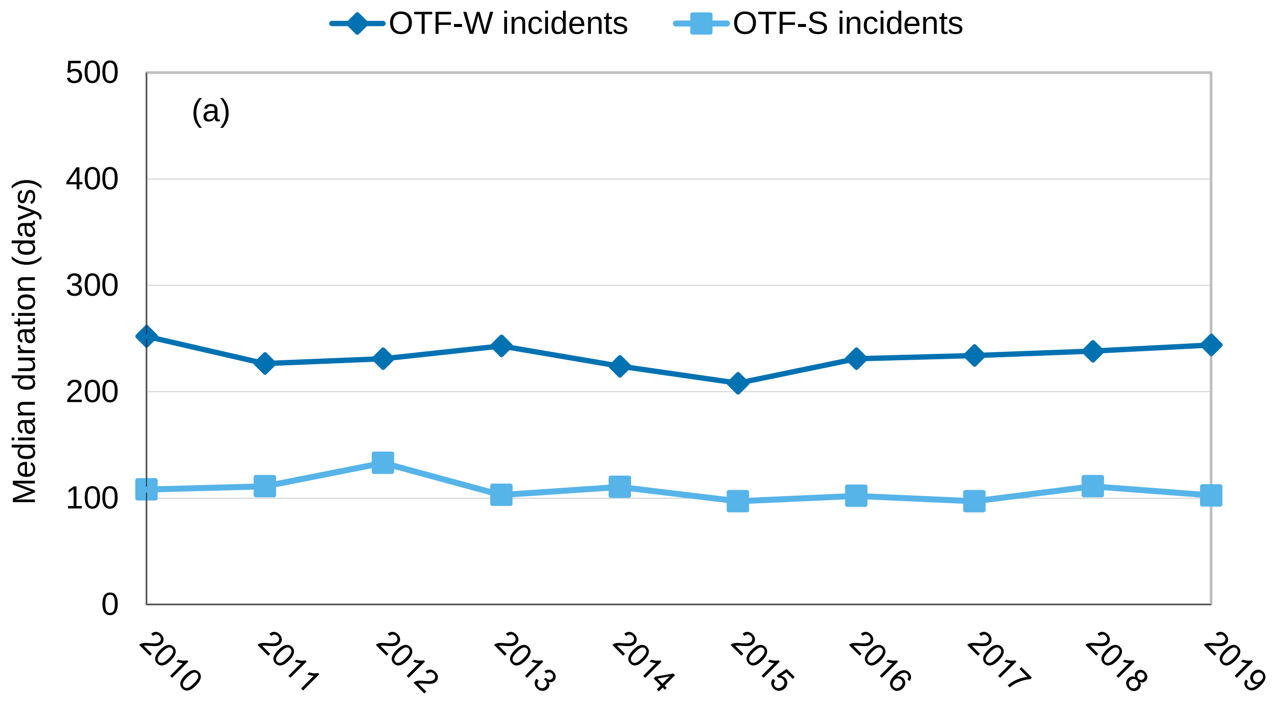
TB Area		Total (% of total)	OTF-W (% of total)	OTF-S (% of total)
High East	Total number of incidents closed	239	227	12
	Up to 100 days	8 (3.3)	0	8 (66.7)
	101 - 150 days	16 (6.7)	14 (6.2)	2 (16.7)
	151 - 240 days	125 (52.3)	123 (54.2)	2 (16.7)
	241 - 550 days	80 (33.5)	80 (35.2)	0
	551 plus days	10 (4.2)	10 (4.4)	0
	Mean incident duration (days)	271.0	279.6	107.8
	Median incident duration (days)	207	211	93
	Duration range (days)	78 – 5,023	136 – 5,023	78 - 210
	Persistent incidents open	29	29	0
High West	Total number of incidents closed	314	295	19
	Up to 100 days	7 (2.2)	()	7 (36.8)
	101 - 150 days	9 (2.9)	3 (1.0)	6 (31.6)
	151 - 240 days	120 (38.2)	116 (39.3)	4 (21.1)
	241 - 550 days	154 (49.0)	152 (51.5)	2 (10.5)
	551 plus days	24 (7.6)	24 (8.1)	0
	Mean incident duration (days)	314.8	325.3	151.0
	Median incident duration (days)	262.5	271	118
	Duration range (days)	89 – 1,566	109 – 1,566	89 - 505
	Persistent incidents open	91	90	1
Intermediate North	Total number of incidents closed	46	37	9
	Up to 100 days	3 (6.5)	0	3 (33.3)
	101 - 150 days	5 (10.9)	0	5 (55.6)
	151 - 240 days	11 (23.9)	10 (27.0)	1 (11.1)
	241 - 550 days	25 (54.3)	25 (67.6)	0
	551 plus days	2 (4.3)	2 (5.4)	0
	Mean incident duration (days)	292.1	334.3	118.3
	Median incident duration (days)	254	270	103
	Duration range (days)	93 - 840	161 - 840	93 - 189
	Persistent incidents open	10	10	0
Intermediate Mid	Total number of incidents closed	67	57	10
	Up to 100 days	4 (6.0)	0	4 (40.0)
	101 - 150 days	13 (19.4)	7 (12.3)	6 (60.0)
	151 - 240 days	27 (40.3)	27 (47.4)	0
	241 - 550 days	20 (29.9)	20 (35.1)	0
	551 plus days	3 (4.5)	3 (5.3)	0
	Mean incident duration (days)	232.9	255.7	103.1
	Median incident duration (days)	188	203	102

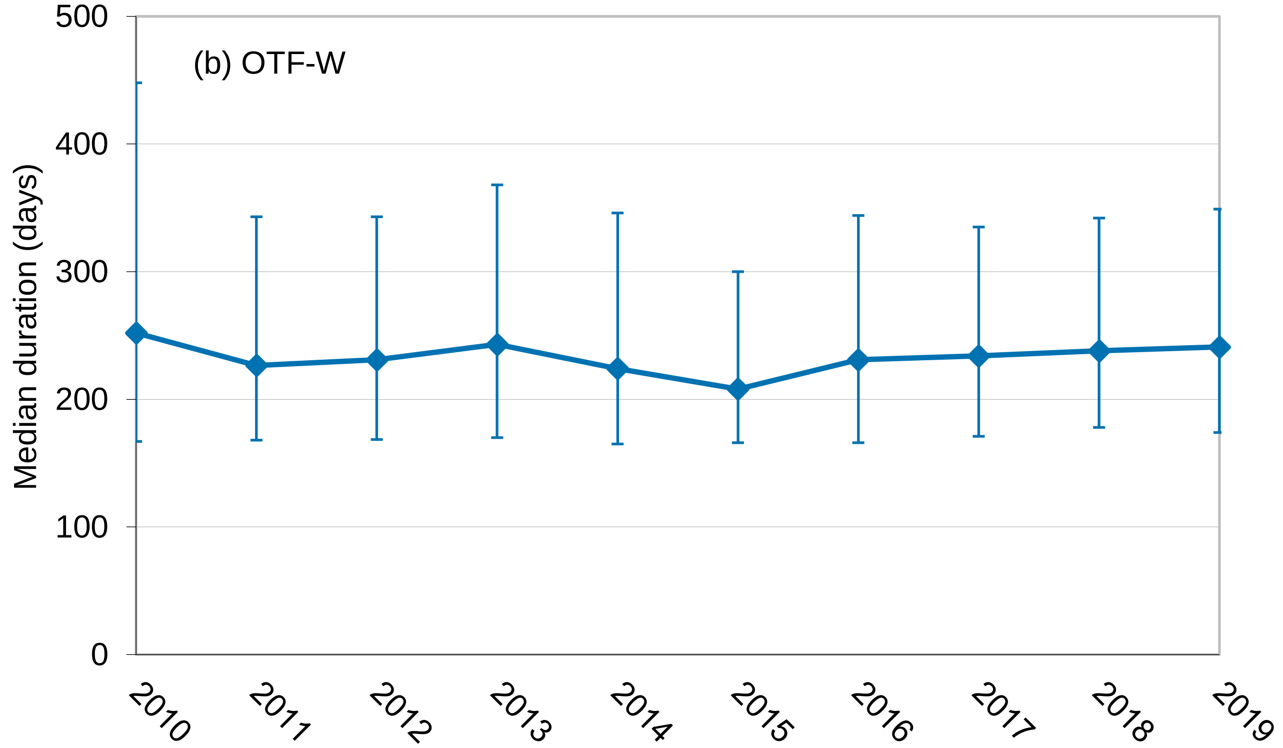
TB Area		Total (% of total)	OTF-W (% of total)	OTF-S (% of total)
	Duration range (days)	81 - 652	130 - 652	81 - 130
	Persistent incidents open	3	3	0
Low	Total number of incidents closed	24	20	4
	Up to 100 days	2 (8.3)	0	2 (50.0)
	101 - 150 days	1 (4.2)	0	1 (25.0)
	151 - 240 days	8 (33.3)	7 (35.0)	1 (25.0)
	241 - 550 days	13 (54.2)	13 (65.0)	0
	551 plus days	0	0	0
	Mean incident duration (days)	248.5	272.0	131.5
	Median incident duration (days)	245.5	259.5	103.5
	Duration range (days)	88 - 464	151 - 464	88 – 231
	Persistent incidents open	2	2	0

The median duration of OTF-W incidents has remained relatively stable over the past ten years at around 240 days, with a decrease of 3.2% in the duration of OTF-W incidents in 2019 compared to 2010 (Figure 4.5.1a). However, there was a 2.5% increase in 2019 compared to 2018.

From January 2011, some TB 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 duration. These incidents were still shorter than the existing OTF-W cases, further reducing the OTF-W mean duration.

Figures 4.5.1b and c show the median duration for OTF-W and OTF-S incidents, respectively, with the 25th and 75th percentiles illustrated as error bars showing the wider variation in the duration of OTF-W incidents.


OTF-W incidents
OTF-S incidents
(a)
Median duration (days)
0
100
200
300
400
500
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019


(b) OTF-W
Median duration (days)
0
100
200
300
400
500
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

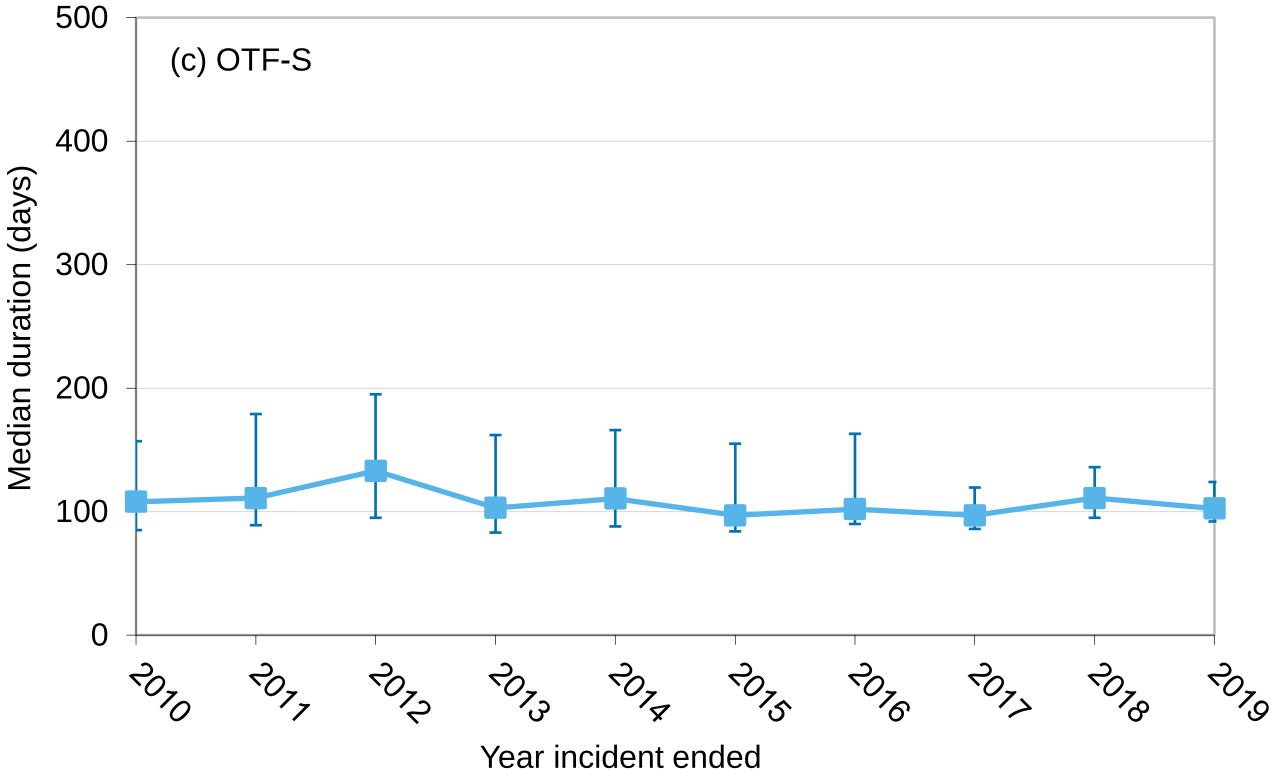


Figure 4.5.1: Median duration of OTF-W and OTF-S incidents ending between 2010 and 2019 (a), with interquartile ranges for OTF-W (b) and OTF-S (c) incidents presented separately

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

Table 4.6.1 shows the duration of movement restrictions of incidents ending in 2019 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 zero, 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). This effect remained for herds with between 11 and 200 animals after adjusting for herd type and location. This is not surprising since increasing herd size is likely to increase density-dependent transmission of infection and could also increase the likelihood of false negatives in the herd. Duration of movement restrictions in herds with 201-300 cattle was not significantly different to herds with over 300 animals (the median was 242 days compared to 315 days in herds with over 300 cattle). Although the multivariate 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, the duration of movement restrictions following a TB incident was 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 West TB 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 High East and Intermediate Mid TB Areas observed a significantly shorter duration of movement restrictions compared to the reference category, the High West TB Area.

Table 4.6.1: Linear regression analysis of factors associated with incident duration (log-transformed), 2019

	Total closed incidents	Mean duration (days)	Median duration (days)	Unadjusted[1] coefficient[3]	95% CI	95% CI	Adjusted[2] coefficient[3]	95% CI	95% CI
OTF status									
OTF-W	637	302	244	*Ref*			*Ref*		
OTF-S	54	126	102.5	-0.82***	-0.95	-0.69	-0.74***	-0.86	-0.61
Herd size									
0 – 10	20	245	220	-0.40***	-0.63	-0.18	-0.10ns	-0.32	0.11
11 – 50	133	217	186	-0.50***	-0.62	-0.39	-0.29***	-0.41	-0.17
51 – 100	142	235	199.5	-0.41***	-0.53	-0.3	-0.23***	-0.35	-0.11
101 – 200	155	307	252	-0.25***	-0.36	-0.14	-0.11*	-0.22	-0.01
201 – 300	99	330	242	-0.17**	-0.3	-0.05	-0.10ns	-0.21	0.02
> 300	142	363	315	*Ref*			*Ref*		
Herd type									
Beef	401	250	196	*Ref*			*Ref*		
Dairy	289	340	290	0.32***	0.25	0.39	0.13**	0.05	0.22
Other/mixed	1	432	432	0.70ns	-0.26	1.66	-0.09ns	-0.25	1.46
TB Area									
High West	315	315	263	*Ref*			*Ref*		
High East	239	271	207	-0.19***	-0.27	-0.1	-0.03*	-0.17	-0.02
Intermediate Mid	67	233	188	-0.28***	-0.42	-0.15	-0.15**	-0.27	-0.04
Intermediate North	46	292	254	-0.07ns	-0.23	0.08	-0.01ns	-0.09	0.18
Low	24	249	245.5	-0.11ns	-0.38	0.04	-0.18ns	-0.24	0.12

*, **, *** 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

Where herds are under movement restrictions for over 550 days (about 18 months), the TB incident is considered to be 'persistent'. Persistent TB incidents could be caused by factors including:

- Limitations of tests in finding all infected animals, particularly in large herds, due to presence of animals that fail to react to the test, with continued within-herd transmission.
- Purchased animals
- Transmission from wildlife or contiguous herds.

Persistent TB incidents are costly to government and industry and also pose a risk to surrounding herds, therefore these are targeted with enhanced measures to clear infection as quickly as possible (https://gov.wales/sites/default/files/publications/2017-11/wales-bovine-tb-eradication-programme.pdf).

Herds under restrictions for long periods of time may occur due to a number of factors which affect the ability to clear a herd of infection, as discussed at the start of this section. 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 4.6.1).

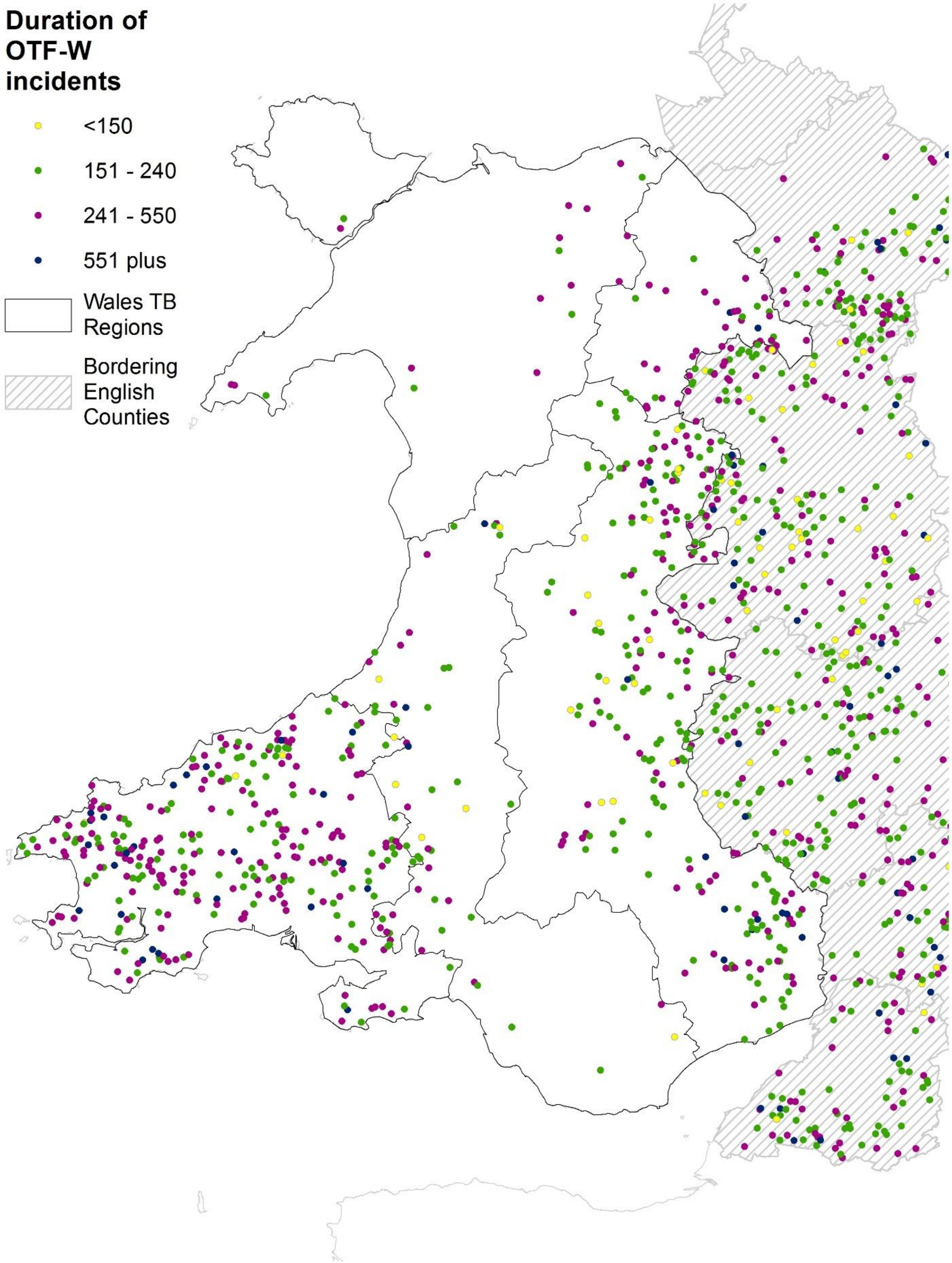


Figure 4.6.1 Number of OTF-W incidents by duration category (days), that closed in 2019

A total of 39 OTF-W incidents were classed as persistent, which had closed in 2019. Figure 4.6.2 which shows the geographical location of persistent TB 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 the Intermediate TB Areas (two in the Intermediate North and three in the Intermediate Mid TB Area, lasting more than 550 days). There were a total of 54 OTF-S incidents that closed in 2019, with only two herds in the High West TB Area that had been under restrictions for longer than 240 days (Table 4.5.1). In 2019, there were no OTF-S incidents in Wales that were considered persistent.

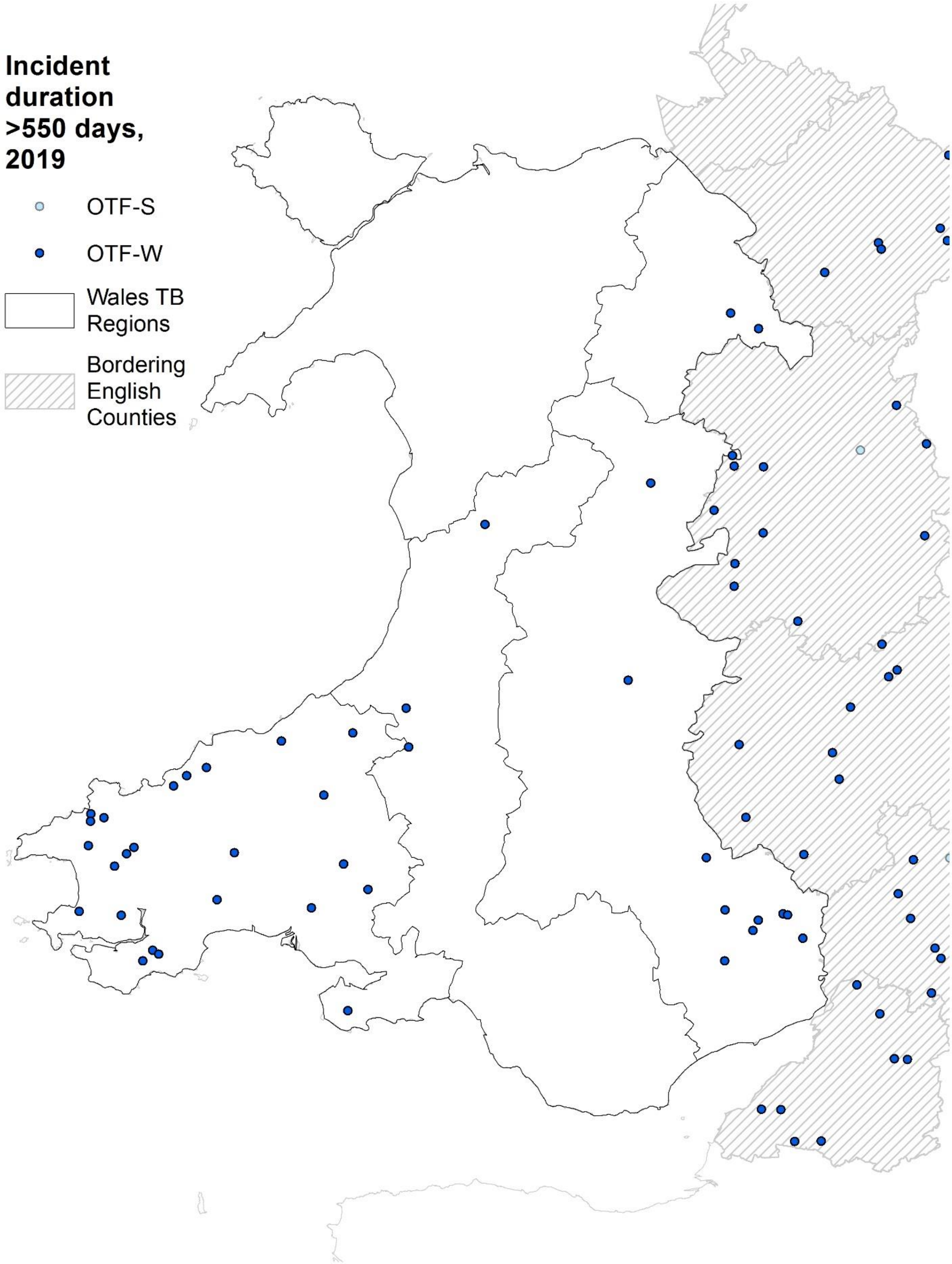


Figure 4.6.2: Persistent TB incidents of over 550 days duration, closing in 2019, by OTF status

5.0 Post mortem examination, culture and genotyping of suspected TB cases

Key Points:

• There was a 9% increase in the number of cattle slaughtered for TB control in 2019 compared with 2018, following a general increasing trend over the past five years. The recent increase in reactors is primarily attributable to increases in IFN-γ testing, which is more sensitive than the SICCT test (90%[9] sensitivity compared to 81%[10] (sensitivity of SICCT tests varying between 50-90% depending on conditions under which it is carried out[11]), respectively).

• In the High West, Intermediate North and Low TB Areas, the percentage of cattle with lesions that were *M. bovis* positive was higher for reactors than for direct contacts and inconclusive reactors; whereas in the High East and Intermediate Mid TB Areas the percentage of cattle with lesions that were *M. bovis* positive was highest for direct contacts.

• In Wales overall, 29% of reactors (at standard interpretation) were confirmed infected by either observation of detectable lesions (DL) or culture of *M. bovis* in 2019. This was higher in the High East TB Area (46%) and lower in all other TB Areas (High West; 24%, Intermediate North; 25%, Intermediate Mid; 26% and Low TB Area; 28%).

• The percentage of samples with detectable lesions (DLs) that were *M. bovis* positive varied by TB Area and was highest in the High TB East Area (96%) and lowest in the Low TB Area (67%).

• Of the 12,599 cattle slaughtered in 2019 for TB control, 68% were reactors to either the skin test, IFN-γ or antibody test, 25% were IRs and 7% were DCs.

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[9] de la Rua-Domenech, R, Goodchild, AV, et al. (2006) Ante mortem diagnosis of tuberculosis in cattle: A review of the tuberculin tests, interferon assay and other ancillary diagnostic techniques. Research in veterinary science (81): 190-210. 0.1016/j.rvsc.2005.11.005

[10] Karolemeas K, de la Rua-Domenech R, Cooper R, Goodchild AV, Clifton-Hadley RS, et al. (2012) Estimation of the Relative Sensitivity of the Comparative Tuberculin Skin Test in Tuberculous Cattle Herds Subjected to Depopulation. PLOS ONE 7(8): e43217. https://doi.org/10.1371/journal.pone.0043217

[11] Javier Nuñez-Garcia, Sara H. Downs, et al. (2018) Meta-analyses of the sensitivity and specificity of ante-mortem and post-mortem diagnostic tests for bovine tuberculosis in the UK and Ireland. Preventive Veterinary Medicine (153) 94-107, https://doi.org/10.1016/j.prevetmed.2017.02.017

• Of the 2,115 samples from animals with no detectable lesions (NDLs) and for which culture results were available, 1.3% were *M. bovis* positive overall. The percentage positive was highest in the High East and Low TB Areas (2.3 and 3.4% respectively).

• There were 377 isolates from cattle for incidents in Wales that started in 2019 and all were genotyped.

• The most common genotype in Wales (spoligotype 9) has two main clusters: one in the south-west corner of Wales and the other mainly located in Mid Powys (Figure 5.6.1).

• Forty three non-bovine isolates were genotyped in 2019.

5.1 Number of suspected TB cases that were slaughtered[12]

The single intradermal comparative cervical tuberculin (SICCT) 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 (IRs) or direct contacts (DCs)) are illustrated in this chapter, which reports on the total number of TB suspect cattle slaughtered per year, regardless of when the incident started.

There were 12,599 cattle slaughtered in 2019 for TB control. This is a 9% increase in the number of cattle slaughtered compared with 2018, following a general increasing trend over the past five years. Of the cattle slaughtered in 2019, 68.2% (8,588) were reactors to either the skin test or IFN-γ. This total also includes 272 antibody tests. Twenty five per cent of cattle slaughtered were IRs (3,130) and 7% (881) were DCs (Figure 5.1.1). In addition, there were 58 slaughterhouse cases where retrospective evidence of TB was identified in cattle from OTF herds (see Chapter 3). This distribution differs from England[13] where 94% of compulsorily slaughtered animals were reactors, 4% were IRs and 2% were DCs. The higher percentage of IRs in Wales could be in part due to all IRs in chronic herd incidents being slaughtered (as part of the ongoing Action Plan process).

Overall in 2019, lesions were detected in 9%[14] (1,156) of slaughtered animals, although this percentage varied depending on the method of disclosure: reactors (12%), IRs (2%) or DCs

[12] 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.

[13] https://www.gov.uk/government/publications/bovine-tb-epidemiology-and-surveillance-in-great-britain-2019

[14] Samples are not sent for culture from the majority of reactors, IRs, and DCs, irrespective of whether they have detected lesions or not (Figure 5.1.1). 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

(4%) (Figure 5.1.1). This also varied according to whether the skin testing was standard (29%) or severe interpretation (6%), or if reactors were identified via IFN-γ testing (3%). There is also wider variation when comparing different TB Areas, with the highest percentage of standard and IFN-γ reactors with DLs in the High East TB Area (46% and 5% respectively), and the highest percentage of severe interpretation reactors with DLs in the Low TB Area (15%; Table 5.1.2).

A lower percentage of IFN-γ positive animals with DLs was anticipated, due to the greater sensitivity of the IFN-γ test. The increased sensitivity of the IFN-γ test (90%[15]) allows for the detection of disease at an earlier stage of infection before pathology (i.e. lesions) has developed. The IFN-γ test has a lower specificity compared to the SICCT (96.6% and 99.98%, respectively[16]) which means that the test is more likely to generate false positive results.

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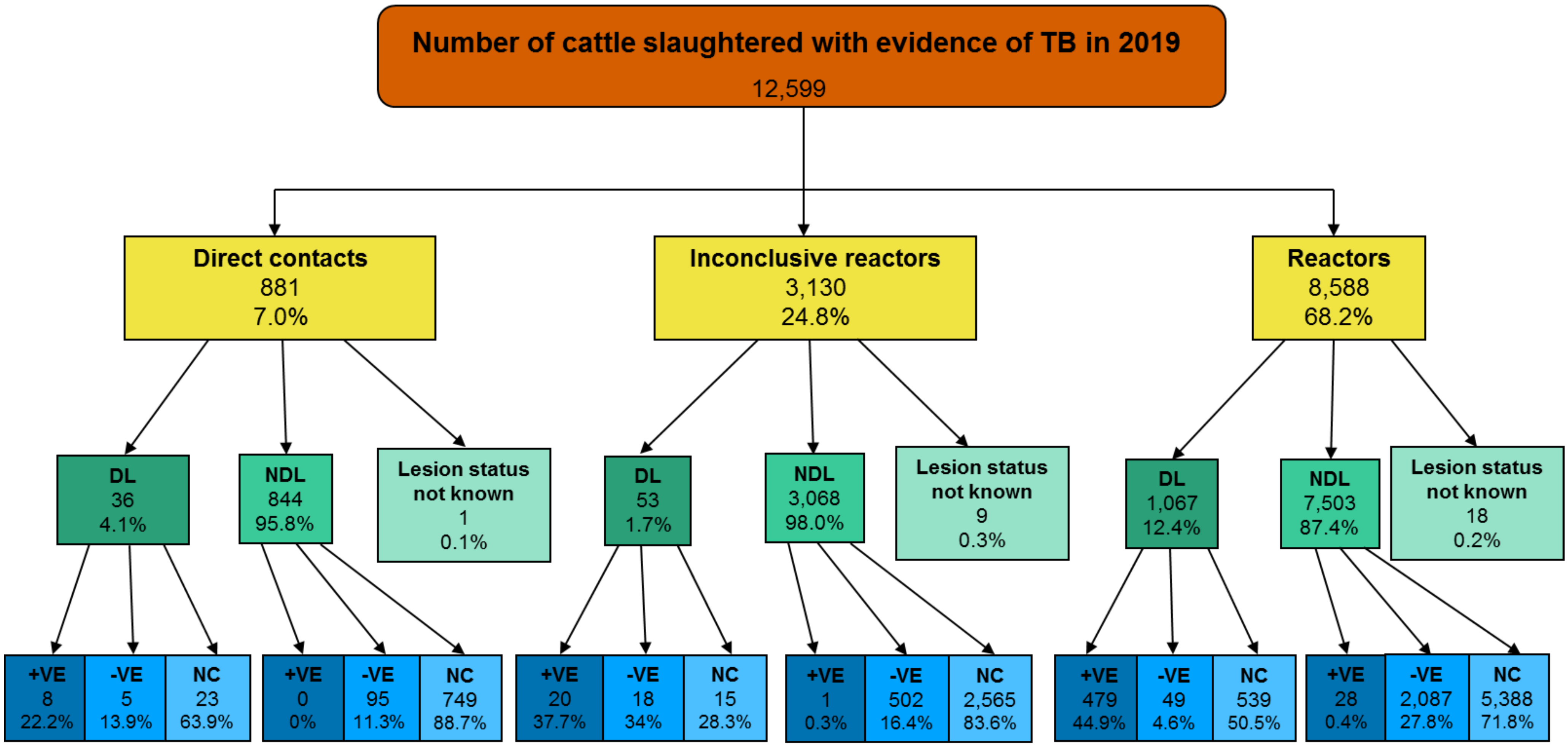
without detected lesions are found to be positive via culture test, we would not expect the true proportion to differ by much.

[15] Karolemeas K, de la Rua-Domenech R, Cooper R, Goodchild AV, Clifton-Hadley RS, et al. (2012) Estimation of the Relative Sensitivity of the Comparative Tuberculin Skin Test in Tuberculous Cattle Herds Subjected to Depopulation. PLOS ONE 7(8): e43217. https://doi.org/10.1371/journal.pone.0043217
[16] Goodchild AV, Downs SH, Upton P, Wood JL, de la Rua-Domenech R. Specificity of the comparative skin test for bovine tuberculosis in Great Britain. *Vet Rec*. 2015;177(10):258. doi:10.1136/vr.102961



KEY: DL = detected lesions; NDL = no detected lesions; +VE = *M. bovis* positive; -VE = *M. bovis* negative; NC = not cultured

Figure 5.1.1: Testing pathways of animals slaughtered for TB control in Wales, 2019

Trends in the number of cattle slaughtered for different TB control reasons are shown in Figure 5.1.2a 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 5.1.2b.

The number of reactors and IRs slaughtered annually, has increased over the past ten years, with over 8,500 animals slaughtered as reactors, and around 3,000 IRs in the current reporting year.

The recent increase in reactors is primarily attributable to increases in IFN-γ testing, which is more sensitive than the skin test. IFN-γ 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. This has since decreased, with 881 in 2019. Since 2017, there has been a large increase in the number of IRs slaughtered (1,731, 2,754 and 3,130 for 2017-2019, respectively). These changes primarily reflect 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. Therefore, these animals were recorded as DCs.

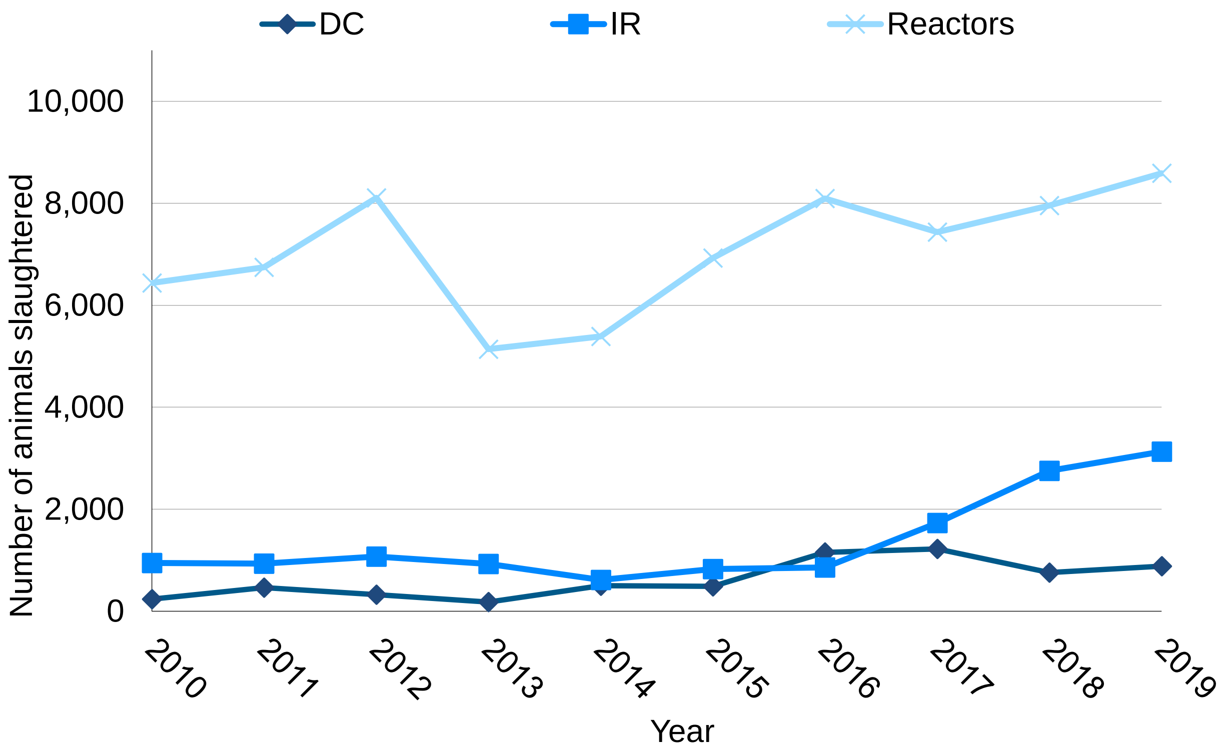


Figure 5.1.2a: Reactors, inconclusive reactors and direct contacts slaughtered for suspected TB, 2010 – 2019

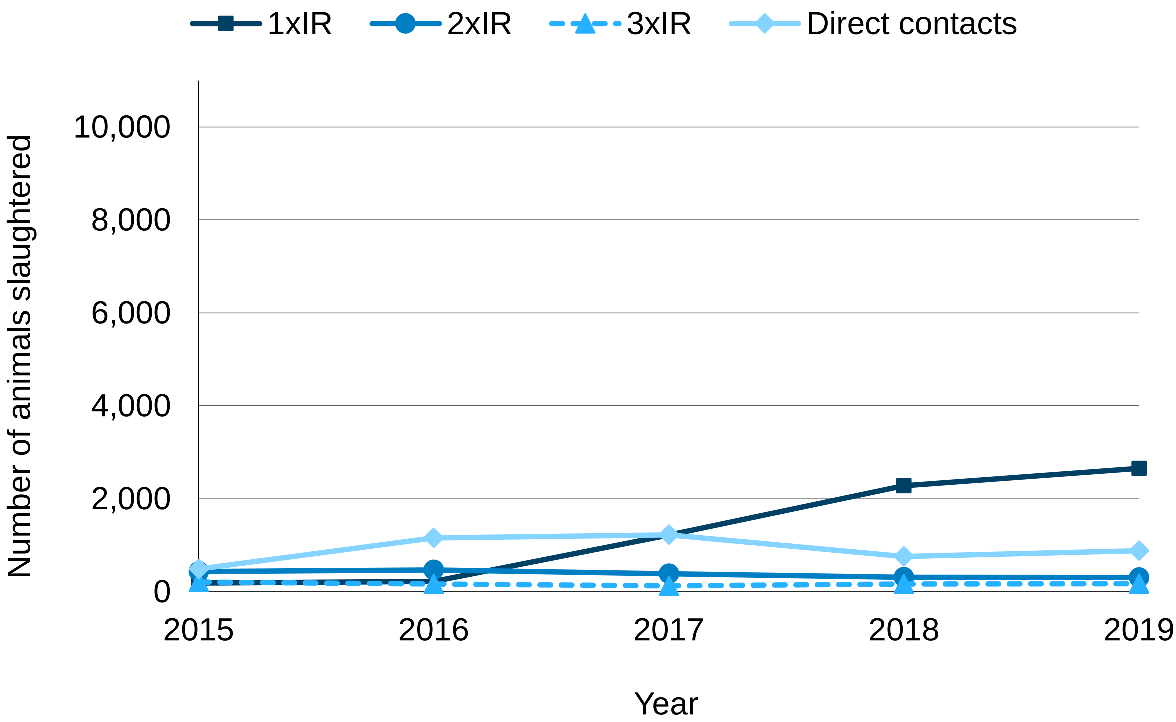


Figure 5.1.2b: Inconclusive reactors[17] and direct contacts slaughtered, 2015 – 2019

5.2 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 2019, split by TB Area, are shown in Tables 5.2.1 a-e.

The overall percentage of reactors (at standard interpretation) in Wales with TB infection confirmed by either DL or culture of *M. bovis* (29%) was lower than those observed in the High Risk Area (HRA) (43%) and Edge Area of England (39%). When comparing TB Areas in Wales, the High East TB Area (46%) was higher than the HRA of England (43%), with other TB Areas lower than Wales overall (High West; 24%, Intermediate North; 25%, Intermediate Mid; 26% and Low TB Area; 28%).

The lower percentages 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. This means, particularly in the lower incidence areas, that infection is detected earlier in cattle before pathology has developed and can be detected during slaughterhouse inspection. Sixty per cent of the samples submitted from slaughterhouses in Wales were *M. bovis* positive, compared to 66% for Great Britain. This would support infection being detected earlier, in addition to more submissions in Wales coming from lesions not caused by *M. bovis*.

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 percentage of these animals yield carcases with detectable lesions (DL) from which *M. bovis* can be isolated and cultured compared with animals classed as reactors via standard interpretation.

The percentage of samples with DLs that were *M. bovis* positive varied by TB Area and was highest in the High TB East Area and lowest in the Low TB Area (96% and 67% respectively; Tables 5.2.1 a-e). There was also variation in the percentage of *M. bovis* positive samples from NDLs, the highest in the Low TB area (3%) and the lowest in the High West, Intermediate North and Intermediate Mid TB Areas (all 1%).

Overall in Wales, a larger percentage of samples from NDL animals had no culture results (pending or not cultured) compared with those from DL animals (76% vs. 50%). Half of

[17] 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.

samples from DL animals in 2019 were not cultured (or were pending), although this was higher in DCs (64%) and IFN-γ reactors (68%).

Table 5.2.1a-e: Lesion status of animals slaughtered in 2019, by TB Area

(a) High East TB Area	Total	Lesion status not recorded	DL % of Total[1]	DL *M.bovis* +ve %[2]	DL Pending or not cultured	NDL % of Total	NDL *M.bovis* +ve %[3]	NDL Pending or not cultured
1. Dangerous contacts (DC)	**231**	**1**	**4.8%**	**100.0%**	**7**	**95.2%**	**0.0%**	**205**
2. Inconclusive reactors (IR)	**356**	**2**	**3.7%**	**81.8%**	**2**	**96.3%**	**0.0%**	**271**
After 1 test as IR	271	1	2.2%	66.7%	0	97.8%	0.0%	228
After 2 tests as IR	57	0	10.5%	100.0%	1	89.5%	0.0%	24
After 3 tests as IR	28	1	3.7%	0%	1	96.3%	0.0%	19
3. Reactors (R)	**1464**	**2**	**25.0%**	**96.9%**	**172**	**75.0%**	**3.1%**	**872**
Antibody	42	0	0.0%	0%	0	100.0%	0.0%	38
IFN-gamma positive	396	1	4.6%	50.0%	16	95.4%	0.0%	331
At standard interpretation	675	1	46.1%	97.7%	138	53.9%	5.1%	265
At severe interpretation[4]	351	0	10.3%	94.4%	18	89.7%	2.6%	238
TOTAL of items 1, 2, and 3	**2051**	**5**	**19.0%**	**96.2%**	**181**	**81.0%**	**2.3%**	**1348**

(b) High West TB Area	Total	Lesion status not recorded	DL % of Total[1]	DL *M.bovis* +ve %[2]	DL Pending or not cultured	NDL % of Total	NDL *M.bovis* +ve %[3]	NDL Pending or not cultured
1. Dangerous contacts (DC)	**520**	**0**	**3.7%**	**37.5%**	**11**	**96.3%**	**0.0%**	**441**
2. Inconclusive reactors (IR)	**2459**	**6**	**1.3%**	**40.9%**	**10**	**98.7%**	**0.3%**	**2076**
After 1 test as IR	2143	6	0.7%	9.1%	5	99.3%	0.0%	1917
After 2 tests as IR	202	0	7.4%	72.7%	4	92.6%	0.9%	81

After 3 tests as IR	114	0	0.9%	0%	1	99.1%	0.0%	78
3. Reactors (R)	**5530**	**14**	**10.1%**	**85.7%**	**299**	**89.9%**	**1.0%**	**3597**
Antibody	115	8	0.0%	0%	0	100.0%	0.0%	92
IFN-gamma positive	1978	3	3.5%	70.8%	46	96.5%	0.0%	1543
At standard interpretation	1751	2	23.5%	92.3%	215	76.5%	2.4%	880
At severe interpretation[4]	1686	1	4.5%	60.5%	38	95.5%	0.4%	1082
TOTAL of items 1, 2, and 3	**8509**	**20**	**7.2%**	**80.9%**	**320**	**92.8%**	**0.8%**	**6114**

(c) Intermediate North TB Area	Total	Lesion status not recorded	DL % of Total[1]	DL *M.bovis* +ve %[2]	DL Pending or not cultured	NDL % of Total	NDL *M.bovis* +ve %[3]	NDL Pending or not cultured
1. Dangerous contacts (DC)	**78**	**0**	**3.8%**	**0%**	**3**	**96.2%**	**0.0%**	**59**
2. Inconclusive reactors (IR)	**191**	**1**	**1.1%**	**0.0%**	**1**	**98.9%**	**0.0%**	**148**
After 1 test as IR	157	1	0.6%	0.0%	0	99.4%	0.0%	129
After 2 tests as IR	16	0	6.3%	0%	1	93.8%	0.0%	8
After 3 tests as IR	18	0	0.0%	0%	0	100.0%	0.0%	11
3. Reactors (R)	**934**	**1**	**7.1%**	**91.4%**	**31**	**92.9%**	**1.4%**	**575**
Antibody	105	0	0.0%	0%	0	100.0%	0.0%	81
IFN-gamma positive	436	0	2.3%	50.0%	6	97.7%	0.7%	282
At standard interpretation	224	0	23.2%	96.6%	23	76.8%	4.1%	99
At severe interpretation[4]	169	1	2.4%	100.0%	2	97.6%	0.0%	113
TOTAL of items 1, 2, and 3	**1203**	**2**	**5.9%**	**88.9%**	**35**	**94.1%**	**1.1%**	**782**

(d) Intermediate Mid TB Area	Total	Lesion status not recorded	DL % of Total[1]	DL *M.bovis* +ve %[2]	DL Pending or not cultured	NDL % of Total	NDL *M.bovis* +ve %[3]	NDL Pending or not cultured
1. Dangerous contacts (DC)	**46**	**0**	**6.5%**	**100.0%**	**2**	**93.5%**	**0.0%**	**40**
2. Inconclusive reactors (IR)	**58**	**0**	**8.6%**	**66.7%**	**2**	**91.4%**	**0.0%**	**18**
After 1 test as IR	20	0	0.0%	0%	0	100.0%	0.0%	8
After 2 tests as IR	26	0	15.4%	66.7%	1	84.6%	0.0%	8
After 3 tests as IR	12	0	8.3%	0%	1	91.7%	0.0%	2
3. Reactors (R)	**538**	**1**	**12.7%**	**97.1%**	**34**	**87.3%**	**1.0%**	**277**
Antibody	0	0	0%	0%	0	0%	1.0%	0
IFN-gamma positive	215	0	3.7%	100.0%	5	96.3%	0.0%	124
At standard interpretation	192	0	25.0%	96.0%	23	75.0%	2.9%	75
At severe interpretation[4]	131	1	9.2%	100.0%	6	90.8%	0.0%	78
TOTAL of items 1, 2, and 3	**642**	**1**	**11.9%**	**94.7%**	**38**	**88.1%**	**0.9%**	**335**

(e) Low TB Area	Total	Lesion status not recorded	DL % of Total[1]	DL *M.bovis* +ve %[2]	DL Pending or not cultured	NDL % of Total	NDL *M.bovis* +ve %[3]	NDL Pending or not cultured
1. Dangerous contacts (DC)	**6**	**0**	**0.0%**	**0%**	**0**	**100.0%**	**0.0%**	**4**
2. Inconclusive reactors (IR)	**66**	**0**	**1.5%**	**0.0%**	**0**	**98.5%**	**0.0%**	**52**
After 1 test as IR	62	0	1.6%	0.0%	0	98.4%	0.0%	52
After 2 tests as IR	4	0	0.0%	0%	0	100.0%	0.0%	0

After 3 tests as IR	0	0	0%	0%	0	0%	0%	0
3. Reactors (R)	**122**	**0**	**9.0%**	**75.0%**	**3**	**91.0%**	**4.5%**	**67**
Antibody	10	0	0.0%	0%	0	100.0%	11.1%	1
IFN-gamma positive	63	0	1.6%	0.0%	0	98.4%	0.0%	45
At standard interpretation	29	0	24.1%	83.3%	1	75.9%	6.7%	7
At severe interpretation[4]	20	0	15.0%	100.0%	2	85.0%	0.0%	14
TOTAL of items 1, 2, and 3	**194**	**0**	**6.2%**	**66.7%**	**3**	**93.8%**	**3.4%**	**123**

[1]The denominator for the percentage 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 percentage is the number with DLs that were cultured.

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

[4]These include *all* animals recorded as reactors irrespective of skin test measurements (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), and also includes bovines classified as a reactor on the basis of severe interpretation of the skin test.

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 percentage of reactors with DLs has declined from around 21% in 2015 to around 13% in 2019, which could be as a result of increased IFN-y testing (Figure 5.2.1). The percentage of 1x IRs with DLs has declined since 2015, as a result of many first time IRs in persistent TB incidents being removed (change in policy from 2016). The percentage of DC's, 2xIRs and 3xIRs increased slightly in 2019 (to 8% in 2018). In 2017 and 2018 there were no 3xIRs with DLs.

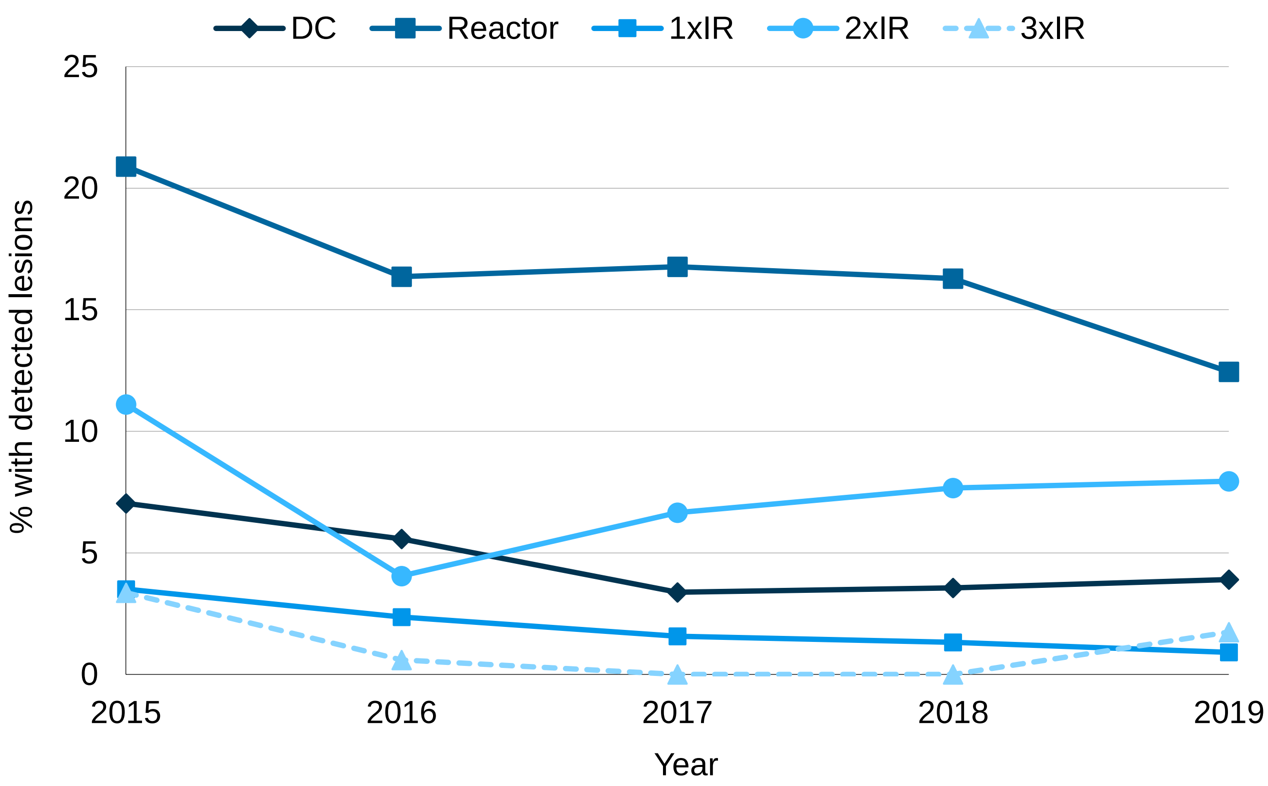


Figure 5.2.1: Percentage of slaughtered cattle with detected lesions[1], 2015 – 2019

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

5.3 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 typing (see Section 5.4). 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 528 DL samples from reactors with culture results in 2019, 91% were *M. bovis* positive. A similar percentage of DL samples with culture results were *M. bovis* positive in England[1] in 2019 (94% average). This percentage has ranged in Wales from 86% to 97% since 2010 (mean = 93%; SD = 3%; Figure 5.3.1).

A total of 2,115 NDL samples had culture results in 2019. Twenty eight (1.3%) were confirmed to be *M. bovis* positive. Importantly however, this does not mean that the remaining 99% were not infected, since infected animals do not always have DLs or yield positive culture results. The earlier in the stages of disease that reactors to the TB test are identified, the less likely they are to have lesions and positive culture results. Since 2010, there has been a gradual decline in the percentage of NDLs that were *M. bovis* positive, despite an increase in 2014 (Figure 5.3.1).

Of the 3,292 animals where both the lesion status and culture result was known (i.e. all DL and NDL animals with a positive or negative result and excluding all animals where lesion status was not known or where no cultures were carried out; excluding slaughterhouse cases), 608 (19%) had evidence of TB: either having detected lesions and/or being culture positive (i.e. all DL, and NDL animals with positive results only; Figure 5.1.1).

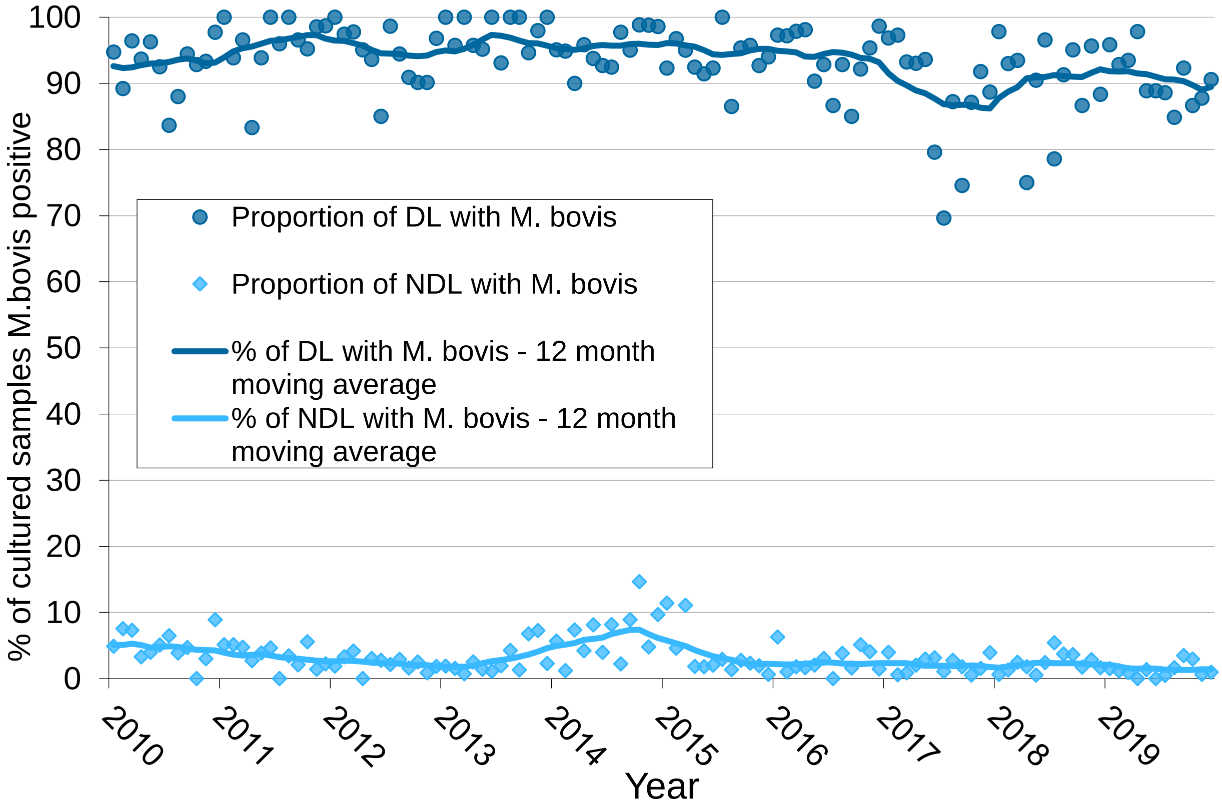


Figure 5.3.1: Monthly percentage of reactor culture samples from which M. bovis was obtained, 2010 – 2019

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[1] https://www.gov.uk/government/publications/bovine-tb-epidemiology-and-surveillance-in-great-britain-2019

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

The APHA has a database of genotypes for over 14,000 isolates of TB from Wales (1988 to end 2019). 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 determine 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 cattle genotypes is shown in Figure 5.4.1. The most frequently found isolates in 2019 were 9:b, located mostly in the High West TB Area, and 17:A, located predominantly in the High East TB Area (bordering the Intermediate North TB Area), although found in all TB Areas.

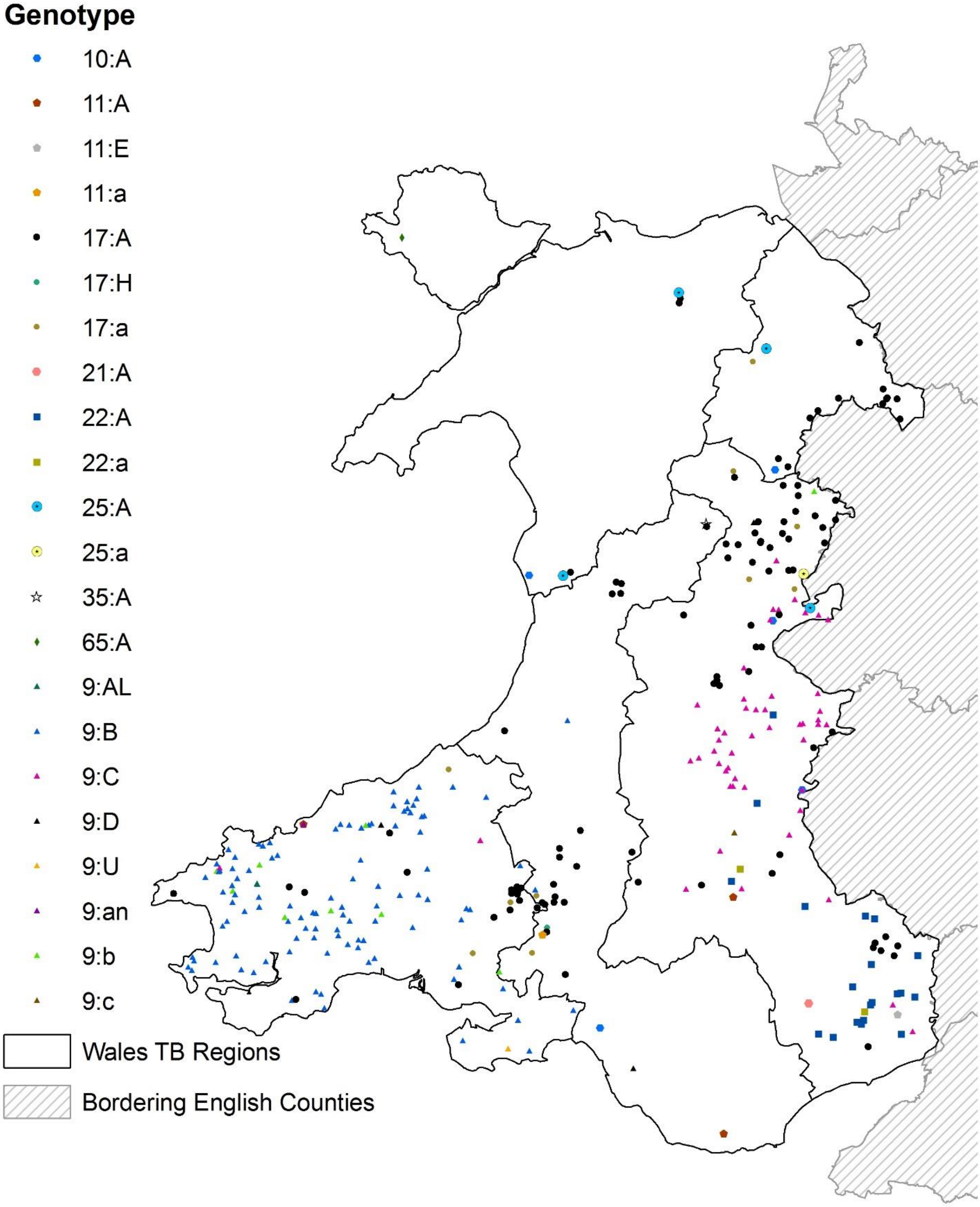

Figure 5.4.1: Geographical distribution of cattle genotypes found in Wales in 2019

Each of these isolates was spoligotyped and VNTR data (using characterisation of six standard genomic loci) is available for 95% of these isolates. The distribution of bovine and non-bovine isolates by year is shown in Table 5.4.1.

Table 5.4.1: The frequency of bovine and non-bovine isolates genotyped by year 1988 to 2019

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	1010	2
2004	675	1
2005	814	3
2006	809	59
2007	867	12
2008	1095	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	433	39
2019	377	43
unknown year*	0	7
Total:	**13,235**	**402**

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

** Year the bovine incident commenced

5.5 Genotype frequency in cattle TB incidents

There were 377 isolates from cattle for incidents in Wales that started in 2019 and all were spoligotyped (2018 = 433). Full genotype (spoligotype plus 6 VNTR loci) was obtained for 95% of these isolates (2018 = 94%). The 359 cattle isolates with full genotype represent 324 separate incidents in cattle herds in Wales (2018 = 363). An average of 1.11 isolates were genotyped per TB incident (2018 = 1.08) [NB. One TB incident had two different genotypes]. Genotypes 17:a, 9:b, 9:c and 22:a made up over 91% of Welsh isolates in 2019 and have home ranges in Wales (Table 5.5.1).

Table 5.5.1: Frequency and percentage of genotypes in OTF-W incidents in cattle, 2018 and 2019

Genotype	2019		2018[1]
	Frequency	Percentage	Percentage
9:b	126	35	38.4
17:a	118	33	29.0
9:c	54	15	12.2
22:a	30	8.4	9.2
10:a	6	1.7	0.8
11:a	5	1.4	0.8
25:a	5	1.4	2.3
9:d	3	0.8	0.3
9:u	1	0.3	0.3
9:al	1	0.3	-
9:an	1	0.3	0.3
9:4-5-5-5*-3-2.1	1	0.3	-
9:7-3-5-5*-3-2.1	1	0.3	-
11:e	1	0.3	-
17:h	1	0.3	-
21:a	1	0.3	0.5
35:a	1	0.3	0.5
65:a	1	0.3	-
119:7-5-2-4*-3-3.1	1	0.3	-
NT:5-5-5-4*-3-3.1	1	0.3	-
Total:	**359**	**-**	**-**

[1] For 2018, not all genotypes are shown in this table if they did not appear again in 2019. The overall total for 2018 was 296.

The geographical distribution of the major spoligotypes identified in OTF-W incidents in 2019 is presented in Figure 5.5.1. The most common spoligotype in Wales (spoligotype 9) had two main clusters: one in the south west corner of Wales and the other mainly located in Mid Powys. 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 North Powys.

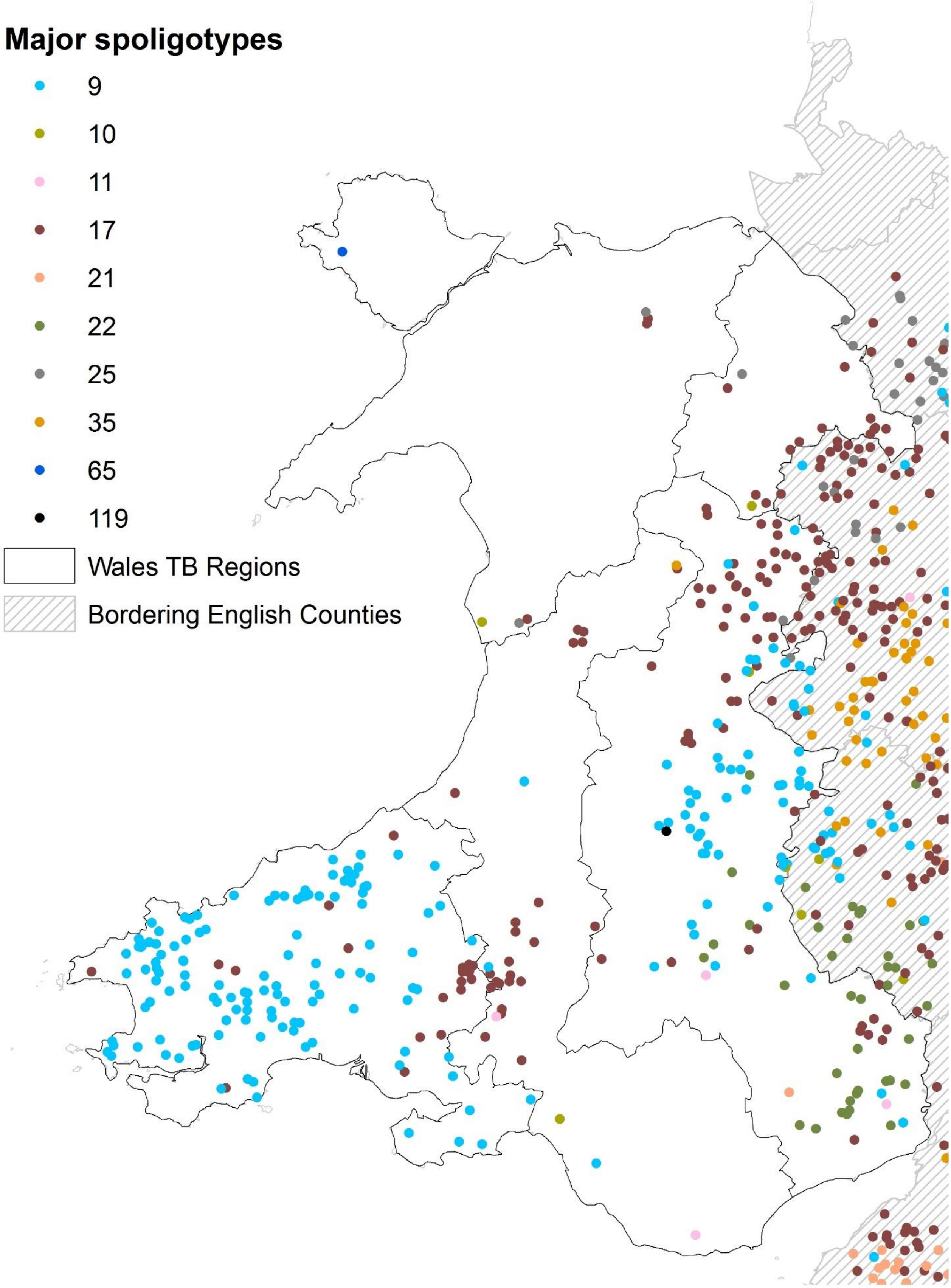

Figure 5.5.1: Geographical distribution of the major spoligotypes in Wales and English bordering counties in 2019

5.6 Non-bovine farm animals and wildlife isolates from Wales.

Forty three non-bovine isolates were genotyped in 2019 (2018 = 39). This total included 38 badger samples (2018 = 18), three deer and two goat (one incident) samples. The complete genotype was available for thirty seven badger isolates, with six of the thirty seven being out of home range. Two of the three deer isolates with complete genotype were within home range and a single goat with complete genotype was within home range. As observed in Figure 5.6.1 (which does not include badger isolates), all non-bovine isolates were located in the High East TB Area.

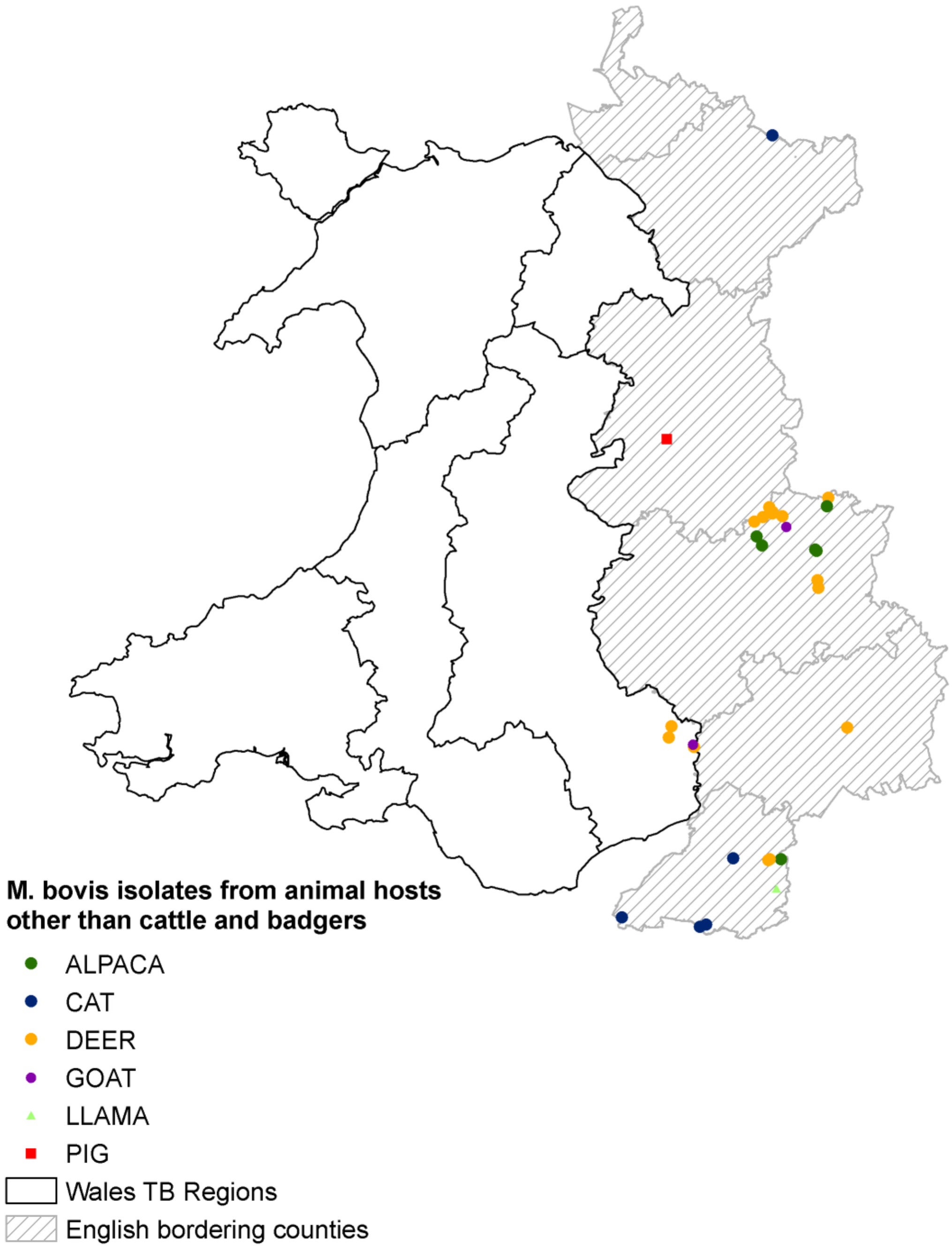

Figure 5.6.1: Geographical distribution of *M. bovis* isolates from animal hosts other than cattle and badgers, in Wales and English bordering counties in 2019

Isolates shown in Wales are from three deer and two goats. Other non-bovine isolates are shown in the English bordering counties.

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 2nd April 2020, and includes skin tests entered on to SAM, APHA's TB surveillance management system, and completed on or before 28th March 2020. 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

To ensure only one herd incident is included for each herd, incidents are screened to determine duplicate, concurrent, and missing incidents. More 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, as are duplicate and concurrent incidents. 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 again, 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 presented for testing on the farm do not all match the population reported in BCMS and which have to be corrected prior to the lifting of restrictions.

Ongoing effort is being 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 reported here 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 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 a 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 TB 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 percentage 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. However, 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 refers to *prevalence* of TB in a herd. 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 percentage 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*. In this report, the *Current Period* refers to a new TB incident disclosed in 2019, and the *History Period* refers to any TB incident in the 36 months prior. 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 2019[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.

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 OTF-W 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, a 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 percentages.

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.

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

In Poisson regression analyses, the incidence rate ratio (IRR) indicates the size of the difference between the different categories of herd size, type and TB Area, relative to the reference category For example, if a category had an IRR of 2.0, this means that the incidence rate in herds within that category was twice as high as that of the reference category. An IRR of less than 1 represents categories where the incidence rate is lower than that of the reference category.

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.

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).

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

[1] The 'odds ratio' in this case is the odds (probability) of an OTF-W incident being detected in the slaughterhouse, divided by the odds of an OTF-W incident being detected via routine skin testing.

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

Detail	Abbreviation	Definition or description
Animal and Plant Health Agency	APHA	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).
Antibody test	IDEXX test	An ancillary antibody detection blood test typically used in herds with persistent infection. The highest sensitivity of the test is dependent on a prior tuberculin skin test, which triggers an anamnestic boost to specific antibody levels in infected cattle. APHA recommend that blood samples are taken within 10 to 30 days of a prior skin test.
Bovine tuberculosis	TB	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.
Dangerous contact	DC	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 because of contact with infected cattle.
Detected lesions	DL	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.
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.

Detail	Abbreviation	Definition or description
Health Check Wales	HCW	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		An animal or group of animals kept on a holding as an epidemiological unit. In GB they are identified with a County Parish Holding Herd (CPHH) number.
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 holdings 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, among the group of herds that have had a herd-level test during the period of interest..
Herd types		*'Beef' includes* Beef, Finishing, Suckler, Beef Dealer, Beef Heifer Rearer, Beef Bull Hirer and Stores herds *'Dairy*' includes Dairy, Dairy Dealer, Dairy Bull Hirer, Dairy Producer, Dairy Heifer Rearer, Flying and Domestic herds; *'Other'* includes Calf Rearers, unspecified Dealer Herds, AI, buffalo herd and herds described on SAM as 'Other herds' and bred or reared for products other than beef or dairy. It may also include atypical herd premises such as temporary gatherings and quarantine facilities, although these are typically not subject to testing.
Holding		A holding is a place where livestock, including cattle, are kept or handled in pursuit of an agricultural activity. It may be a farm, or other premises such as a

Detail	Abbreviation	Definition or description
		market, lairage, abattoir or showground. Some keepers may have more than 1 holding and some holdings may be used by more than one keeper. A holding is not the same as a business. It is expressed as a County Parish Holding (CPH number) and a single holding may comprise of one or more herds.
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 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).
Inconclusive reactor	IR	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. 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.
Intensive Action Area	IAA	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.
Interferon-gamma test	IFN-γ or gIFN	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.

Detail	Abbreviation	Definition or description
		http://intranet/v1p3r/workareas/Tuberculosis/Bovines/Gamma_Test/Eligibility_in_Wales.html
Inter-quartile range	IQR	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).
Live herd or Active herd	CPHH	Bovine herd defined in the County/Parish/Holding/Herd notation which was flagged as active on SAM on 31st December, 2019. 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 or the Cattle Tracing System (CTS), 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. 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.
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).
Mycobacterium avium	*M. avium*	The causative organism of avian tuberculosis, which occasionally infects cattle.
Mycobacterium bovis	*M. 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*,

Detail	Abbreviation	Definition or description
		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.
No detected lesions	NDL	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.
Officially bovine tuberculosis free	OTF	See Appendix 3 for Extract from European Union (1998), Council Directive 98/46/EC for full definition of the officially TB free status.
Officially bovine tuberculosis free status suspended	OTF-S	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. A TB incident that did not meet the conditions for an OTF-W incident (see below) is classified as an OTF-S incident.
Officially bovine tuberculosis free status withdrawn	OTF-W	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 TB incidents upgraded to OTF-W for epidemiological reasons.
Persistent herd or persistent TB incident herd		A TB incident herd that has been under movement restrictions for at least 550 days (approximately 18 months).
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.
Post mortem examination	PME	Examination (to various extents) of the carcass and organs of slaughtered cattle for suspected lesions of bovine TB. Such post mortem examinations includes 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.
Pre-movement testing	PrMT or PRMT	Mandatory testing for cattle over 42 days moving out of an at least annually tested herd into other herds and for cattle moved out of herds in the LRA to Scotland, unless the animal had spent its entire life in the LRA.
Prevalence		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.

Detail	Abbreviation	Definition or description
Reactor	R	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, or to an IDEXX Antibody test, 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. An animal reacting to more than one test will only count once to statistics, and hierarchically assigned to the SICCT, then IFN-γ, then IDEXX.
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.
Reference category	Ref	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 (six monthly and annual testing) and Low Risk Area (LRA; four yearly testing). In 2017 Wales adopted a regionalised approach to TB distinguishing five TB areas (Low TB Area, Intermediate TB Area North, Intermediate TB Area Mid, High TB Area West and High TB Area East)[1] [see 'TB Area'].
SAM database	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.
Sensitivity (of a test)	Se	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.

[1] https://gov.wales/sites/default/files/publications/2017-11/wales-bovine-tb-eradication-programme.pdf

Detail	Abbreviation	Definition or description
Single Intradermal Comparative Cervical Test	SICCT, tuberculin skin test, skin 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.
Slaughterhouse case	SLH	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.
Specificity (of a test)	Sp	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.
Standard deviation	SD	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.

Detail	Abbreviation	Definition or description
TB Area		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. 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	TAR	Time spent not under restriction since the most recent herd-level test or end of incident.
VetNet database	VetNet	VetNet is the predecessor of SAM, APHA's TB control and surveillance system. Data was migrated into SAM from VetNet when SAM was launched in 2011.
VNTR type	VNTR	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
IFN_ANOM	Gamma interferon anomalous reactions procedure
IFN_LOW_IN	Gamma interferon testing in an OTF-W herd in a low TB incidence area
IFN_PERSI	Gamma interferon testing in an OTF-W herd with persistent infection
IFN_SLHERD	Gamma interferon testing in whole or partial slaughter of reactor herds
IFN_2x_IR	Gamma interferon testing of 2x IR cattle
IFN_NSR	IFN Non-Specific Reactor Herd - Investigation and Intervention
IFN_OTH_SP	IFN test performed due to disease in other species
IFN_BOV_OTH	Ad hoc use of the gamma test; not one of the established scenarios
IFN_FLEX	Flexible extended test using the synthetic peptide antigens, providing additional sensitivity
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)
SI (& 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')

Surveillance test type	Definition
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
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)
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
CT-HS1, 2	First and second tests of a herd in a recognised hotspot
CT-RTA	Check test following the discovery of an infected road-killed badger
CT-NH1, 2, 3	First, second and third check tests of newly-established herds
CT-RH1, 2, 3	First, second and third check tests of re-formed herds
6M (& IA6)	Test six months after the end of an incident (& those done in the 'intensive action area')
12M (& IA12)	Test twelve months after the six-month (VE-6M) test (& those done in the 'intensive action area')
CON	Test carried out on herds contiguous to OFT-W herds outside their regular test frequency (first test)
CON6	Test of a contiguous herd (after 6 months)
CON12	Test of a contiguous herd (12 months after VE-CON, or 12 months after VE-CON6, if done)
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.
WHT	Whole herd test in a parish with a testing interval of one year
WHT2	Whole herd test applied to a herd in a parish with a testing interval of 2 years
RHT	Routine herd test (only in parishes tested at intervals of 2 or more years)
CTW1	(Whole herd) Check test for herds previously tested at longer intervals in Health Check Wales
CTW2	Check test for Health Check Wales, done at the scheduled time but upgraded to a whole herd test
IR	Inconclusive reactor re-test
TR	Forward tracing test of bovines moved from OFT-W herds prior to service of restrictions
SLH	A pseudo-test code applied to an incident disclosed by confirmed infection in a routinely slaughtered animal (*slaughterhouse case*)
EX	Test on cattle to be exported from Great Britain

Surveillance test type	Definition
PII	Post-import test performed on cattle imported from Northern Ireland and the Republic of Ireland
PIO	Post-import test performed on other imported cattle
AI	Test performed on cattle prior to admission to an artificial insemination centre
PRI	Private TB test (a test approved by the AHDO, paid for by the owner and carried out by an official veterinarian)
PRMT	Pre-movement test
POSTMT	Post-movement test to be carried out where cattle have been moved to a holding without a required pre-movement test
POSTMTOV	Post-movement test at 60-120 days of any animal arriving in the Low TB Area
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.*
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

Test type[1]	Surveillance tests[2] No. Tests	Surveillance tests[2] Reactors	Surveillance tests[2] TB incidents	Disease control tests[3] No. tests
Routine	**430,501**	**266**	**140**	**177**
CTW1	0	0	0	0
CTW2	0	0	0	0
WHT	406,650	234	129	177
WHT2	0	0	0	0
IA6	14,342	18	5	0
IA12	9,509	14	6	0
Herd Risk	**168,046**	**433**	**112**	**560**
12M	44,963	167	33	445
6M	123,083	266	79	115
Area Risk	**459,285**	**921**	**271**	**837**
CON	306,233	714	188	583
CON12	119,822	169	73	1
CON6	33,209	38	10	0
CT-HS1	21	0	0	253
Movement Risk 1	**11,116**	**17**	**12**	**400**
TR	9,199	15	11	219
EX	104	0	0	0
AI	17	0	0	0
PII	1,793	2	1	181
PIO	3	0	0	0
Movement Risk 2	**130,228**	**102**	**59**	**1,127**
POSTMOVOV	10,660	0	0	115
POSTMT	23	0	0	0
PRI	1,723	0	0	0
PRMT	128,482	102	59	1,127
Inconclusive reactors	**1,646**	**0**	**0**	**1,288**
IR	1,643	0	0	111
VE_IFN_2X_IR	3	0	0	1,177
Slaughterhouse	**189,725**	**0**	**59**	**48,506**
QSLH	0	0	0	0
SLH	189,725	0	59	48,506
New Herds	**7,544**	**1**	**2**	**0**
CT-NH1	7,279	1	2	0
CT-NH2	265	0	0	0
CT-NH3	0	0	0	0

Test type[1]	Surveillance tests[2] No. Tests	Surveillance tests[2] Reactors	Surveillance tests[2] TB incidents	Disease control tests[3] No. tests
Control	**16,238**	**31**	**6**	**857,648**
90D	0	0	0	0
CT	0	0	0	0
IFN	0	0	0	0
IASI	0	0	0	0
SI	2,411	4	1	692,837
CT(I-I)	10,080	8	4	107,368
CT(EM)	2,066	0	0	2,679
VE_IFN_ANOM	0	0	0	0
IFN_LOW_IN	0	0	0	11,607
IFN_NSR	0	0	0	329
IFN_OTH_SP	0	0	0	0
IFN_PERSI	194	19	1	33,157
IFN_SLHERD	0	0	0	6,853
TBU	1,487	0	0	2,818
Other	**0**	**0**	**0**	**0**
SV	0	0	0	0
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. 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,

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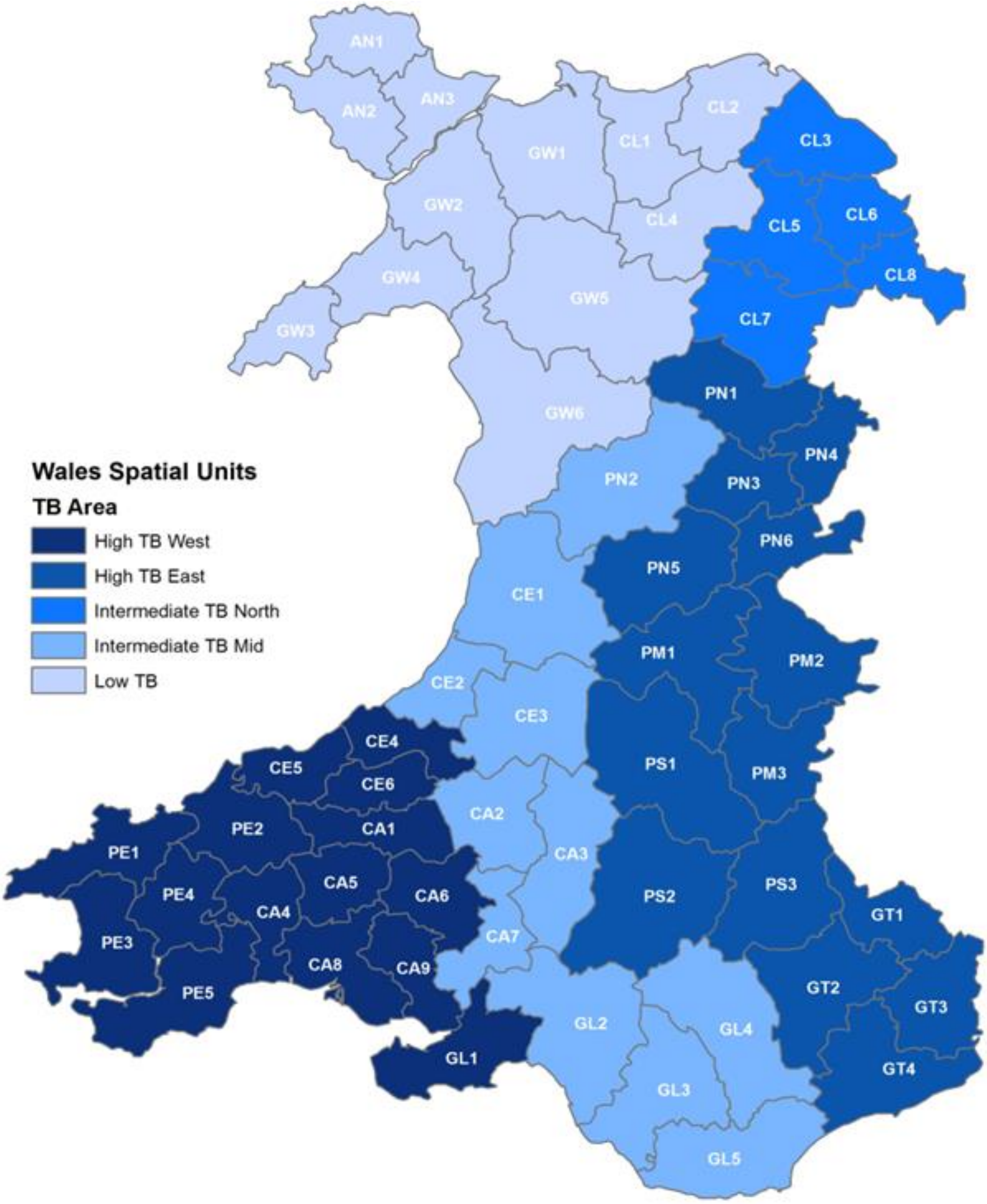

Appendix Figure 1: Wales TB Areas and spatial units

Appendix 6. The number of herds, incidents, herds under restriction and cattle slaughtered for different reasons relating to TB control (2007-2019)

Appendix Table 4 a-e: The number of herds, incidents, herds under restriction and cattle slaughtered for different reasons relating to TB control between 2007 and 2019

a) High East TB Area

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]
2007	3502	372	236	263	113	2304	211
2008	3386	434	250	313	111	2684	174
2009	3253	423	254	222	259	2656	74
2010	3214	384	247	251	203	2071	59
2011	3223	367	277	252	167	2026	321
2012	3202	358	281	273	181	2313	161
2013	3174	295	249	182	156	1443	80
2014	2946	325	283	213	107	1988	121
2015	2801	275	241	163	148	1801	114
2016	2770	260	232	178	135	1629	186
2017	2737	299	278	231	319	1898	216
2018	2862	251	231	205	352	1684	199
2019	2806	210	196	176	356	1464	231

b) High West TB Area

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]
2007	3995	443	196	358	79	4341	362
2008	3890	574	303	499	152	6400	831
2009	3669	519	218	412	848	6017	467
2010	3625	434	199	374	611	3572	159
2011	3546	451	337	405	662	3983	124
2012	3533	518	439	492	746	4973	135
2013	3515	385	339	331	654	3086	73
2014	3358	355	330	284	422	2559	235
2015	3243	405	365	357	606	4209	340
2016	3236	319	307	307	652	5147	818
2017	3293	330	314	331	1289	4454	954
2018	3251	332	308	356	2223	4970	482
2019	3185	308	294	350	2459	5530	520

c) Intermediate North TB Area

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]
2007	1125	29	15	15	0	108	
2008	1101	49	23	26	8	251	14
2009	1078	70	21	25	47	259	3
2010	1042	60	16	18	36	213	
2011	1022	71	40	32	31	237	6
2012	1004	80	43	42	58	438	9
2013	998	64	31	37	56	303	16
2014	951	60	36	27	34	445	97
2015	921	44	26	19	26	443	3
2016	921	38	34	29	17	483	16
2017	1183	63	49	39	58	642	34
2018	953	67	58	49	118	551	36
2019	920	45	37	52	191	934	78

d) Intermediate Mid TB Area

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]
2007	2394	79	26	40	9	375	34
2008	2331	118	41	65	9	645	35
2009	2217	131	45	65	88	704	40
2010	2178	115	39	60	74	512	22
2011	2190	105	42	50	47	406	7
2012	2175	84	37	44	51	324	18
2013	2163	78	45	40	39	251	5
2014	2062	65	45	28	36	255	44
2015	1992	75	44	42	33	359	29
2016	1991	51	41	36	31	572	132
2017	2089	68	49	40	47	365	16
2018	2048	60	49	43	46	525	34
2019	2038	75	59	52	58	538	46

e) Low TB Area

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]
2007	3129	11	6	5	0	27	2
2008	3086	17	9	10	2	66	
2009	2999	49	15	10	42	161	8
2010	2925	43	6	8	20	70	
2011	2875	62	7	14	27	88	3
2012	2848	45	14	14	36	66	4
2013	2838	47	12	19	22	68	6
2014	2752	38	14	15	15	142	3
2015	2719	34	11	11	13	115	2
2016	2733	39	16	16	23	263	1

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]
2017	2676	28	17	15	18	75	2
2018	2841	34	21	21	15	229	9
2019	2826	23	17	17	66	122	6

[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.

Appendix 7. Duration between new TB incidents in 2019, and previous TB incidents in the last 36 months

Appendix Table 5: 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 TB incident in the current period

Previous incident type[1]	2019 incident type[2]	Mean[3]	Median[3]	SD[3]	Min[3]	Max[3]
Any	Any	486	461	292	13	1,093
OTF-W	Any	712	857	283	234	1,023
OTF-S	Any	480	456	290	13	1,093
Any	OTF-W	487	462	292	13	1,093
OTF-W	OTF-W	791	878	207	532	1,023
OTF-S	OTF-W	480	456	290	13	1,093
Any[4]	OTF-S	234	234	-	234	234
OTF-W	OTF-S	-	-	-	-	-
OTF-S	OTF-S	234	234	-	234	234

[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 2019; OTF-W: OTF-W incident(s) occurred at any time in 2019 (not necessarily the first); OTF-S: only OTF-S incident(s) occurred in 2019

[3] 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 2019. Includes only recurrent incidents where the preceding incident ended between 1st January 2016 and the end of April 2019; If the first incident in 2019 was OTF-S but the herd subsequently had an OTF-W incident, the 2019 incident type is shown as OTF-W but the date of the first incident (OTF-S) is used to calculate the time elapsed.