



Animal &  
Plant Health  
Agency

Asiantaeth  
Iechyd Anifeiliaid  
a Phlanhigion

# **Supplementary material for the annual surveillance report:**

## **Epidemiology of bovine tuberculosis in Wales**

**For the period: January to December 2020**



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# Supplementary document for Wales TB surveillance report

## S1. 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 1st April 2021, and includes skin tests entered on to SAM, APHA's TB surveillance management system, and completed on or before 28th March 2021. 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 six 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 in recent years these are now very few with none since 2018, 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-returns 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. This now the most common cause of a delay to ending 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 (SHC) 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 SHC 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', or incidence rate. 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 2020, and the *History Period* refers to any TB incident in the 24 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 (2<sup>nd</sup> July 2020<sup>1</sup>) unless a TB incident starts in the Current Period. Recurrence in previous iterations of this report have been related to incidents with history within 36 months, but this has been updated to 24 months in line with the reporting of recurrence on the WG TB dashboard.

- 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 (2<sup>nd</sup> 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 24 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.

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<sup>1</sup> 2<sup>nd</sup> July is actually day 183 of a 365-day year or day 184 of a 366-day year.

## Inconclusive reactor herds that subsequently suffer a TB incident

Chapter 7 of the Wales epidemiology report 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.

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<sup>1</sup>.

## 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.

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.

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<sup>1</sup> [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/733938/AG-TBYHW-03.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733938/AG-TBYHW-03.pdf)

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<sup>1</sup> 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 v14.0.

## **OTF-W-2 herds**

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

In January 2011, changes were implemented in Wales that were designed to ensure that the officially tuberculosis free (OTF) status of cattle herds was withdrawn rather than merely suspended in cases of incidents that met defined epidemiological criteria.

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

In reports prior to 2014, OTF-W-2 herds were difficult to identify within the data available for analysis, and so were included in the OTF-S cohort. These difficulties with the data

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<sup>1</sup> 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.

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.

## **Duration of TB incidents**

Incident duration refers to the number of days that a herd is under movement restrictions due to a TB incident and can be influenced by a number of factors. TB incidents identified as having a longer duration can be due to:

- changes in the incident management policy (such as the application of interferon gamma [IFN- $\gamma$ ] testing within a herd or the minimum number of short-interval tests required to regain OTF herd status),
- a high within-herd prevalence of infection,
- continued cattle to cattle transmission despite removal of identified infected animals and,
- continued re-infection (e.g., from badgers and other local wildlife reservoirs or contiguous/ neighbouring herds).

Additionally, the logistics of staff availability and testing protocols may also have an impact.



## S2. Definitions and abbreviations

Table S1: 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 <i>Mycobacterium bovis</i> .
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.
Direct 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- $\gamma$ test reactor at <i>post-mortem</i> 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 <sup>1</sup>		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.
Health Check Wales	HCW	A surveillance initiative operating between 1 <sup>st</sup> October 2008 and 31 <sup>st</sup> December 2009 during which all herds

Detail	Abbreviation	Definition or description
		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. 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	HYR	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 (see incidence rate)
Herd types		<i>'Beef'</i> includes Beef, Finishing, Suckler, Beef Dealer, Beef Heifer Rearer, Beef Bull Hirer and Stores herds <i>'Dairy'</i> includes Dairy, Dairy Dealer, Dairy Bull Hirer, Dairy Producer, Dairy Heifer Rearer, Flying and Domestic herds; <i>'Other'</i> 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 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

Detail	Abbreviation	Definition or description
		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 <i>M. bovis</i> 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 to create a 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).
Incidence rate		per 100 herd-years at risk (see ‘Herd-years at risk’)
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- $\gamma$ 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- $\gamma$ ) assay is only approved as an ancillary diagnostic tool and measures the release of IFN- $\gamma$ in whole blood cultures stimulated with tuberculin. Most frequently used to enhance the sensitivity of testing in OTF-withdrawn herds.  <a href="http://intranet/v1p3r/workareas/Tuberculosis/Bovines/Gamma_Test/Eligibility_in_Wales.html">http://intranet/v1p3r/workareas/Tuberculosis/Bovines/Gamma_Test/Eligibility_in_Wales.html</a>

Detail	Abbreviation	Definition or description
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 31 <sup>st</sup> December 2020. 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).
<i>Mycobacterium avium</i>	<i>M. avium</i>	The causative organism of avian tuberculosis, which occasionally infects cattle.
<i>Mycobacterium bovis</i>	<i>M. bovis</i>	The causative organism of bovine tuberculosis.
Monitoring programme <sup>1</sup>		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 <i>M. bovis</i> 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 <i>restriction</i> , and thus the incident, begins on the disclosing test date and ends on the date that <i>Form TB10</i> is issued.

Detail	Abbreviation	Definition or description
		To qualify as being “new”, the incident must have been <i>disclosed</i> in the period specified.
No detected lesions	NDL	No lesions typical of bovine TB detected in the carcass of a SICCT or IFN- $\gamma$ test reactor at <i>post-mortem</i> examination or during routine slaughterhouse inspection of cattle.
Officially bovine tuberculosis free	OTF	See section S3 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 <i>M. bovis</i> 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 <i>M. bovis</i> infection has been identified in at least one slaughtered bovine animal, i.e., <i>M. bovis</i> identified in a cultured tissue sample and/or lesions detected in the carcass of a SICCT or IFN- $\gamma$ 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.
<i>Post-mortem</i> 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 <i>in vivo</i> 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 (England) to Scotland unless the animal had spent its entire life in the LRA.
Prevalence		The percentage of active herds under movement restrictions on a given date due to a TB incident, excluding herds restricted due to an overdue test.
Reactor	R	An animal showing a particular pattern of reactions to a single intradermal tuberculin comparative test

Detail	Abbreviation	Definition or description
		(SICCT test) or to a gamma interferon (IFN- $\gamma$ ) 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- $\gamma$ , 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 24 months (in previous reports, 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) <sup>1</sup> [see 'TB Area'].
Risk trading score		The risk trading score for each holding/CPH is the score at a point in time based on the proximity to a previous TB incident within the same holding. All holdings are given a minimum of 1 point and then further points are added according to years to the last breakdown e.g., 0 to 2 years (+3 points), >2 to 5 years (+2 points), 5 to 10 years (+1 point).  In addition, any cattle moved on in the last three years from a holding with a risk score of 5 generates an additional 1 point. The maximum risk score is 5 and can only be achieved by moving cattle on from another holding with a score of 5.
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.

<sup>1</sup> <https://gov.wales/sites/default/files/publications/2017-11/wales-bovine-tb-eradication-programme.pdf>

Detail	Abbreviation	Definition or description
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.
Single Intradermal Comparative Cervical Test	SICCT, tuberculin skin test, skin test	Commonly referred to as the 'skin test' or 'tuberculin skin test'. The testing procedure involves the simultaneous injection of a small amount of <i>M. bovis</i> and <i>M. avium</i> 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	SLH	Abbreviation for slaughterhouse (observed in tables or figures). Also used as a pseudo test code.
Slaughterhouse case	SHC	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, <i>M. bovis</i> must be isolated on culture from samples of the lesions. Until <i>M. bovis</i> 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 <i>Mycobacterium tuberculosis</i> 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

Detail	Abbreviation	Definition or description
		bovine reaction more than 4mm greater than a negative or positive avian reaction are deemed reactors.
Surveillance		Surveillance refers to activities to collect and record data on specific diseases in defined populations over a period of time, in order to assess the epidemiological evolution of the diseases and the ability to take targeted measures for control and eradication.
TB10 form		The form issued at the end of a TB incident to lift the restrictions imposed on cattle movements onto and off the holding.
TB Area		Following a 12-week consultation with industry in 2016, the Welsh Government's strengthened TB Programme committed to a regionalised 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 section S4.
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.

<sup>1</sup> 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.

**Table S2: 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



<b>Surveillance test type</b>	<b>Definition</b>
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 2 <sup>nd</sup> SI tests performed on OTF-S herds done in the 'intensive action area')
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 performed 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' (or IAA))
CON	Test carried out on herds contiguous to OTF-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)

Surveillance test type	Definition
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 OTF-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 ( <i>slaughterhouse case</i> )
EX	Test on cattle to be exported from Great Britain
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. <i>This code is removed from VetNet when testing is performed.</i>
ASG	Testing of restricted isolated groups of cattle within an incident or a non-incident herd at the RVL's discretion

### **S3. 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.

## S4. Geographical areas used in the 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 (Figure S1). Spatial units are compatible with the CPHH system and each contain a similar number of herds.

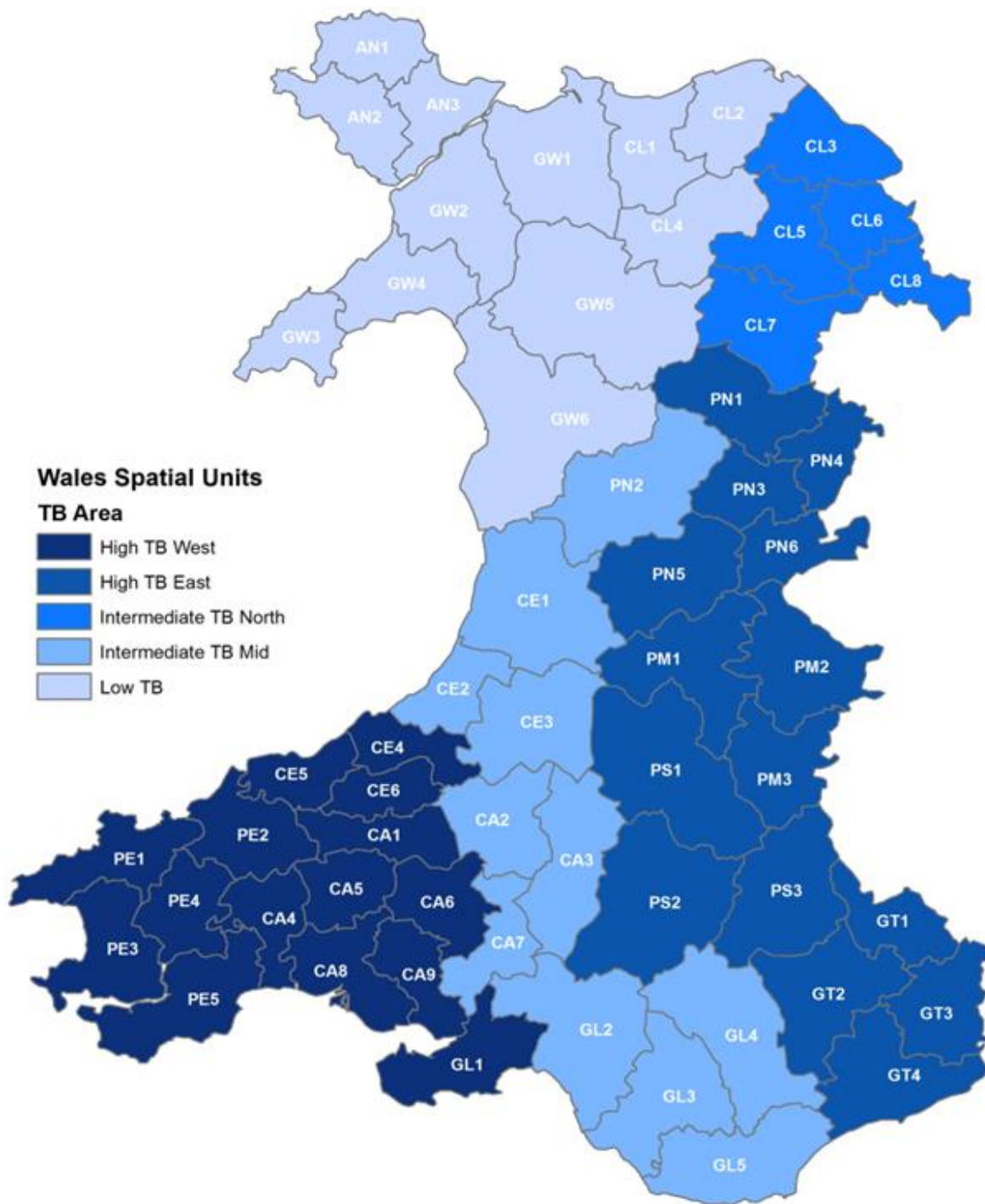
The splitting of Wales into a number of TB Areas reflects the need to recognise the differing disease situations. The approach to disease control in each area reflects the prevailing local circumstances and measures are developed that are best suited to make a difference to disease in those areas.

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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**Figure S1: Wales TB Areas and spatial units**