



Animal &
Plant Health
Agency

Bovine tuberculosis in England in 2018

Epidemiological analysis of the 2018 data and historical trends

September 2019



© Crown copyright 2018

You may re-use this information (excluding logos) free of charge in any format or medium, under the terms of the Open Government Licence v.3. To view this licence visit www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ or email PSI@nationalarchives.gov.uk

This publication is available at www.gov.uk/government/publications

Any enquiries regarding this publication should be sent to us at

Department of Epidemiological Sciences

Animal and Plant health Agency

Weybourne Building, Level 2, Area F, Woodham Lane, Addlestone, Surrey, KT15 3NB

TBSecretariat@apha.gov.uk

www.gov.uk/apha

Contents

1. Executive summary.....	4
2. Preface	6
3. The TB epidemic in England.....	10
3.1 Incidence, geographic distribution and trends over time	10
3.2 Characteristics of herds found infected with TB	25
3.3 Finding Infected herds: Effectiveness of different TB surveillance streams.....	42
3.4 Impact of disease and control measures: prevalence, duration and persistence	59
4.1 Epidemiology of TB in the High Risk Area.....	77
4.2 Epidemiology of TB in the Edge Area.....	94
4.3 Epidemiology of TB in the Low Risk Area	96

HOW TO READ THIS REPORT: The detail in this report is tiered and readers are advised to read the Executive Summary first, followed by the bulleted text at the start of each section. If more detail is wished on any of the points described this can then be explored in the relevant section.

1. Executive summary

1. Bovine TB in England is subject to a statutory eradication programme based on the government's strategy published in April 2014. Within the strategy England is divided into three 'risk' areas as determined by the level of disease. The High Risk Area (HRA), mainly in the west and south-west, disclosed over three quarters of new TB incidents in 2018. As in previous years, the Low Risk Area (LRA) in the north, east and south-east disclosed very few TB incidents in 2018, just over a third of which were fully confirmed by the presence of animals with typical lesions of TB and/or positive bacteriology results (OTF status withdrawn – OTF-W incidents). Twenty per cent of the new TB incidents in 2018 were found in the Edge Area, which lies between the HRA and LRA.
2. The Edge Area increased in size in January 2018 to fully include the five counties previously split between the Edge Area and the HRA. To allow for a consistent comparison, the analysis of long-term trends in the TB epidemic by risk area have applied the 2018 spatial boundaries to all years. Pre- 2018 HRA and Edge Area figures presented in this report are therefore not comparable to those published in previous reports.
3. Eradication of bovine TB is based on the systematic testing of herds to quickly identify and remove infected cattle, coupled with the application of movement restrictions and additional interventions during incident management to prevent the spread of disease and reduce the risk of disease persistence. Within the higher incidence portions of the Edge Area, six monthly routine surveillance TB testing replaced annual testing in January 2018. Herds in the rest of the Edge Area remained under annual surveillance testing, although this was supplemented by radial testing of herds located within a 3km radius of a fully confirmed (OTFW) breakdown. Within the HRA, additional licensed badger control areas were introduced in 2018, with one licensed badger control area implemented in the LRA.
4. The incidence rate of bovine TB in England increased steadily from 1986 to 2010 and has since plateaued. This plateau at the national level hides an increasing trend in incidence within the Edge Area. In 2018 TB incidence in the HRA decreased significantly compared to 2017; the level of TB in the LRA remains very low.
5. Over half the herds with new TB incidents in the HRA had suffered another TB incident in the previous three years, confirming that recurrent infection remains an important driver of the epidemic in this area. This is also highlighted by the frequency with which TB infection is revealed by check tests carried out 6 or 12 months after herds affected by TB incidents regain OTF status. Unsurprisingly, such 'risk-based' testing was more successful at finding infected herds in the HRA.
6. In the Edge Area the epidemic continued to propagate, driven mainly by the introduction of cattle with undetected infection, but also by the development of local areas of endemic bovine TB that in some cases may be driven by infection in the local badger population.

7. In 2018, as in previous years, herds located in the HRA (where there is high infection pressure from infected herds and from infection in badgers), herds with over 300 cattle (which have a greater tendency to be in the HRA) and herds that had previously been infected, were the most likely to sustain a new TB incident. Dairy herds were found to have an additional risk of infection that could not be fully explained by their size, testing history or location.
8. There was an increase in the use of interferon gamma (IFN- γ) blood tests in 2018. IFN- γ tests are used in parallel with the routine skin test (SICCT) to increase the probability of detecting and removing infected cattle from herds where a TB incident has been confirmed. In addition to other criteria, mandatory IFN- γ was introduced in the HRA for OTF-W herds located in licensed badger control areas where at least two seasons of effective control have been completed. As more badger control areas reached the threshold for this testing in 2018 the number of herds subject to IFN- γ testing increased and is expected to rise in the coming years.

Table 1.1 Key bovine TB parameters¹ in 2018 (selected 2017 values given in brackets)

	<i>High Risk Area</i>	<i>Edge Area</i>	<i>Low Risk Area</i>	<i>England Total</i>
Overview				
Number of new TB herd incidents detected	2,761 (3,033)	717 (660)	129 ² (123)	3,306 (3,816)
Number of open (continuing) incidents at the end of 2018	2,258 (2,511)	553 (468)	64 (56)	2,875 (3,035)
Herd incidence per 100 herd-years at risk	18.5 (19.8)	9.2 (9.1)	0.8 (1.0)	9.4 (11.0)
Average monthly prevalence (%)	11.5 (11.8)	5.6 (4.6)	0.3 (0.3)	5.9 (5.8)
Duration				
Median duration of restrictions for incidents (days) (25-75 th percentile) that closed in 2018	202 (166-320)	200 (167-284)	146 (97-189)	199 (165-307)
Median duration of restrictions for incidents (days) (25-75 th percentile) that closed in 2017	193 (155-293)	181 (150-241)	123 (90-187)	189 (153-283)
% persistently infected herds (duration >550 days) that closed in 2018	8.1 (6.9)	4.7 (2.1)	1.7 (0.0)	7.3 (6.0)
Number of persistent cases (duration >550 days) open at the end of 2018	348 (343)	45 (33)	3 (1)	396 (377)
Recurrence				
% new TB incidents in 2018 in herds that were previously infected (in the last 36 months)	57.7 (57.6)	38.1 (31.9)	6.3 (13.9)	51.8 (51.6)

¹ Includes all TB incidents (including OTF herd status suspended (OTF-S) and OTF herd status withdrawn (OTF-W))

² 37 (29%) of TB cattle incidents in the LRA were lesion- and/or culture-positive (OTF-W)

2. Preface

This report is published concurrently with a data report titled ‘Bovine tuberculosis in Great Britain. Surveillance data for 2018 and historical trends’ (referred to hereafter as the ‘GB TB data report’) which provides supporting detailed surveillance data tables, additional graphics and presents all similar data for England, Scotland and Wales.

Note these data are derived from the same source as Defra’s ‘National Statistics’ on the incidence and prevalence of bovine tuberculosis (TB) in Great Britain. These include monthly statistical reports and other quarterly statistics on specific aspects of the TB surveillance regime¹, such as pre-movement testing. However, additional time has been spent removing duplication and correcting other transactional errors in the dataset before compiling this report, so the data in this report will not exactly match those in the statistics notices.

Purpose of this report

This epidemiology report describes the TB epidemic in cattle in England in 2018 and includes commentary and analyses in light of the associated disease eradication policies. The report has sections that separately present and discuss the level of disease and changes over time, our success in finding new cases (surveillance) and the impact of the disease and control measures.

Bovine TB surveillance and control are complex processes and a wealth of jargon has developed over time, which has become common parlance to those closely engaged with the eradication programme. This report tries to limit its use and to include explanatory text. Technical language is explained when first used, and there is a glossary within an Explanatory Supplement² which is published concurrently with additional explanation about the disease, the data and methodologies used and the approach to control.

Interpretation of the data

The potential for finding herds that are infected with TB is directly related to (a) how hard we look – i.e. the design and effectiveness of the surveillance carried out (particularly the type and frequency of testing), and (b) the level of disease, which differs by risk area.

There are also factors that affect the probability of a herd becoming infected with TB that are unevenly distributed in the population, for example

- (i) Herd size; large herds have an increased risk of infection
- (ii) Herd type; dairy herds have an increased risk of infection
- (iii) Presence of infection in the local cattle population, which increases the chance of local transmission between cattle herds

¹ <https://www.gov.uk/government/publications/bovine-tb-epidemiology-and-surveillance-in-great-britain-2017>

² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

- (iv) Presence of TB (*M. bovis*) infection in other species to which cattle are exposed, the most important being the local badger population, which is endemically infected in much of the West of England and West Midlands.

Furthermore, changes in surveillance intensity and control measures over time exert their own effects on the measures used to track changes in the epidemic.

The analyses in this report take such factors into account to provide as accurate a measure as possible of the relative risk and frequency of TB in different herds. This enables more accurate assessment of the efficacy of applied control measures.

Eradication of bovine tuberculosis (TB) in England

Bovine tuberculosis (TB) is the most pressing animal health problem in England. It is an infectious and contagious bacterial disease, with two main reservoirs here (cattle and badgers), that threatens our cattle industry and presents risks to other livestock, wildlife and domestic pets. TB in animals can also threaten human health, although the widespread pasteurisation of cows' drinking milk and milk products largely protects the public from undisclosed cases of TB in cattle. Nevertheless, the bovine epidemic in cattle and badgers, with occasional spill-over into other domestic species, represents a low but ongoing public health risk.

In view of these impacts, bovine TB has been subject to a statutory eradication programme in England since the 1950s with substantial success over its first three decades. Progress stalled in the late 1980s and the incidence and range of endemic areas of disease increased steadily until 2010-11. In April 2014, the government published its Strategy³ for achieving Officially Bovine Tuberculosis Free Status (OTF) for England (Figure 2.1).

³ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300447/pb14088-bovine-tb-strategy-140328.pdf

Figure 2.1 Summary graphic of the England TB Eradication Strategy

The Strategy defines disease control measures that aim to achieve officially TB Free (OTF) status for England incrementally by 2038, whilst maintaining trade and an economically sustainable livestock industry. One of the key features of the current Strategy was to divide the country into three 'risk areas' defined by the level of TB, each of them with bespoke control measures. Compulsory TB controls in cattle are based on the regular testing of herds to detect disease, slaughter of positive animals and the imposition of movement restrictions following a failed test. The latter remain in place until there is sufficient evidence that TB infection has been removed from the herd. Such evidence will differ according to local circumstances, in particular the risk area in which the herd resides.

New TB surveillance and control measures introduced in England in 2018

- The boundary of the Edge Area was re-defined from 1st January 2018. Previously split HRA/Edge counties of Cheshire, Derbyshire, East Sussex, Oxfordshire and Warwickshire all became fully incorporated into the Edge Area, reducing the size of the HRA (Figure 2.1).
- Increase in the sensitivity of routine surveillance testing in the Edge Area⁴
 - Six-monthly herd tests were introduced in the higher incidence regions of the Edge Area including: the former HRA part of Cheshire (in addition to the rest of Cheshire, which has been subject to six-monthly testing since 2015), the former

⁴<https://www.gov.uk/guidance/bovine-tb-testing-intervals-2018>

HRA part of Derbyshire, the whole of Oxfordshire and Warwickshire, Berkshire west and northwest Hampshire. Annual tests were supplemented with radial testing in the rest of the Edge Area (Berkshire east, Buckinghamshire, East Sussex, the rest of Hampshire, Leicestershire, Northamptonshire and Nottinghamshire). In addition radial testing remained in place in the north and east of Derbyshire, where it has been implemented since 2015.

- Changes to statutory compensation payments for cattle removed for TB control reasons (from November 2018)
 - Defra now pay full compensation for cattle privately slaughtered, if the carcass is totally condemned by the slaughterhouse operator due to TB infection.
 - A fifty percent reduction in compensation is applied to cattle slaughtered for TB control, where the animal cannot be processed for human consumption at a slaughterhouse because of a dirty hide; and for animals moved into a TB breakdown herd, if that animal is removed as a TB reactor or direct contact before the herd regains OTF status.
 - The Tuberculosis (Non-bovine animals) Slaughter and Compensation (England) Order 2017 came into force on 2nd Jan 2018⁵. This set out revised amounts of compensation payable to deer and camelid owners, and introduced for the first time in England specific rates of statutory compensation for other non-bovine farmed species (pigs, sheep and goats).
- Eleven new Badger Control Programme (BCP) areas were licensed by Natural England⁶
 - Ten new areas were introduced in the HRA, and one in the LRA, bringing the total number of BCP areas to 32, including two areas that have moved into a phase of licensed Supplementary Badger Control (See Chapter 4, TB control in wildlife).

⁵<http://www.legislation.gov.uk/ukxi/2017/1254/contents/made>

⁶https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765439/badger-control-monitoring-2018.pdf

3. The TB epidemic in England

3.1 Incidence, geographic distribution and trends over time

- In 2018 changes were made to the boundary between the High Risk Area (HRA) and Edge Area. The five split counties that used to straddle the HRA and the Edge Area fully moved into the Edge Area. In this report, TB trends by risk area have applied the current 2018 spatial boundaries to all years, and HRA and Edge Area totals are therefore not comparable with figures published in previous reports.
- In 2018 there were 3,607 new TB incidents in England as a whole, the lowest number disclosed since 2009. In recent years the total numbers per annum have remained relatively stable, between 3,600 and 4,000 since 2010. As in previous years, most new incidents (76.5%) occurred in the High Risk Area (HRA), with 19.9% in the Edge Area and 3.6% in the Low Risk Area (LRA).
- The lower number of new TB incidents disclosed in England in 2018 compared to 2017 was driven by a marked reduction in the HRA. The number of incidents increased in the Edge Area and (very marginally) in the LRA.
- Since the start of 2011 the epidemic appears to have slowed indicating that the epidemic as a whole in England is plateauing. However, the current quarterly number of incidents is still more than double the number before the UK outbreak of foot-and-mouth disease in 2001.
- Within the HRA, the TB incidence rate has fluctuated between 18 and 20 incidents per 100 herd years at risk between 2011 and 2018; and was 18.5 incidents per 100 herd years at risk in 2018. Since 2010, there has been a continued increase in TB incidence within the Edge Area to 9.2 incidents per 100 herd years at risk in 2018, whilst incidence has remained very low and stable during the same period in the LRA (less than one TB incident per 100 herd years at risk).
- Lesions typical of TB and/or positive culture results for *Mycobacterium bovis* were detected in cattle removed from 68% of new incidents in the HRA, 56% in the Edge Area and 29% in the LRA (OTF-W incidents).
- There was a net spread of 506km² of the areas considered to harbour endemic *M. bovis* infection in England overall (2017-18), i.e. expansion of certain parts of the 'endemic TB area' exceeded retraction elsewhere.
- In 2018, 219 premises with non-bovine species were under movement restrictions due to a TB incident. Goat premises were most frequently identified (87), followed by South American Camelids (60).

Changes to the HRA and Edge Area boundary

In 2018 there was a change to the spatial boundary separating the HRA and Edge Area. Previously split counties that used to straddle the HRA and the Edge Area (Cheshire, Derbyshire, East Sussex, Oxfordshire and Warwickshire) fully moved into the Edge Area. This caused an increase in the size of the Edge Area and a decrease in the size of the HRA, relative to previous years. To allow for a consistent comparison, TB trends exploring changes in the TB epidemic by region in multiple years have applied the 2018 spatial boundaries to all years. Pre-2018 HRA and Edge Area figures presented in this report are therefore not comparable to those published in previous reports. Where 2017 data within the historical (pre-2018) boundary lines of the HRA and Edge Areas are presented, this is clearly labelled. As a result of the boundary change between the HRA and Edge Area, herds previously located in the HRA that moved into the Edge Area became subject to more stringent control measures, including six monthly testing and mandatory interferon gamma testing. This will exert an additional influence on the level of new TB cases disclosed in 2018 compared to previous years.

Number of TB infected herds

The number of herds newly infected with TB that were detected during the year (new herd incidents) reflects the control effort needed and the impact on individual farmers, but can be misleading in terms of comparisons between years⁷.

In 2018, the total number of newly infected herds decreased in England overall compared to 2017, driven by a marked drop in the number of newly infected herds detected in the HRA. In the Edge Area the number of newly infected herds increased in 2018 compared to 2017. The LRA experienced a very marginal increase.

The LRA had 129 TB incidents in 2018, a slight increase compared to 2017 (n=123), but fewer than in recent years (156 in 2015 and 137 in 2016). Just under a third of new TB incidents in the LRA (n=37, 29%) were lesion and/or culture positive (i.e. fully confirmed or OTF status withdrawn (OTF-W)). Note that as the skin test has a lower positive predictive value when there is very low level of disease, OTF-W incidents are a better measure of both disease incidence and prevalence in the LRA than elsewhere in England. In contrast, the higher level of TB in both the Edge Area and HRA means that a positive skin test result (i.e. a test reactor) is a good indicator of infection in that herd, irrespective of post-mortem and laboratory results (See Explanatory Supplement⁸ for further details). The proportion of TB incidents that were OTF-W in the HRA and Edge Area was 68% and 56%, respectively in 2018. Overall, the proportion of TB infected herds that were OTF-W in England decreased in 2018 compared to 2017, a trend that was observed in all three risk areas.

In summary, the highest levels of TB in England were found in the HRA, where 41% of cattle herds are registered. The LRA, which also contains 41% of cattle herds has the fewest TB

⁷ The number of herds and of herds that are tested, and choice of test and the way tests are interpreted, changes between years, and the majority of incidents are found by skin testing of cattle on farms, so the number of new cases found only partly reflects the true disease (incidence) level in the cattle population.

⁸ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

incidents; while the Edge Area, which includes 18% of cattle herds, had a moderate level of TB in 2018. The proportion of OTF-W TB incidents was highest in the HRA and lowest in the LRA (Table 3.1.1).

Table 3.1.1 Number of TB infected herds¹ and incidence rate² in England, by risk region, 2017 & 2018

		High Risk Area (HRA)	Edge Area	Low Risk Area (LRA)	England
New TB incidents (% of total for England)	2018	2,761 (76.5) ↓	717 (19.9) ↑	129 (3.6) ↑	3,607 ↓
	2017 ⁴ (2018 boundaries)	3,033 (79.5)	660 (17.3)	123 (3.2)	3,816
	2017 ⁵ (pre-2018 boundaries)	3,259 (85.4)	434 (11.4)	123 (3.2)	3,816
TB infected herds that were lesion and/or culture positive (OTF-W incidents) (% of total for risk area)	2018	1,868 (67.7) ↓	405 (56.5) ↓	37 (28.7) ↓	2,310 (64.0) ↓
	2017 ⁴ 2018 boundaries	2,166 (71.4)	413 (62.6)	50 (40.7)	2,629 (68.9)
	2017 ⁵ pre-2018 boundaries	2,327 (71.5)	252 (58.0)	50 (40.7)	2,629 (68.9)
TB incidence rate per 100 herd-years at risk³ (% change from 2017 – according to 2018 risk area boundaries)	2018	18.5 (-6.7) ↓	9.2 (+1.7) ↑	0.8 (-19.1) ↓	9.4 (-14.7) ↓
	2017 ⁴ (2018 boundaries)	19.8	9.1	1.0	11.0
	2017 ⁵ (pre-2018 boundaries)	19.2	7.7	1.0	11.0

¹Includes all herds with a new TB incident identified in 2018 regardless of *Mycobacterium bovis* infection confirmation status (OTF herd status withdrawn (OTF-W) with at least one lesion and/or tissue culture positive animal and OTF herd status suspended (OTF-S) cases, not yet confirmed by lesion or positive tissue culture of *Mycobacterium bovis*).

² see Explanatory supplement for further explanation regarding how incidence rates are calculated.

³Calculated from all incidents including OTF-W and OTF-S cases; incidence rate of OTF-W only cases was 0.2 per 100 herd years at risk, a decrease on 2017 (0.4).

Note – red upward arrow denotes increase in number from 2017, green arrow denotes decrease from 2017 and amber arrow denotes no change

⁴Includes herds in the HRA and Edge Area defined by the spatial boundaries in 2018, therefore comparable with the 2018 data.

⁵Includes herds in the HRA and Edge Area defined by the spatial boundaries 2011-2017, therefore accurately reflects the situation as it was in 2017

Temporal trends in the number of new TB infected herds detected in England

From 1986 to 2000, before the foot and mouth disease (FMD) outbreak in 2001, the number of herds newly infected with TB was rising at a year on year rate of over 14% and the time it was taking for the epidemic to double in size was estimated at 5.3 years (Figure 3.1.1a).

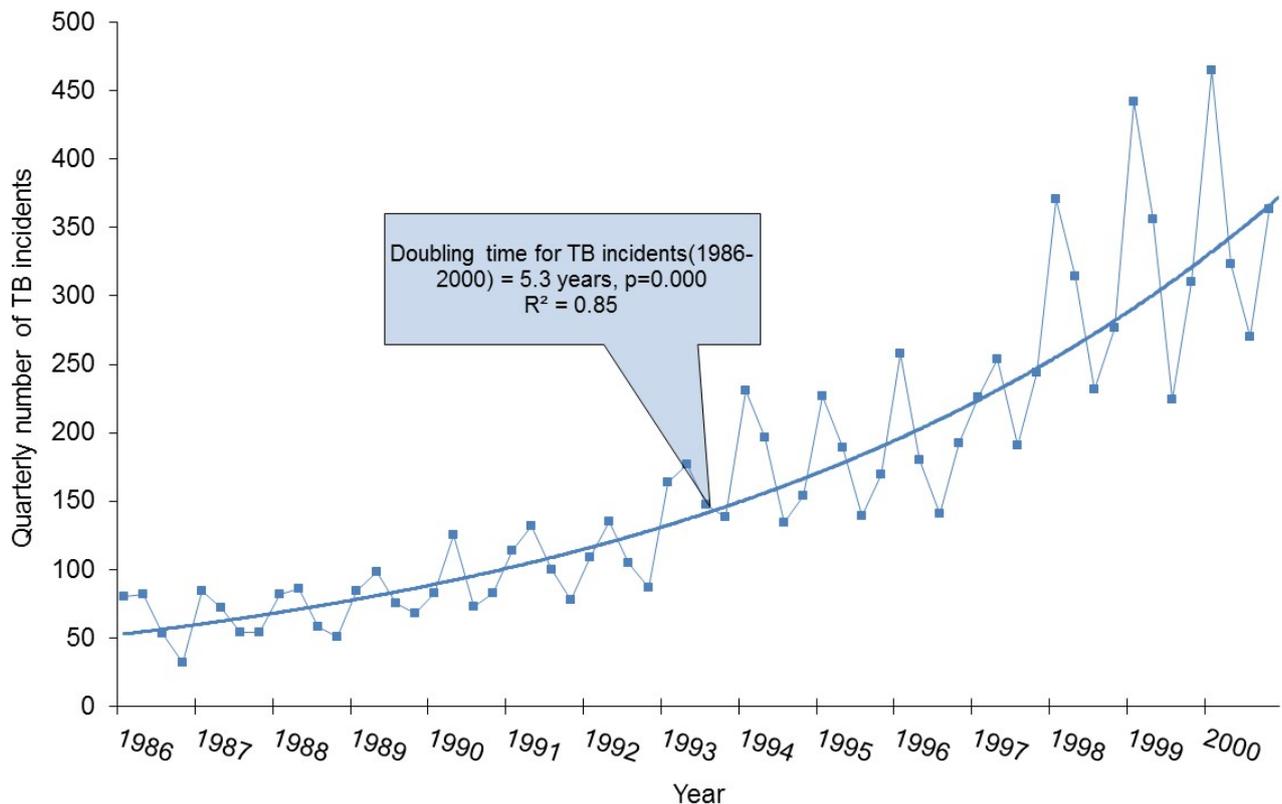


Figure 3.1.1a Quarterly totals for new TB incidents detected in England between January 1986 and December 2000

- The doubling time indicates the time it would take for incidents to double in number, given the trend of the data. The R^2 indicates 'goodness of fit' of the superimposed trend line to the raw data (quarterly values) and here shows this is an accurate estimate (an R^2 of 1 would indicate a perfect fit).

Surveillance testing and control measures and movement patterns in cattle herds across GB were disrupted during the FMD epidemic in 2001, and the number of TB infected herds increased rapidly over this period, leaping from 363 in the last quarter of 2000 to 662 in the last quarter of 2002 with a 25.3% annual rate of increase.

The rate of increase in TB incidents reduced once controls were re-established after the FMD epidemic (Figure 3.1.1b). From 2003 to 2010 the epidemic continued a steady but significant ($p=0.005$) upward trend with an annual rate of increase for all incidents of 5.6% (doubling time of 12.8 years). Since the start of 2011 the epidemic appears to have slowed indicating that the epidemic as a whole in England is plateauing (note that the current quarterly number of incidents is still more than double that before FMD).

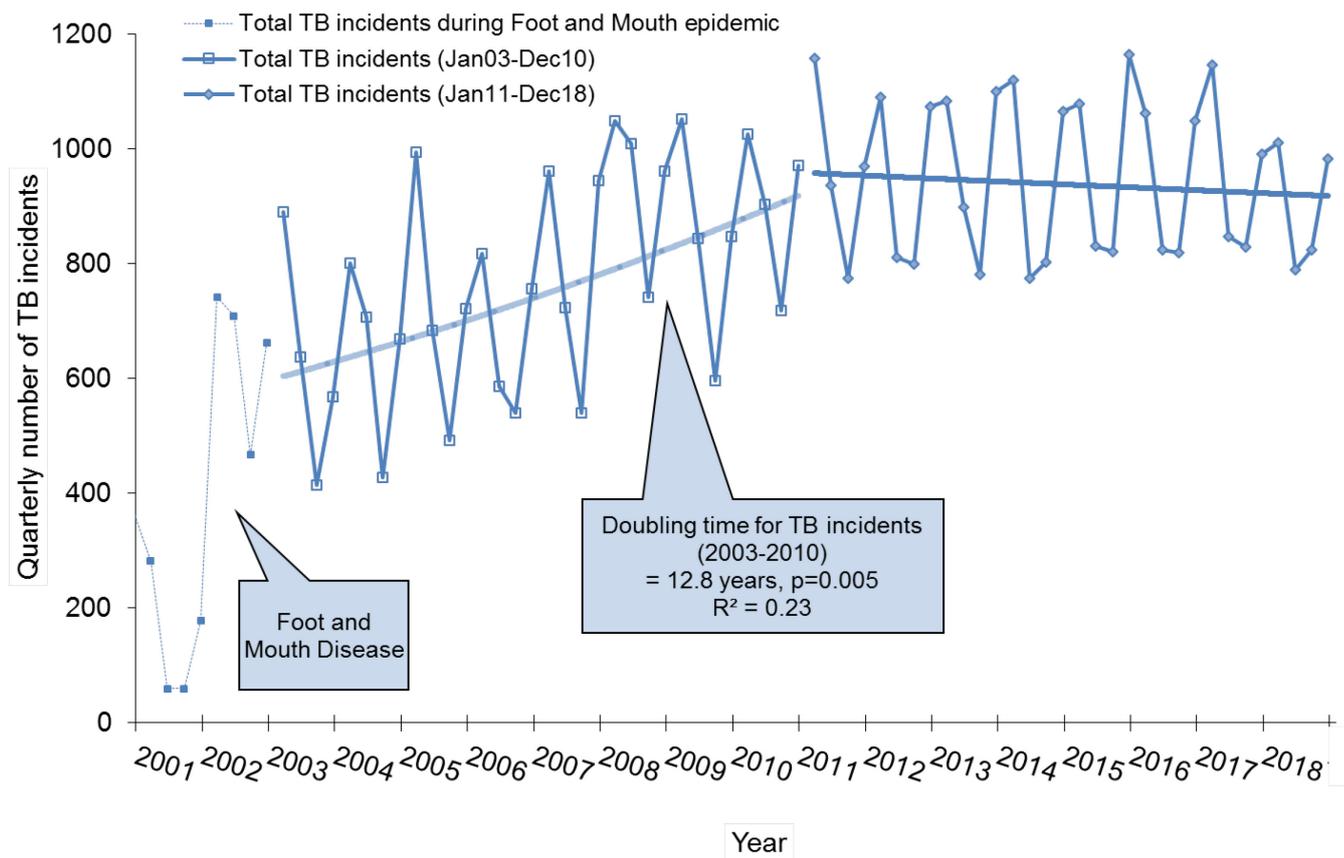


Figure 3.1.1b Quarterly totals for new TB incidents detected in England between January 2001 and December 2018

- Trend lines are shown for the two periods 2003-2010 and 2011-2018. The doubling and halving times, respectively, indicate the time it would take for incidents to double or halve in number, given the trend of the data. This is shown for the period 2003-2010 and 2011-2018 separately. The R^2 value indicates 'goodness of fit' of the superimposed trend line to the raw data, and here shows the trend was quite erratic in both time periods, largely due to seasonal trends (an R^2 of 1 would indicate a perfect fit).
- The upward trend observed between 2003 and 2010 was significant, but for the period 2011-2018 the epidemic appears to be now plateauing.

The total number of new TB herd incidents in England decreased in 2018 to 3,607, however the level has remained fairly stable at between 3,600 and 4,000 since 2010 (Figure 3.1.2a). This is despite the expansion of the annual surveillance testing area, the introduction of radial testing in the LRA and the then Edge Area parts of Derbyshire and Cheshire from 2013 and the adoption of six monthly surveillance testing of herds in parts of the Edge Area (adopted in Cheshire in 2014 and in high incidence parts of the Edge Area in 2018 (see Section 2, Figure 2.1 for details of testing zones). However, the proportion of new incidents found each year in the Edge Area has increased since 2013 when annual surveillance testing was first introduced throughout the area.

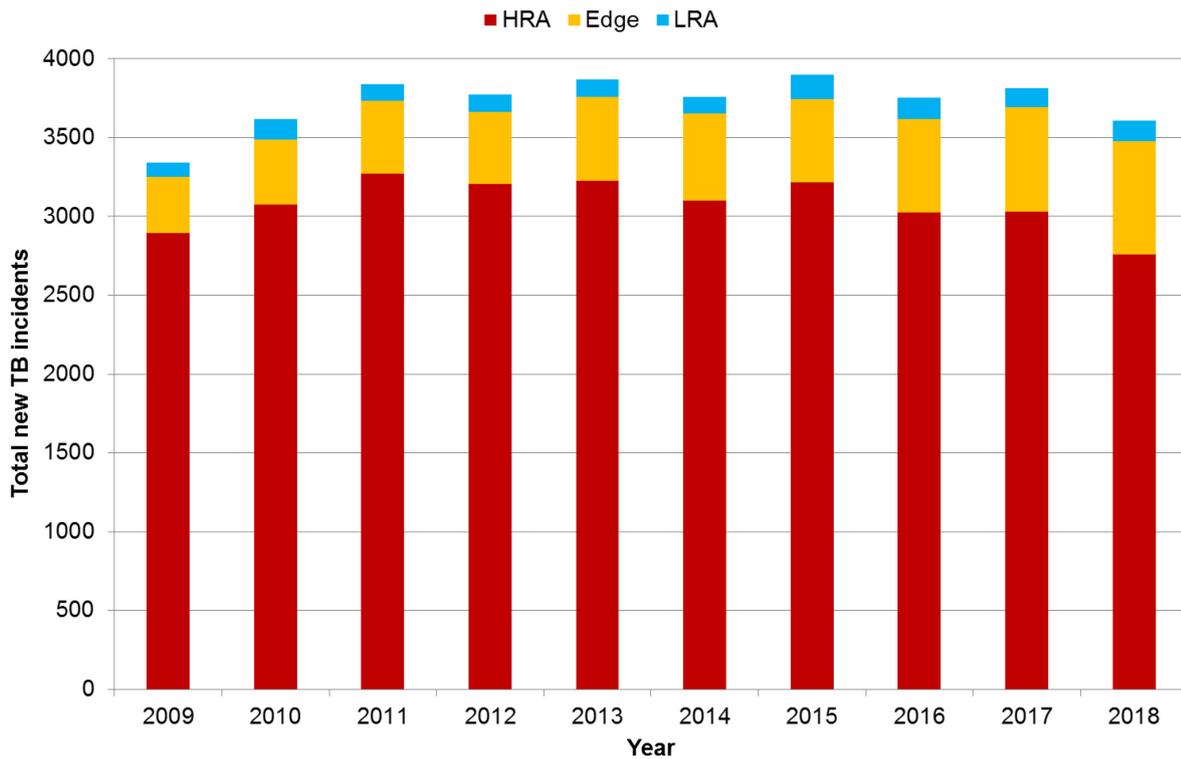


Figure 3.1.2a Annual trends in the total number of new TB infected herds, by risk area

- The total number of new TB incidents has ranged between 3,600 and 4,000 since 2010.
- The introduction of annual testing for herds in the Edge Area in 2013, and the subsequent introduction of six monthly testing in some parts of the Edge Area since 2016 contributed to the increased proportion of new TB incidents detected there. The increasing trend continued in 2018.
- The number of new TB incidents in the HRA decreased in 2018.

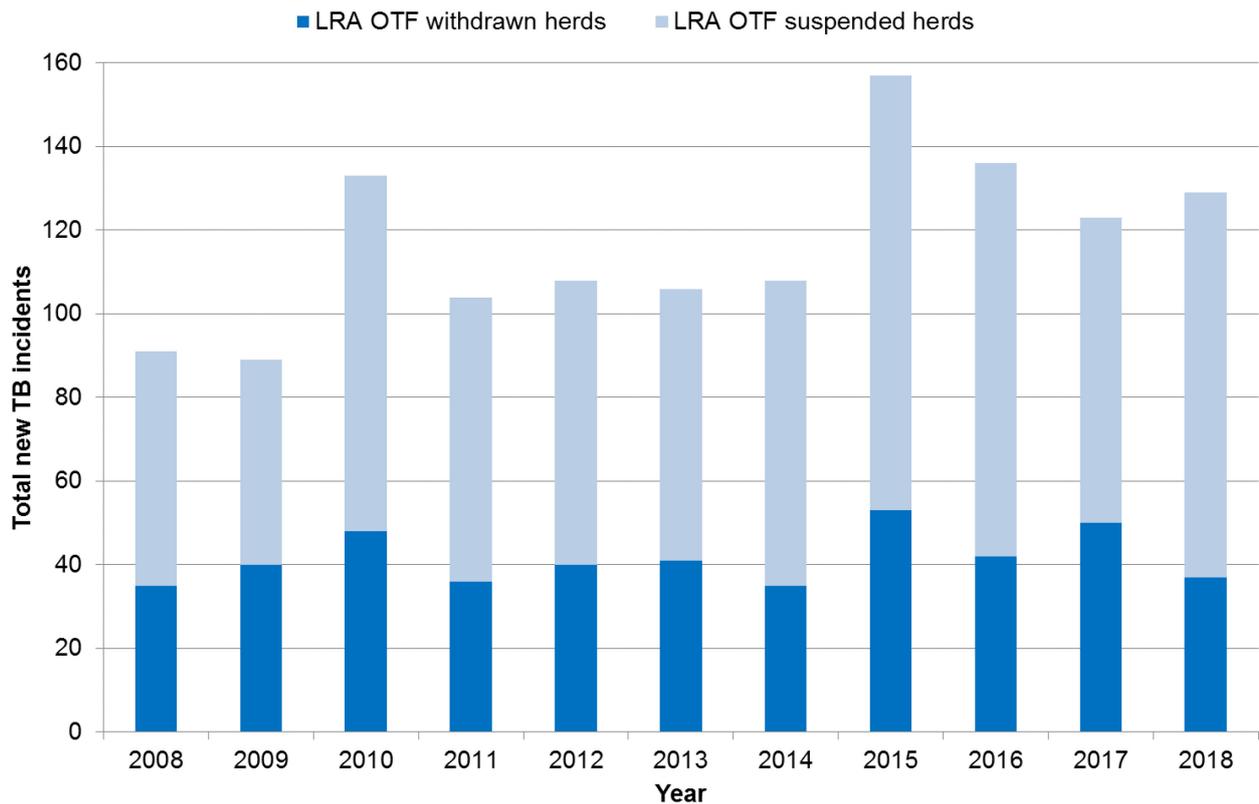


Figure 3.1.2b Annual total number of TB incidents in the LRA, by post-mortem result status (Officially Tuberculosis Free status withdrawn (OTF-W) and OTF status suspended (OTF-S)).

- The number of herds in the LRA with fully confirmed *M. bovis* infection (OTF status withdrawn) has not varied much over the past ten years. Although it was highest in 2015 (n=52), there is no obvious temporal trend.
- In 2018, one third of new TB incidents in the LRA were fully confirmed at post-mortem and/or culture (OTF-W).

The number of new TB incidents reported within each county of the HRA, Edge Area and LRA was highly variable in 2018, consistent with previous years (Figure 3.1.3a-c). Further analysis and discussion on new TB incidents in individual counties of the Edge Area and LRA are presented in the Year End Descriptive Epidemiology Reports⁹. Further details about the epidemiology of TB within the HRA can be found in this report, in Section 4 (Epidemiology of TB in the High Risk Area).

⁹ <https://www.gov.uk/government/publications/bovine-tb-epidemiology-reports-2018>

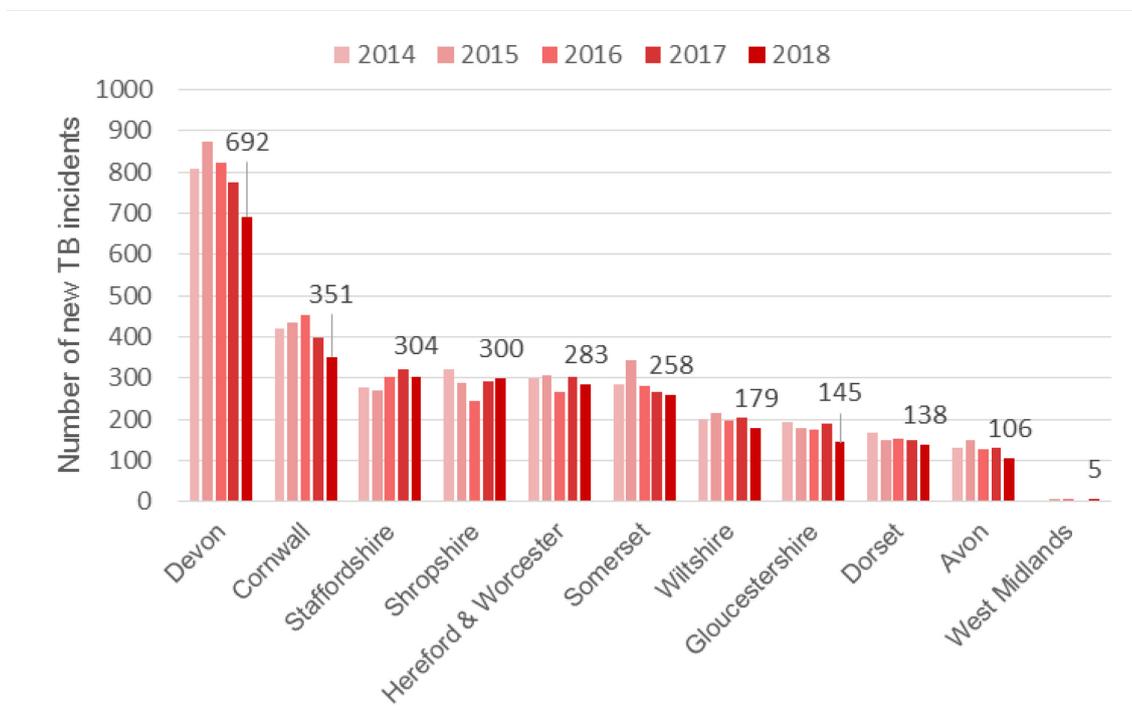


Figure 3.1.3a Annual total number of new TB incidents (OTF-W and OTF-S) by HRA county 2014 to 2018 (2018 incidents labelled on chart)

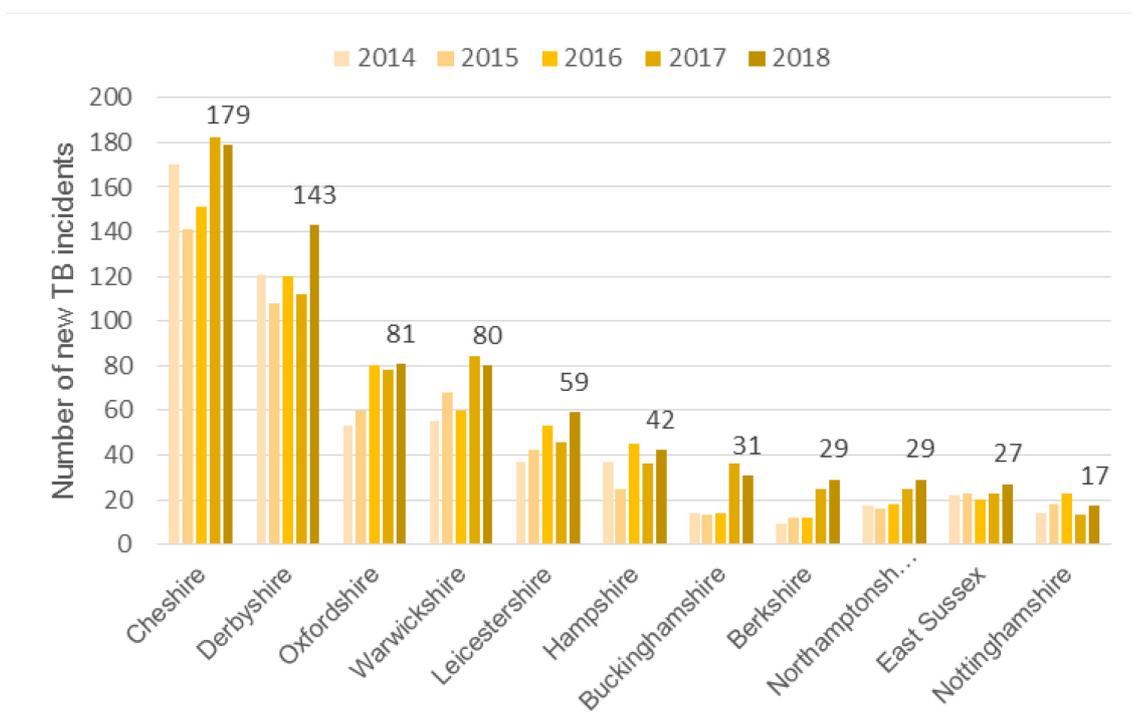


Figure 3.1.3b Annual total number of new TB incidents (OTF-W and OTF-S) by Edge Area county 2014 to 2018 (2018 incidents labelled on chart)

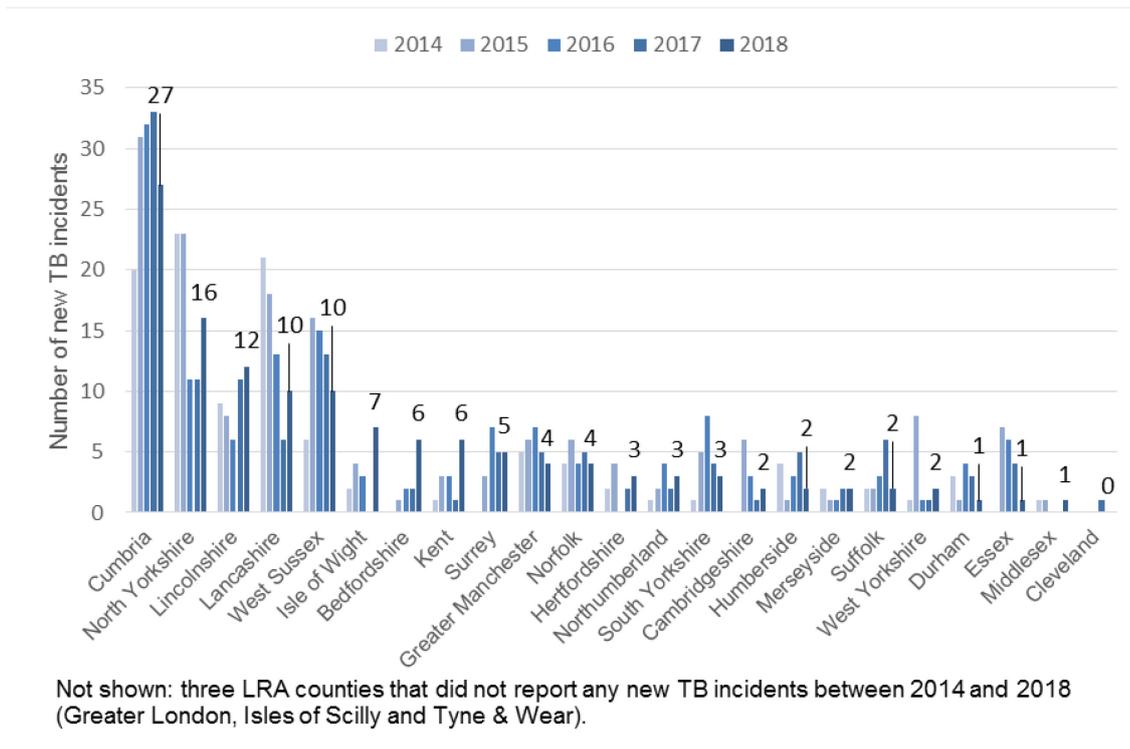


Figure 3.1.3c Annual total number of new TB incidents (OTF-W and OTF-S) by LRA county 2014 to 2018 (2018 incidents labelled on chart)

Annual herd incidence rate and geographical distribution of new TB incidents

Current Situation

The TB epidemic in England is best measured by the herd incidence rate¹⁰, which reflects the rate at which herds become newly infected. The annual incidence rate of TB in England in 2018 was 9.4 TB incidents per 100 herd-years at risk. This rate has fluctuated by one or two per cent over the past decade and has been following a slightly increasing trend overall, with a drop every fourth year (2006, 2010, 2014) (Figure 3.1.4).

This pattern was repeated in 2018 with a statistically significant ($p < 0.001$) decrease in incidence rate from 11.0 in 2017 to 9.4 in 2018 (-14.7%). However, the number of newly infected herds only slightly decreased in 2018 compared to 2017 (-5.5%). The change in incidence was largely driven by a 10.8% increase in the number of OTF herds tested (measured by herd years at risk), compared to 2017.

Similar increases in the number of herds tested compared to the previous year were observed in 2006 (44.8%), 2010 (27.2%) and 2014 (11.3%). This is thought to be an artefact

¹⁰ In this report the incidence rate is calculated as number of any new TB incident per ‘100 herd-years at risk’ which compensates for changes in the number of herds over time, for differences in how often herds are tested between areas, and for delays in testing. This enables a more accurate comparison between areas and between years than the just the number of incidents that occur.

of the four yearly testing regime in the LRA coupled with the knock on effect of the FMD crisis in 2001. An inflated population of herds were tested in 2002 in the wake of FMD and every fourth year those herds are re-tested. Over time, the effect of this event on the data is diminishing, but still needs to be considered when comparing consecutive years. Measures (incidence, prevalence, number of new herds infected), and years should not be examined in isolation when assessing the impact of control strategies.

When considering incidence trends within the HRA and Edge Area, the static spatial HRA and Edge Area boundaries as defined in 2018 were applied to all years. Despite the four yearly trend, limited fluctuation has been observed in England as a whole (Figure 3.1.4). TB incidence in the Edge Area, however, has been increasing since 2013, and this increase continued in 2018, with a rise in TB incidence of 1.7% compared to 2017, from 9.1 to 9.2 TB incidents per 100 herd-years at risk (Table 3.1.1 and Figure 3.1.4). The slight increase in TB incidence in the Edge Area, likely to be related in part to the increased testing frequency for some Edge Area herds, was not statistically significant in 2018 compared to 2017 ($p=0.758$), however the continued upward trend remains a concern.

Incidence in the HRA decreased by 6.7% in 2018, a statistically significant drop ($p=0.009$). Both the denominator (herd-years at risk) and the numerator (number of TB incidents) declined in the HRA in 2018, while in the Edge Area both values increased compared to 2017.

In the LRA, the incidence rate has remained stable and two thirds of the new TB incidents were not fully confirmed by post-mortem tests of TB suspect animals (Figure 3.1.2b).

TB surveillance and case management policy changes implemented in 2017 and 2018 aim to support timely detection of infected herds in the Edge Area where incidence has continued to increase. These are further discussed in Section 3.3 and in the Explanatory Supplement, which details the new policy changes that have been implemented.

In the HRA approximately one in seven herds experienced a new TB incident in 2018. This was slightly lower compared to 2017.

There are substantial differences in TB incidence rates between risk areas as well as between counties within the same risk area (see Table 3.1.1, Figure 3.1.5). Historical trends in TB incidence rate show that overall incidence rates in the HRA and LRA have been relatively stable since 2011 as have the numbers of incidents, however there has been an increase in the Edge Area over the same time period (Figure 3.1.4).

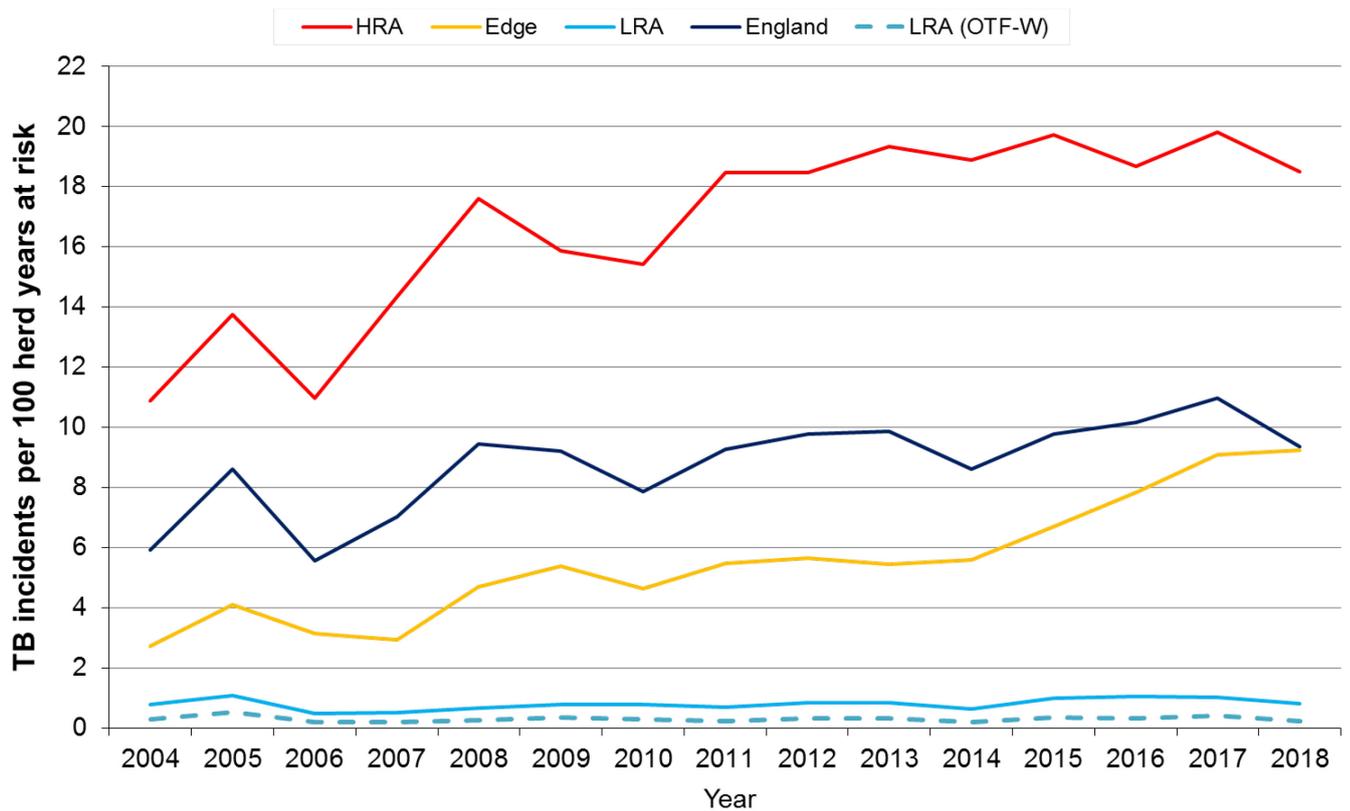


Figure 3.1.4 Annual incidence rate (per 100 herd-years at risk (HYR)) for England and by risk area, from 2004 to 2018.

- The decrease in incidence rate in England as a whole was significant in 2018 compared to 2017 ($p < 0.001$), but it is important to consider long term trends when interpreting this data.
- Incidence rates have been relatively stable in the LRA and HRA since 2011. The decrease in the HRA in 2018 compared to 2017 was statistically significant ($p = 0.009$), while the slight decrease in the LRA was not significant ($p = 0.093$).
- The incidence rate has continued to rise over the same period in the Edge Area, however the increase in 2018 compared to 2017 was not significant ($p = 0.758$).

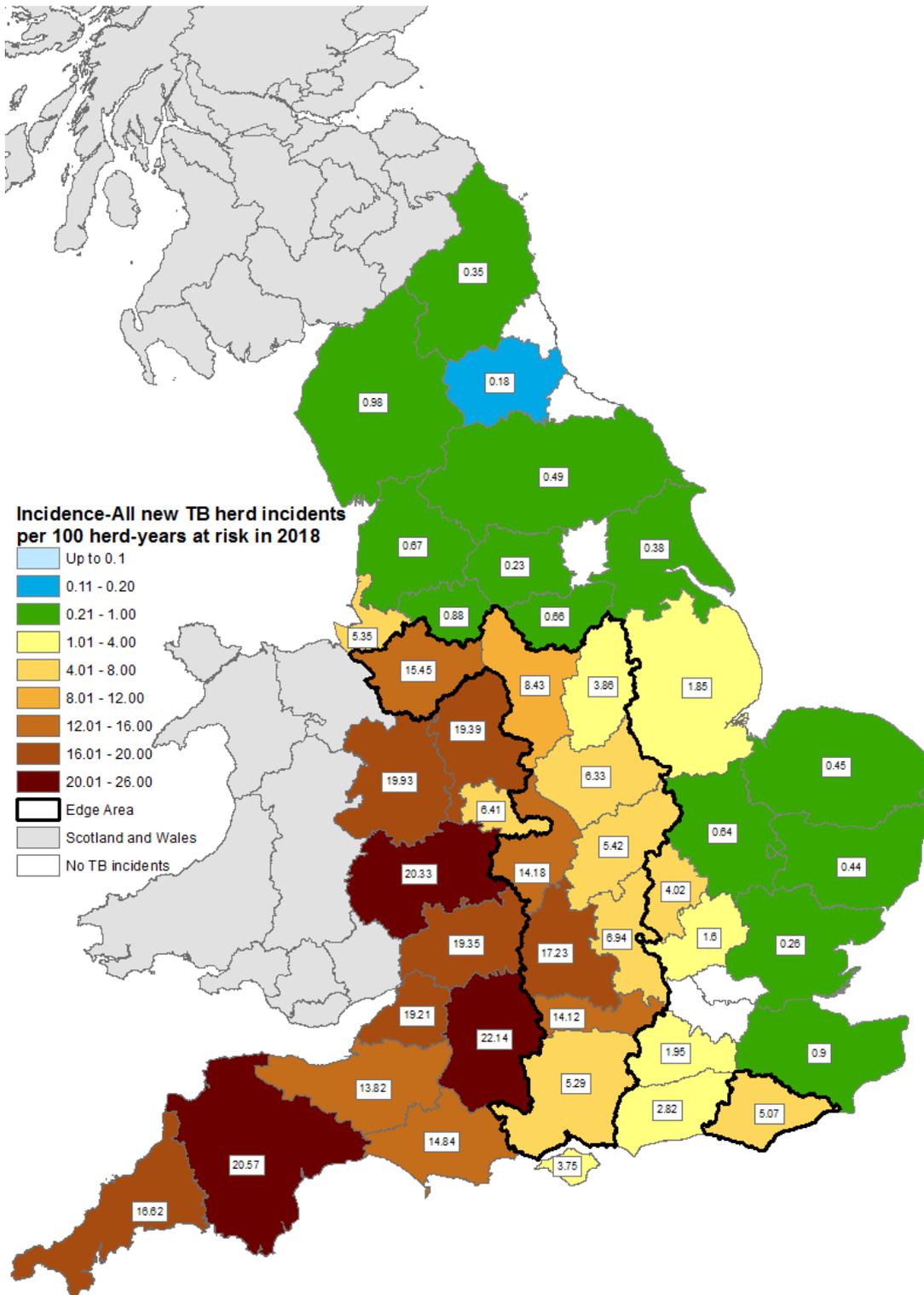


Figure 3.1.5 County incidence of all TB incidents per 100 herd years at risk in England in 2018

- There is wide variation in incidence rates by county and risk area. Incidence was highest overall in the HRA counties, particularly Wiltshire, Hereford and Worcester and Devon.

Spatial changes in the TB epidemic

Changes between 2017 and 2018 in the areas of England that can be defined as 'endemically infected' have been assessed (see Explanatory supplement for definition and methodology for endemic infection). The results of this methodology can be influenced by areas of low cattle density and local purchasing behaviour, which in isolated cases may give the appearance of spread or retraction as the result of these factors, and not the endemicity of TB in cattle populations. Overall, the comparison shows that the majority of the HRA is, and remained, 'endemically' infected, along with areas in the Edge, particularly where they border the HRA. Most of the rest of England, particularly the LRA, is not 'endemically' infected. Veterinary assessment has highlighted most of the changes in the South West of England are associated with low herd densities, while the endemicity identified in West Sussex is most likely purchase driven. Elsewhere spread and retraction observations broadly reflect the situation observed locally.

In England there was calculated to be approximately 2,937.8km² of spread in some parts of this endemically infected area and 2431.4km² of retraction in other parts, resulting in a net change of 506.4km² from 2017-2018. The net spread refers to the area for which rate of spread was able to be calculated, which does not include a few isolated areas that have appeared but not joined up with previous endemic areas yet.

TB Spread and Retraction 2017 - 2018

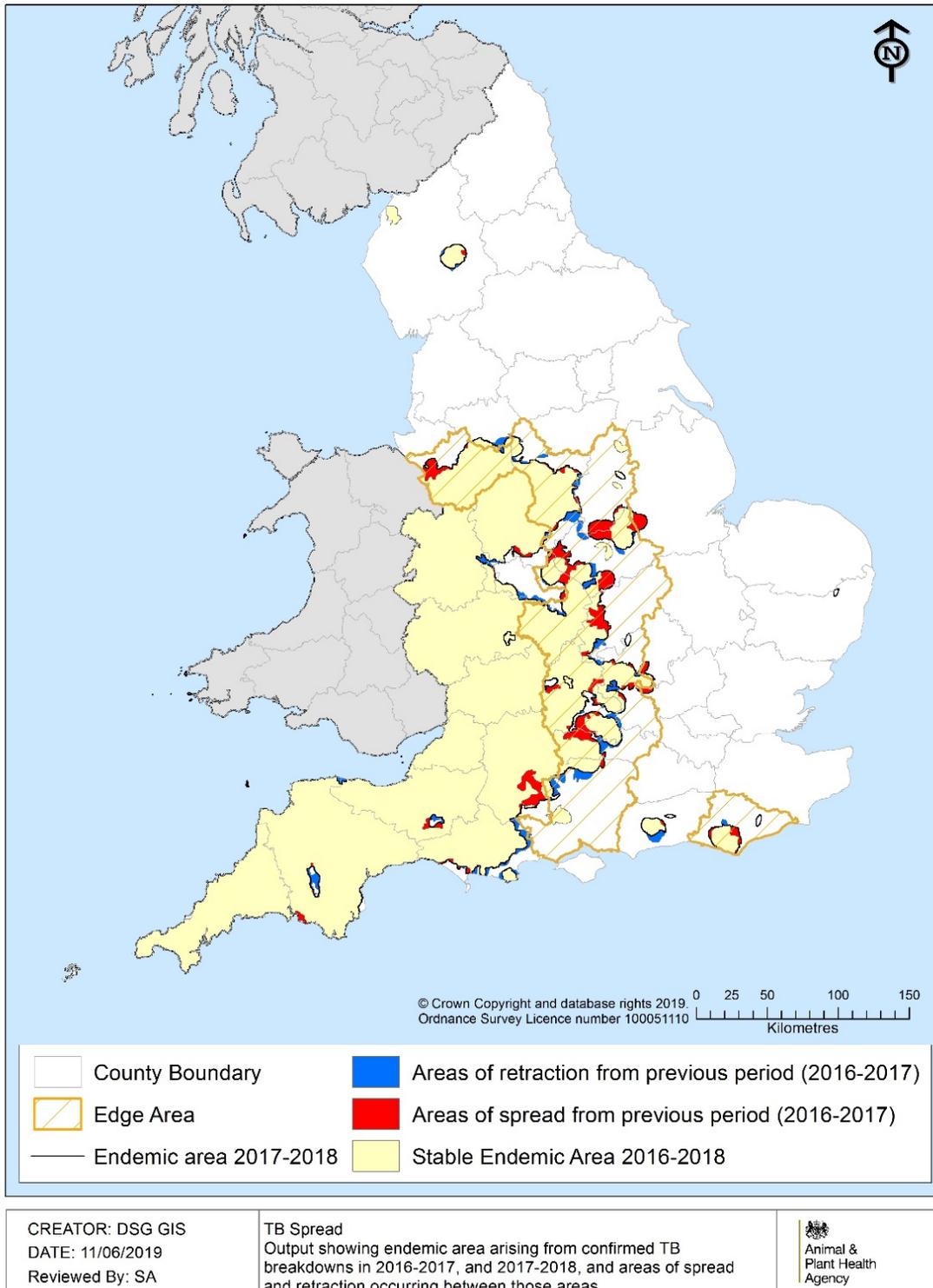


Figure 3.1.6 Spread and retraction of endemic TB areas in 2018 compared to 2017

- There was a net change of 506.4km² in the calculated endemic area from 2017-2018

TB in other animals

Specific procedures are in place to deal with TB incidents in species other than cattle. Table 3.1.2 summarises statistics on TB in non-bovine species, which is an extract of data from TB in non-bovine species 2011-2018¹¹, updated on 17th July 2019.

In England in 2018, the highest proportion of premises with non-bovine species under movement restrictions due to a TB incident was goat premises (40%), followed by South American camelid (SAC) premises and pig premises (27% and 17%, respectively).

Table 3.1.2 Data on bovine TB in species other than cattle in England in 2018

	SA Camelids	Sheep	Goats	Pigs	Deer	Other
Premises under movement restrictions at the end of the period due to TB incident	60	6	87	38	18	10
Total tests carried out on individual animals	4,314	2,132	24,325	122	500	162
Reactors slaughtered	72	6	97	5	8	0
Animal specimens which underwent laboratory culture	61	16	17	261	54	30
Animal specimens that were culture positive for <i>M. Bovis</i>	22	0	12	25	25	11

¹¹ <https://www.gov.uk/government/statistical-data-sets/other-tb-statistics>

3.2 Characteristics of herds found infected with TB

- Four key factors increased the risk of a herd sustaining a TB incident in England in 2018:-
 1. having over 300 cattle,
 2. being located in the HRA,
 3. being a dairy herd and
 4. having experienced a TB incident in the past three years.
- These risk factors often co-exist in the same herd, with herds in the HRA tending to be larger, and many dairy herds being large, located in the HRA and having a history of TB.
- There is a substantial population of cattle in the north of England that is not infected, showing that other factors are also important. These factors include the existing level of infection in the local cattle population and the presence of TB infection in other susceptible species that, along with cattle, act as maintenance hosts of *M. bovis* (particularly badgers) in a shared environment.
- Analysis shows that the probability of TB being found in a dairy herd was more than twice that of a beef herd, reflecting the large part of the burden of TB that is carried by the dairy industry. Adjusting for both herd size and location (i.e. looking at any herd of a given size in a given TB risk area) shows that dairy herds had a twenty one per cent greater risk of infection than beef herds ($p < 0.001$). This is in contrast to previous years (prior to 2016), when the differences between beef and dairy risk could be explained by location and herd size, and this warrants further investigation.
- A history of TB infection was also an important risk factor in all risk areas. Across England over half the herds that were found infected in 2018 had sustained a previous TB incident within the last three years. Recurrence was highest in the HRA (58%) followed by the Edge Area (38%) and LRA (6%).
- The most likely source of TB infection, assessed for each TB incident by epidemiological veterinary assessment, varied by region in 2018. Within the HRA, badgers constituted 64% of the attributed source, weighted by the level of veterinary certainty. In the Edge Area, the source was still most strongly ascribed to badgers (57%), but cattle movements (22%) were also identified as posing a high risk of introduction, and considerable variation was seen between counties. In the LRA, TB incidents were most strongly attributed to cattle movements (32%).
- Most TB incidents from which *M. bovis* was recovered and typed were attributed to a locally abundant genotype (strain) of the bacterium (78%), i.e. they occurred within the expected 'home range' of the isolated strain.

Factors associated with the likelihood that a herd will become infected

Many factors are associated with the risk of a herd becoming infected with TB, including local herd density, herd size and type, TB history and the geographical location of a herd. Other factors are also important in explaining the distribution of TB, such as contiguous herds (and their TB history), herd management (such as cattle purchasing) and environmental/wildlife factors.

Local herd density

Herd size and the local density of herds are closely associated with the risk for a particular herd to become infected with TB and these factors make a strong contribution to the spatial pattern of the TB epidemic in England (Figs 3.2.1a and b).

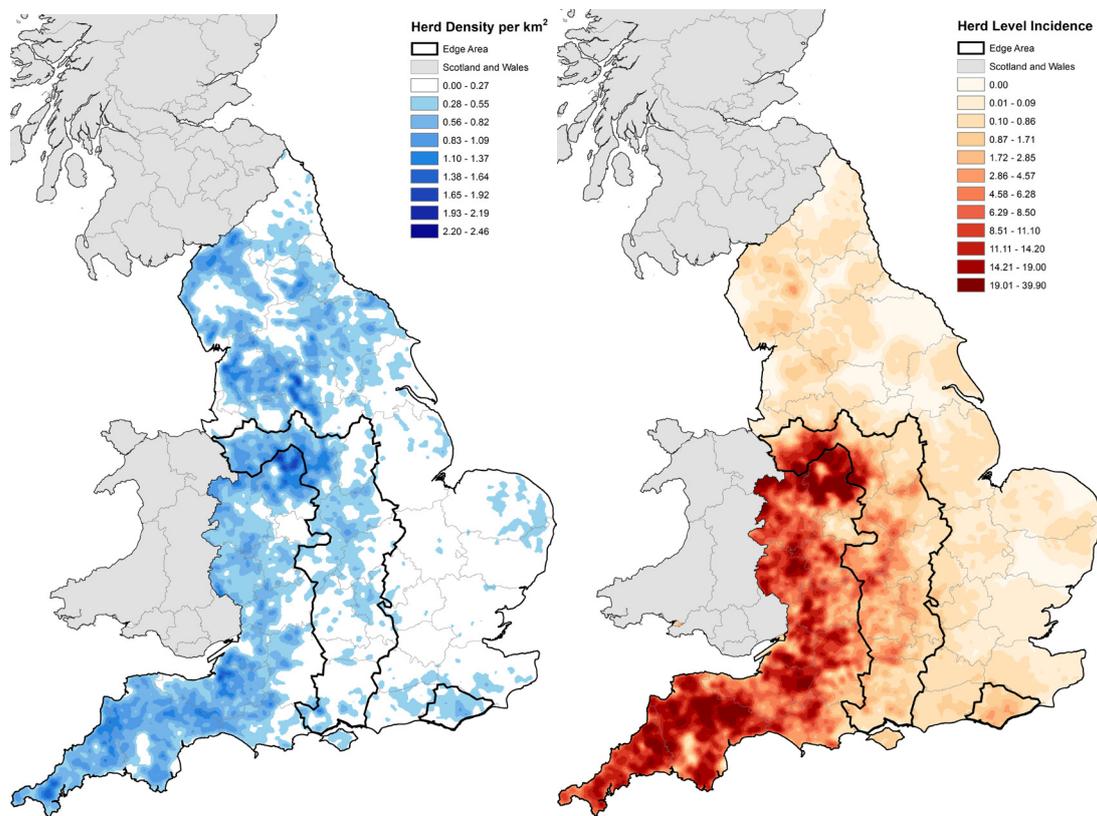


Figure 3.2.1(a) Herd density and (b) herd level incidence of TB in England in 2018. Herd density is measured as the number of herds per square kilometre; herd incidence is the average incidence in the 100 closest herds to each herd location which ‘smooths’ the effect of administrative boundaries

- The highest numbers of cattle and the highest density of herds are mostly found in the HRA and parts of the Edge Area. The sparsest population in terms of both holding and cattle numbers is found in Eastern England.
- However, cattle demographics alone cannot explain the geographic distribution of TB as can be seen by the differences between the maps, particularly in Northern England, where cattle density is high in places but TB incidence is low.

Other factors are also important in explaining the distribution of TB such as herd type, size of herds, their TB history, proximity to other infected herds, herd management (such as cattle purchasing) and environmental/wildlife factors.

Herd size and type

Figure 3.2.2 shows the proportional distribution of herds within each surveillance risk area by size and type in 2018. This has remained similar in recent years. Herds with over 200 cattle, which have been shown to have a higher risk of infection with TB, form less than 15% of all herds in the LRA but 19% in the HRA (17% in the Edge Area). This may account for some of the difference in disease level between these two areas.

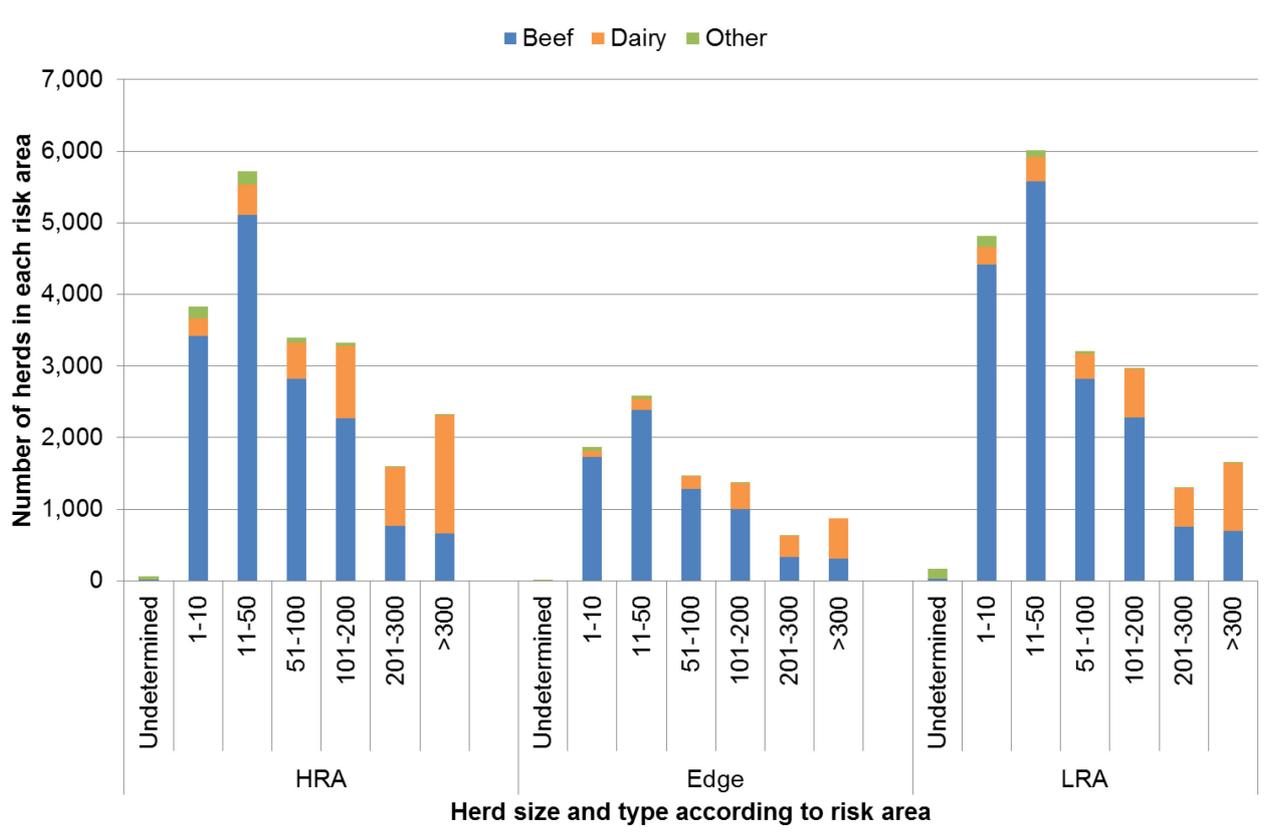


Figure 3.2.2 Proportion of herds by type and herd size in each risk area of England

- A greater number of large herds, and dairy herds are located in the High Risk Area.

Overall, the proportion of TB incidents that were disclosed in beef and dairy herds since 2007 has been fairly consistent at close to 60% in beef and 40% in dairy (one percent or fewer in herd types classed as ‘Other’). However, there are many more beef than dairy herds, so this does not reflect their likelihood of becoming infected. Figure 3.2.3a shows that dairy herds had nearly three times the risk of becoming infected (incidence) in 2018 than beef herds, however much of this can be explained by the fact that dairy herds also tend to be large herds and are more commonly located in the HRA (3.2.2).

There are differences in both the number of TB infected herds and incidence rates (which reflect a herd’s likelihood of becoming infected), across herd types and herd size categories and this also varies across risk regions in England. Rates for new TB incidents starting in England in 2018, according to these demographics, are shown in Figure 3.2.3a.

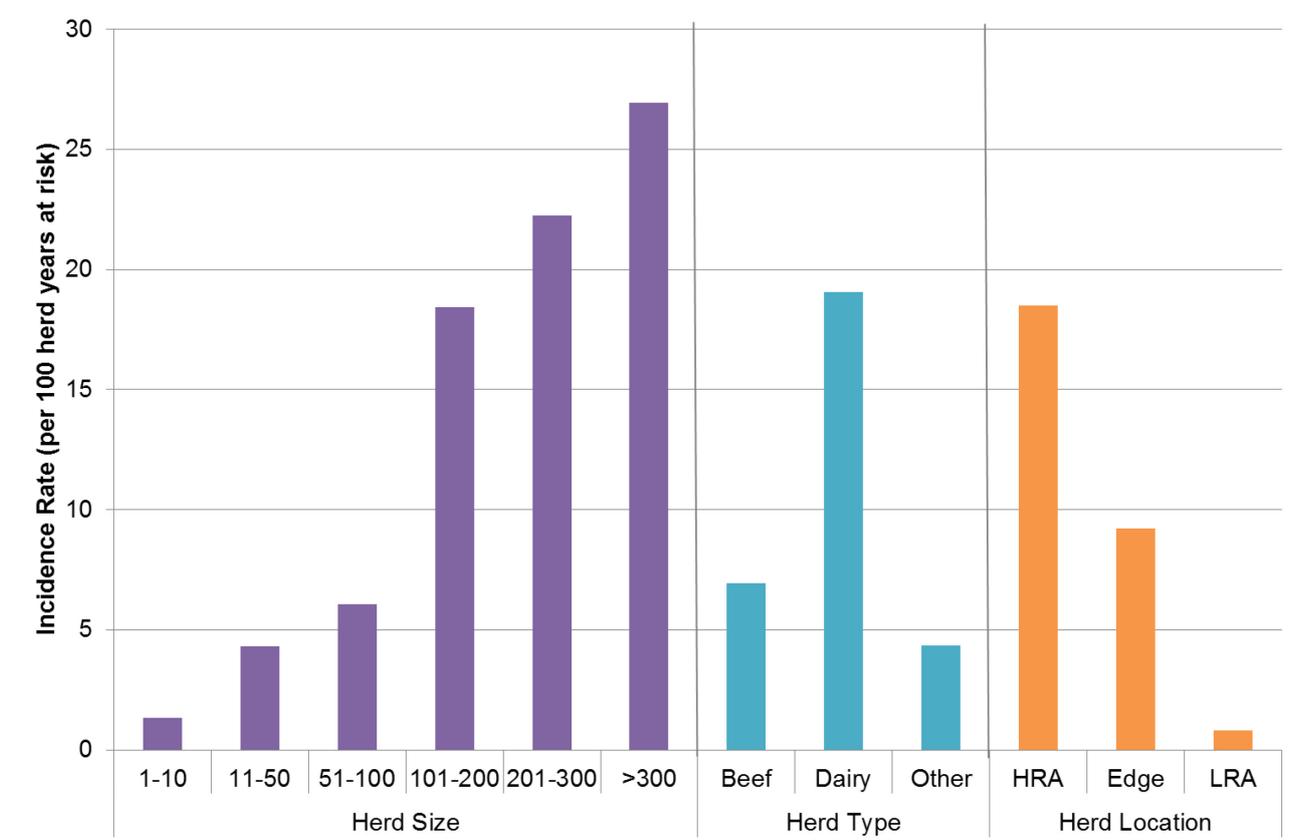


Figure 3.2.3a Incidence rates for new TB incidents in herds of different size or type, and in each risk area of England, in 2018

- Herd size was strongly associated with the likelihood of a herd becoming infected with TB; in officially TB free herds with over 300 cattle, the incidence rate of TB in 2018 was 27%, while it was <6% in herds with 50 or fewer cattle.
- Dairy herds were 2.7 times more likely to be found infected in 2018 than beef herds.
- Herds in the HRA were over 2 times as likely to be found infected with TB as herds in the Edge Area and 23 times more likely than herds in the LRA.

Exploring some of the potential risk factors is important in terms of determining the risk of infection. This is done by calculating the incidence rate ratio (IRR, i.e. the proportion of herds in each category that become infected compared with the proportion in a reference category), and then taking other factors into account which could also affect the rate of infection. These comparative ratios are shown in Figure 3.2.3b, which shows, for example, that if the location and herd type are taken into account when calculating the incidence rate in a herd of a particular size, the adjusted rate ratio hardly changes, so herd size is an important explanatory factor.

The IRR increased with herd size, but it was 0.04 to 0.83 times the rate of TB infection in herds of more than 300 animals (the reference category). This effect remained after adjusting for the effects of herd type and risk area, and has been consistently observed over several years. The high incidence rate in dairy herds is largely caused by the fact that they tend to be large herds and located in the HRA, and adjusting for both herd size and location in the 2018 data greatly reduces the estimated risk associated with being a dairy herd. Even so, as in 2017, dairy herds are at higher risk of new infection than beef herds of the same size and in the same location (IRR=1.21, 95% CI 1.12-1.30, p<0.001). As expected, the incidence rate was significantly lower in the Edge and LRA compared to the HRA, even after adjusting for the effects of herd size and type, indicating that location is an important risk factor for suffering a TB incident, like the herd size. (Data can be seen in table form in the GB data Report¹²).

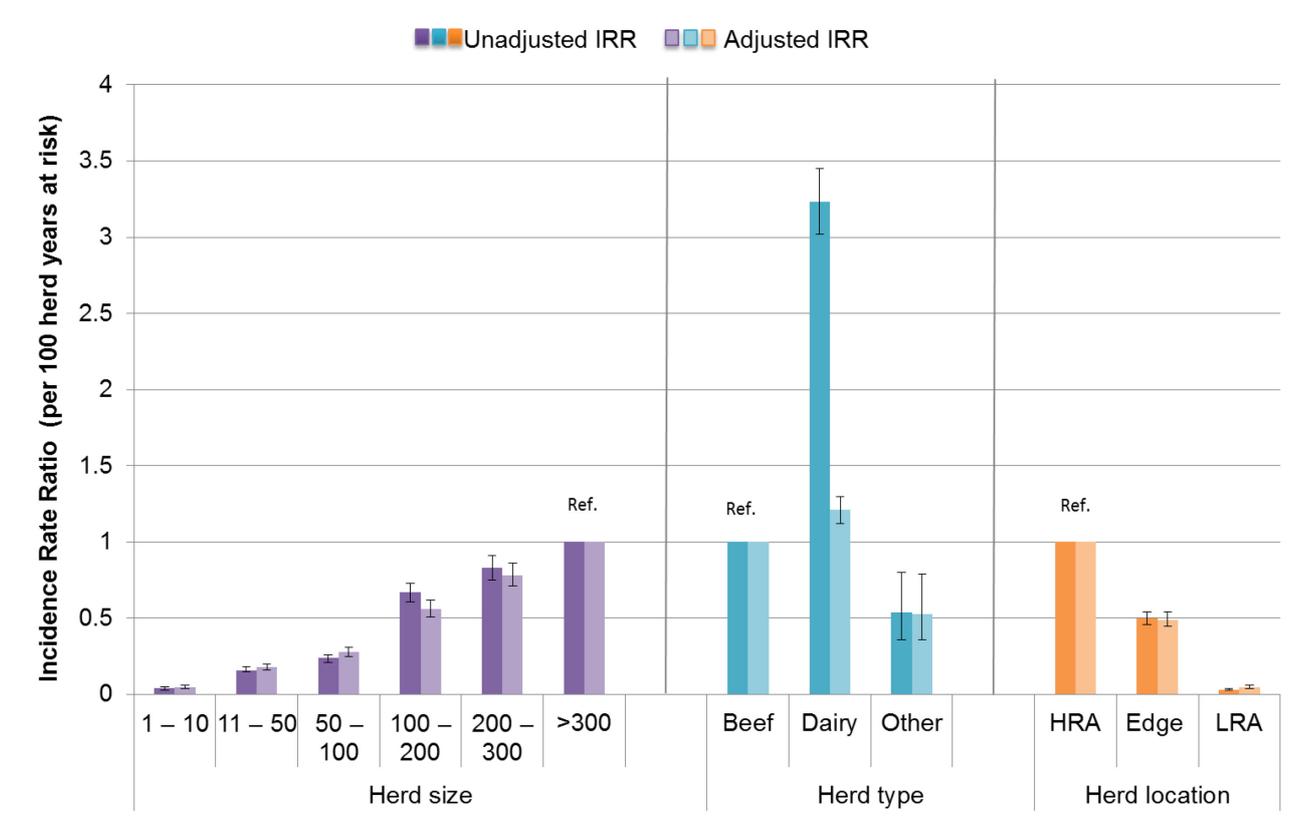


Figure 3.2.3b Incidence Rate Ratios (Unadjusted and Adjusted) for new TB incidents¹³ in herds of different size or type, and by risk area in 2018 (Poisson analysis, methodology similar to that in Appendix 4, in 2015 report¹⁴)

¹² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739906/GBDataReport.ods

¹³ All TB infected herds – includes OTF-W and OTF-S

¹⁴ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/593226/tb-epidemiology-england-2015.pdf

- The denominator value (time at risk) is slightly higher in the aggregated data as this aggregates time at risk in herds that have had multiple whole herd tests in each year used in the Poisson regression, which as a result reduces the incidence rate
- Herd size and location (risk area) are the most important explanatory factors for the incidence rate.
- The unadjusted incidence rate in dairy herds was three times greater than beef herds. However, dairy herds are consistently larger, and more concentrated in the HRA than beef herds.
- After adjusting for herd size and location, dairy herds were 21% more likely to have a TB incident than beef herds.
- The incidence rate for herds in the Edge Area was less than half the rate for herds in the HRA.

Recurrent TB incidents

In the Edge Area and LRA, the odds of having a new TB incident in 2018 was approximately two and a half times higher in herds with a history of TB compared to herds with no TB history (Edge OR 2.6 95% CI 2.2-3.1; LRA OR 2.4 95% CI 1.1-4.9), while in the HRA it was approximately twice as high (OR 1.9 95% CI 1.8-2.1).

For the Edge Area and HRA these results were similar to 2017, however in the LRA, a herd with a history of TB was six times more likely to have a further TB incident than a herd with no TB history in 2017, albeit with wide confidence intervals (OR 5.8, 95% CI 3.4-9.8). This represented a decrease relative to 2017 in the odds of a herd in the LRA having a TB incident with previous history of TB, which was driven by a reduction in the number of TB incidents (eight in 2018 compared to 17 in 2017, -53%), while the number of TB incidents in herds with no recent TB history moderately increased (120 in 2018 compared to 105 in 2017, +14%).

When the same analyses were run for OTF-W incidents only in 2018, in the LRA the odds of having a TB incident rose slightly to approximately three times higher in herds with a history of TB compared to herds with no TB history (OR 2.9 95% CI 1.1-8.2).

In 2018, the odds of having a TB incident in herds with previous TB history was over three times higher in small herds (10 cattle or less) (OR 3.3 95% CI 1.9-5.7). The odds of recurrence was lowest for herds with 51-100 cattle (OR 1.6 95% CI 1.4-1.9), and for all remaining herd sizes, the odds of recurrence in herds with TB history compared to no TB history were close to double (Figure 3.2.4).

When comparing herd type, the odds of having TB was roughly two times higher in both beef and dairy herds with a TB history, compared to herds with no TB history. The 'other' category was much higher (OR 3.8 95% CI 1.5-9.9) although it has a very wide confidence interval due to the small number of herds in this category.

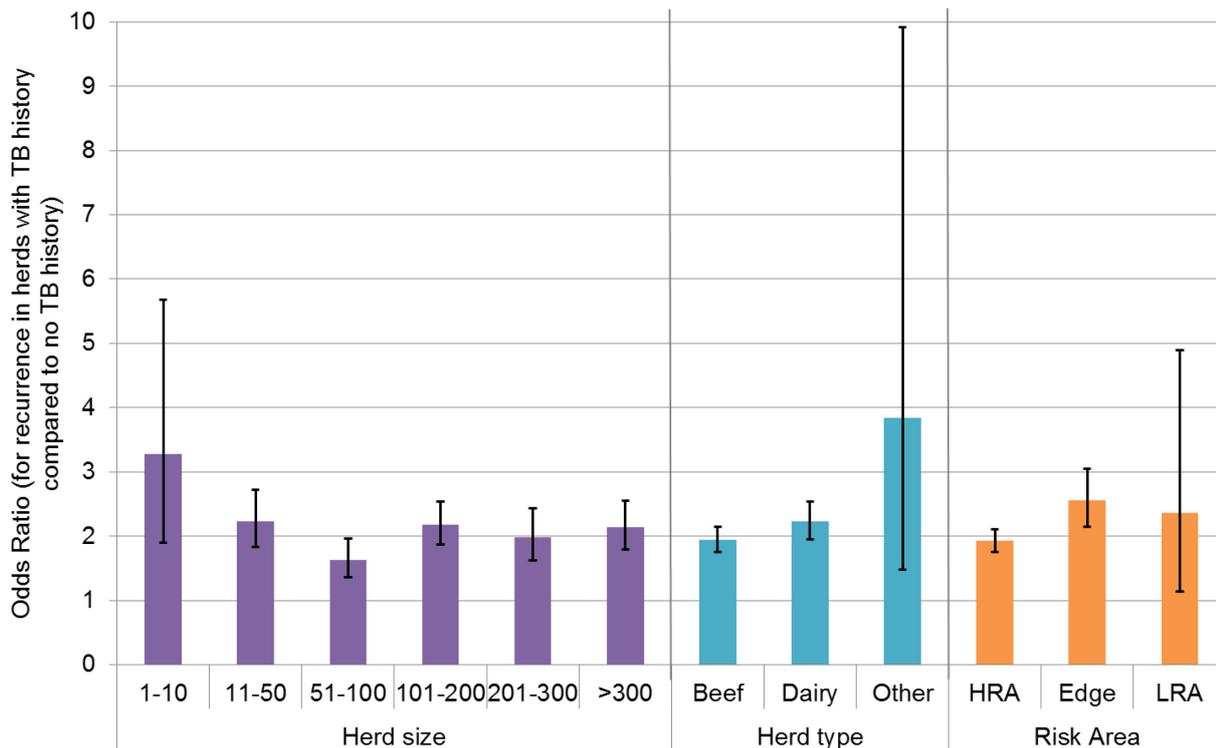


Figure 3.2.4. The odds of recurrent infection in herds with a history of TB compared to herds with no TB history, by herd size, herd type and risk area (error bars show 95% confidence intervals)

- Beef and dairy herds, and herds in most size categories that had a history of TB all had similar odds of recurrent infection (around double). This trend was slightly higher in small herds and for other herd types, however there is a high level of uncertainty around the odds ratios for these categories (both have wide confidence intervals).
- In the HRA the odds of recurrent infection in herds with a history of TB compared to herds with no TB history was also around double, while in the Edge Area and LRA the odds were higher, at around two and half times for herds with a history of TB compared to herds with no TB history.

Within each region, herds were split according to their TB history over the previous three years. The proportion of herds with a history of TB that went on to experience a TB incident in 2018 and the proportion of herds without a history of TB that went on to have a TB incident in 2018 were calculated in each risk area, by herd type separately (Figure 3.2.5).

In all three risk areas, the proportion of recurrent TB incidents was highest in dairy herds, with around half the proportion of beef herds enduring a recurrent infection. In the Edge Area ‘Other’ herds also had a high proportion of TB in herds with a history of TB, although this is based on one herd with a TB incident out of four herds with TB history).

Recurrence may have a number of causes, likely relating to location, biosecurity, residual undetected cattle infection, and/or buying or other management practices. The increased

risk of recurrence for particular farms as described here will be used in ongoing work to develop more targeted interventions determined by farm characteristics. Farmers' knowledge of their herds' increased risk may also help those keepers with a history of TB infection make informed decisions about their management practices using advice from initiatives such as the TB Hub¹⁵ and TBAS (TB Advisory Service) to help promote safer buying practices and improved biosecurity.

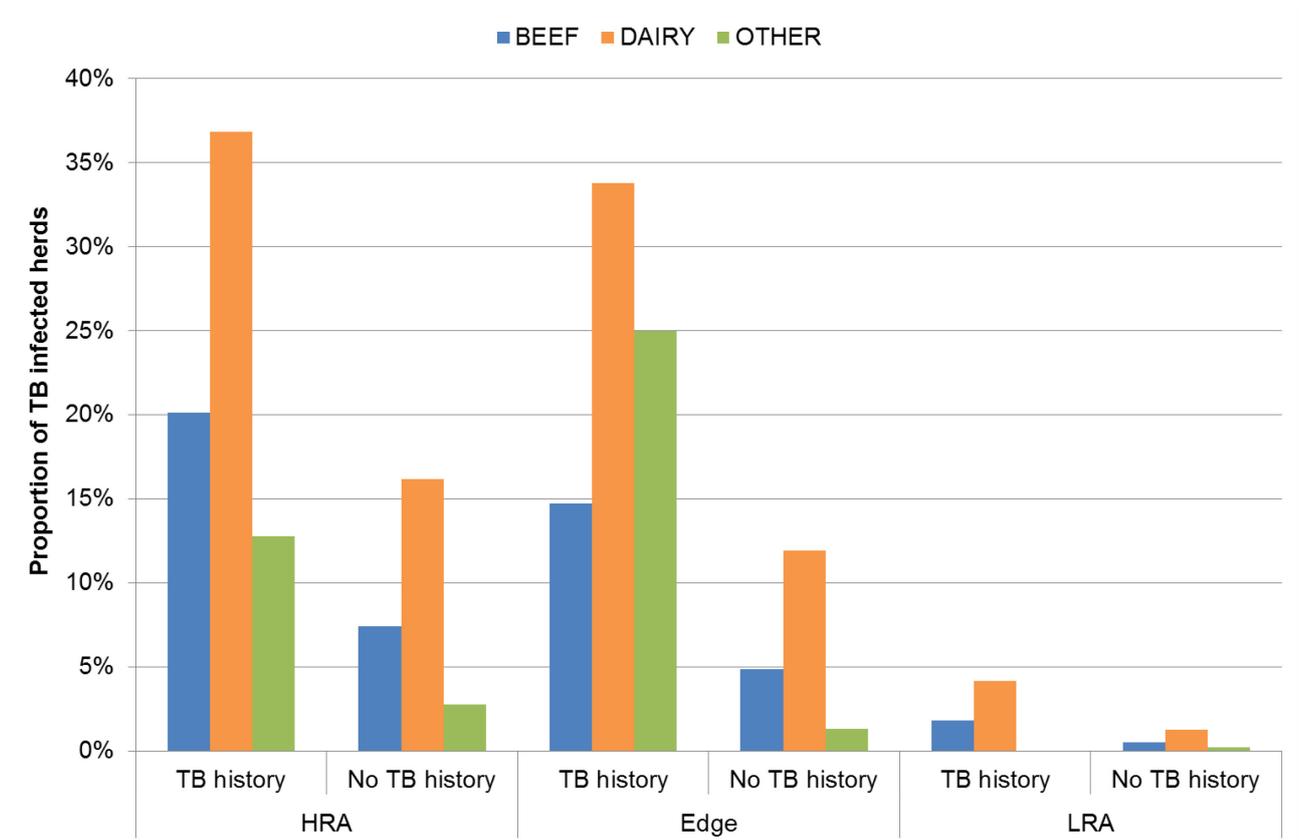


Figure 3.2.5. The proportion of herds with and without a history of TB, that went on to experience a TB incident in 2018, by risk area and herd type

- The proportion of herds with a TB incident in 2018 was highest for herds with a TB history than those without, for all risk areas and herd types.
- In all risk areas, dairy herds had the highest proportion of TB incidents in herds with a history of TB, compared to beef and 'other' herds.

Molecular typing

Attempts are made to recover *M. bovis* from all TB incidents and to subject at least one isolate per TB incident to a combination of spoligotyping and Variable Number Tandem Repeat (VNTR) typing in order to identify its molecular type (genotype). This knowledge is used to describe areas where particular genotypes are common, so-called 'home ranges'

¹⁵ <http://www.tbhub.co.uk/tb-facts/statistics/>

and then to compare isolates from new TB incidents with the previous known distribution, including the home range, of the particular genotype identified. Most isolates are recovered from premises located within the home range of the genotype identified. Of the 1,933 isolates with location and a full genotype that had a calculated home range identified in 2018, 1,512 (78%) were in their home range (421 out-of-home range isolates). The most frequent genotype found in England in 2018 was 17:a, in which accounted for 20% of the *M. bovis* isolates subjected to genotyping. This was followed by 25:a (16%) and 11:a (16%), based on 2,409 incidents starting in 2018 with a genotype identified. These three genotypes accounted for 52% of all genotypes disclosed and cover extensive areas in the South West of England and Wales (Figure 3.2.6). Further information about genotyping is given in the Explanatory Supplement¹⁶. The assessments described in the next section on source of infection have been informed by knowledge of the genotype where available. Further statistics on the outcomes of *M. bovis* genotyping carried out in 2018 is included in the GB Data Report¹⁷.

Molecular typing through analysis of the entire sequence of the bacterium's DNA, known as Whole Genome Sequencing (WGS), can provide greater discrimination between strains of *M. bovis* than genotyping, which analyses only specific regions of the bacterial genome. This will be particularly important in the HRA where it is generally not possible to distinguish local sources of infection because they are defined by the same genotype using the current methodology. This could potentially allow explicit identification of transmission pathways between some farms, or confirm whether recurrent incidents have been caused by residual infection in the herd from a previous incident, or from a new introduction. Isolates sent for genotyping at APHA have also been sequenced since mid-2017 and the APHA now has ISO accreditation for high-throughput sequencing, although WGS from non-bovine species is very limited due to the availability of submissions. Work is currently ongoing to facilitate replacement of genotyping with WGS in routine TB control and surveillance operations.

¹⁶ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

¹⁷ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739906/GBDataReport.ods

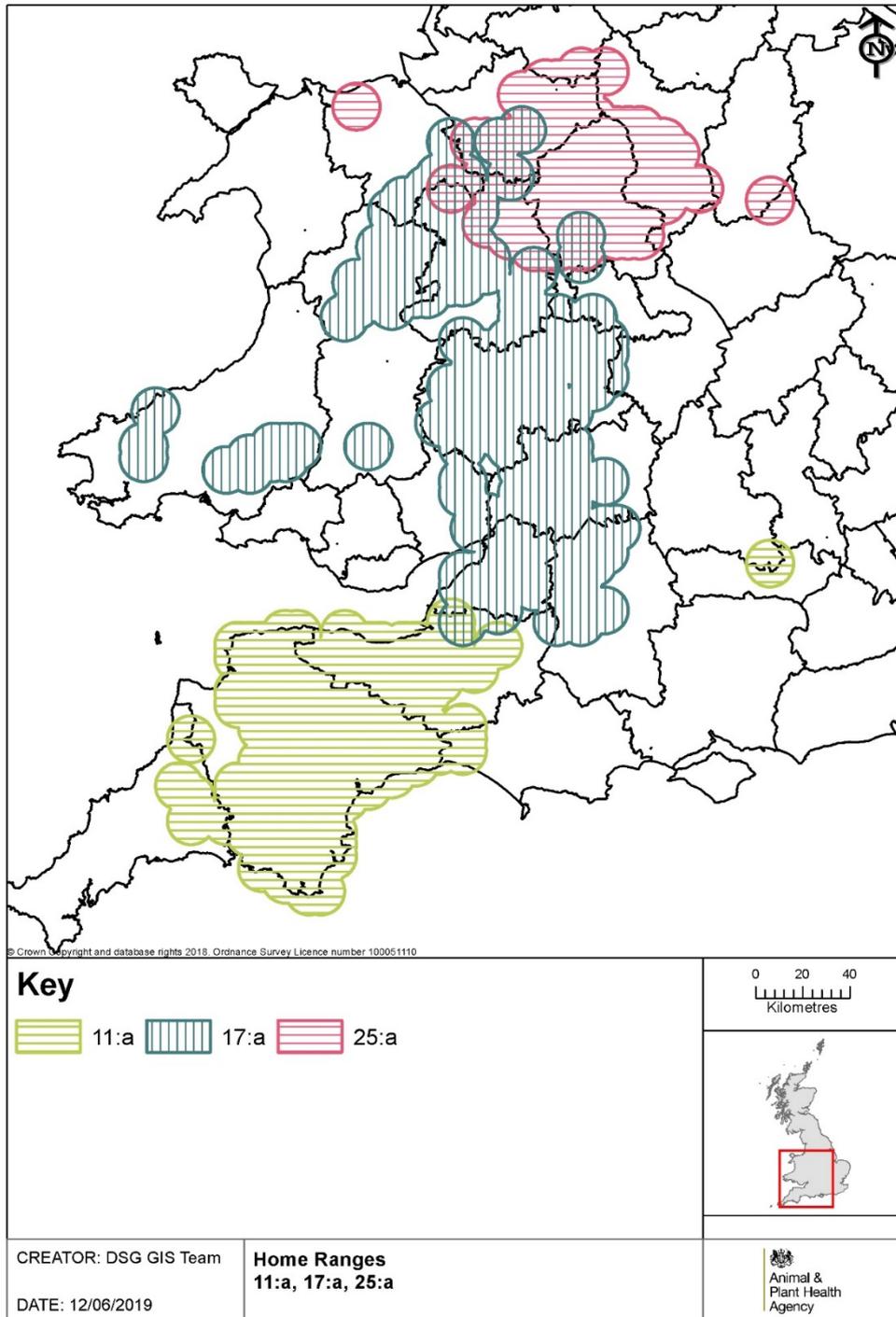


Figure 3.2.6. Home ranges¹⁸ of the three most common genotypes of *M. bovis* in GB: 11:a, 17:a and 25:a

¹⁸ “Please note that some bTB Home Ranges may be larger than presented in previous reports due to improvements in the production tool to minimise the effects of low resolution location coordinates and

Source of infection by veterinary assessment

Assessing how a herd became infected with TB is very challenging, as TB is a chronic insidious infection in which clinical signs are usually only apparent when the disease is advanced. TB is generally disclosed through skin testing (proactive surveillance) on farm or post-mortem surveillance at the slaughterhouse. Therefore, the evidence to retrospectively establish which route brought the infection into a herd can be difficult to reconstruct. Clarifying the source and full route of infection, for the affected herd (the 'risk pathway') facilitates the use of targeted farm biosecurity measures.

Currently, a proportion of new TB incidents are fully investigated by the APHA. All new TB incidents in the LRA (both OTF-W and OTF-S) undergo an epidemiological assessment. For the Edge Area, as many assessments as possible are completed with the finite resources available, and the level is close to 100%. In situations where not all incidents can receive an assessment, new incidents are randomly selected for assessment in order to maintain a representative overview of the area. Additionally, one third of new incidents in the HRA are randomly selected, as well as those that meet specified criteria (e.g. those with more than 15% of the herd or 20 cattle removed as test reactors). For incidents selected for assessment, an APHA case veterinarian conducts a thorough on-site investigation, supplementing information recorded during the visit with routinely collected data; such as cattle movement records and the results of molecular analyses, if available. Intelligence gathered from genotyping *M. bovis* isolates can be a powerful tool in identifying a likely source of infection, however this is limited to OTF-W incidents where *M. bovis* has been cultured.

During the assessment, the APHA veterinary officer selects up to three risk pathways of infection for each herd, indicating their relative order of likelihood. This is recorded as either definite, most likely, likely or possible. A more detailed description of this methodology is provided in the Explanatory Supplement¹⁹ to this report.

The source(s) for each TB incident are weighted by the certainty ascribed by the investigating officer. Any combination of Possible (Score 1), Likely (Score 2), Most Likely (Score 4) and Definite (Score 8) sources can contribute towards the overall picture for possible routes of introduction. The proportion each source contributes towards a single TB incident, weighted by certainty, can be explored at county, region or national level. For example, a single TB incident may have the following source and risk pathway profile:

Source	Likelihood	Weighting	Proportion
Badgers	Most Likely	4	0.66
Cattle Movement (HRA)	Possible	1	0.17
Cattle Movement (Edge)	Possible	1	0.17
Total for incident A		6	1

Due to the importance in controlling the spread of TB within the Edge Area, additional time was spent examining the conclusions made for the route of introduction within these TB

¹⁹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

incidents. This time consuming activity was not carried out for TB incidents in the HRA and LRA.

All incidents detected in England in 2018 that had undergone a completed epidemiological veterinary investigation were identified for analysis, amounting to 1,669 of 3,607 new TB incidents in 2018. For the purposes of this analysis the 38 possible risk pathways have been aggregated into 9 hazards. Where aggregated, no data has been removed i.e. if an investigation identifies multiple risk pathways relating to infected cattle movement, they are all included in the analysis.

Most likely and definite scores were more frequently ascribed in the HRA (32%) than in the Edge Area (29%) or LRA (19%) (Figure 3.2.6). The increased confidence selected for pathways in the HRA, followed by the Edge Area may be related to the greater proportion of OTF-W incidents in these areas, and subsequent availability of genotyping information for these cases.

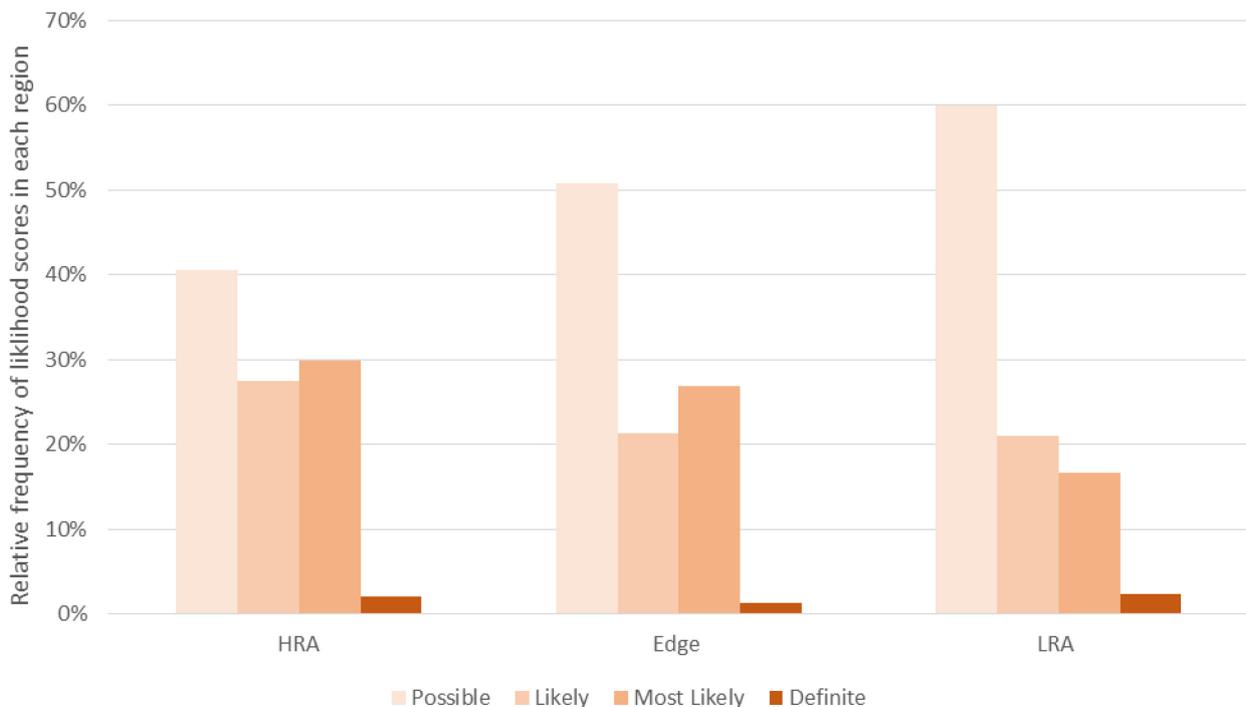


Figure 3.2.7. Relative frequency of likelihood scores given to each identified source in the LRA, Edge Area and HRA

When considering the level of certainty in each incident, the source was most commonly attributed to either exposure to infected badgers (at pasture or while housed) or to the movement of undetected infected cattle onto the holding. At county level, the most common source of infection attributed within the HRA or Edge Area was badgers, in Cornwall (80.7%) and Derbyshire (77.4%) (Table 3.2.1).

Table 3.2.1 Number of incidents that started in 2018, and the weighted contribution each source of infection made to those incidents, by Risk Area and HRA and Edge Area county

County ¹	Badgers	Cattle Movements	Contiguous	Residual	Domestic	Non-specific	Fomites	Wildlife	Other or unknown	Number of investigations
Cornwall	80.7%	5.8%	0.0%	2.9%	0.0%	0.0%	0.4%	10.2%	0.1%	138
Devon	65.6%	7.7%	1.6%	8.4%	0.5%	0.3%	0.7%	12.8%	2.5%	215
Dorset	53.6%	17.2%	8.3%	13.3%	0.0%	0.0%	2.1%	5.2%	0.3%	59
Gloucestershire	58.3%	6.1%	7.5%	7.5%	0.0%	2.8%	0.8%	7.6%	9.3%	41
Hereford & Worcester	54.5%	17.7%	3.4%	12.4%	0.0%	1.1%	0.3%	9.3%	1.1%	117
Avon	43.8%	15.8%	4.6%	10.4%	0.0%	2.5%	1.5%	9.4%	11.9%	33
Shropshire	69.8%	14.4%	1.4%	7.2%	0.0%	0.3%	0.3%	3.5%	3.1%	90
Somerset	56.1%	20.6%	2.9%	4.3%	0.0%	0.4%	0.9%	9.2%	5.7%	93
Staffordshire	71.0%	12.4%	5.8%	6.1%	0.0%	0.4%	1.0%	2.6%	0.8%	127
Wiltshire	57.3%	10.6%	3.9%	7.8%	0.0%	6.7%	0.8%	6.0%	6.8%	63
West Midlands	33.3%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	0.0%	3
HRA	64.2%	12.0%	3.1%	7.6%	0.1%	1.1%	0.7%	8.3%	2.9%	979
Berkshire	36.3%	30.8%	2.1%	13.5%	0.0%	0.0%	0.0%	17.3%	0.0%	24
Buckinghamshire	27.2%	57.0%	2.6%	10.1%	0.0%	0.0%	0.0%	3.2%	0.0%	29
Cheshire	66.2%	14.8%	5.3%	9.7%	0.1%	0.6%	0.6%	1.3%	1.3%	154
Derbyshire	77.4%	9.7%	4.4%	5.4%	0.0%	0.8%	1.0%	0.8%	0.6%	120
Hampshire	23.3%	36.8%	5.9%	20.8%	0.0%	0.0%	0.0%	13.2%	0.0%	37
Leicestershire	50.7%	30.3%	3.6%	7.9%	0.0%	1.2%	0.5%	0.5%	5.3%	43
Northamptonshire	62.9%	32.3%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	2.3%	21
Nottinghamshire	25.0%	35.7%	8.3%	0.0%	0.0%	7.1%	0.0%	16.7%	7.1%	14
Oxfordshire	51.9%	29.3%	1.9%	15.8%	0.0%	0.0%	0.4%	0.8%	0.0%	64
East Sussex	36.8%	24.0%	7.8%	3.7%	0.0%	12.7%	1.7%	3.7%	9.8%	27
Warwickshire	60.2%	12.5%	1.8%	8.5%	0.0%	0.0%	3.1%	12.5%	1.3%	52
Edge Area	56.9%	22.0%	4.1%	9.3%	0.0%	1.2%	0.8%	4.1%	1.7%	585
LRA	12.7%	31.9%	2.3%	9.5%	3.8%	14.1%	5.8%	0.5%	19.3%	105
England Total	58.4%	16.7%	3.9%	7.8%	0.1%	2.3%	1.1%	6.6%	3.2%	1,669

(1) Counties in the LRA are not presented separately due to the low number of TB breakdowns within those counties.

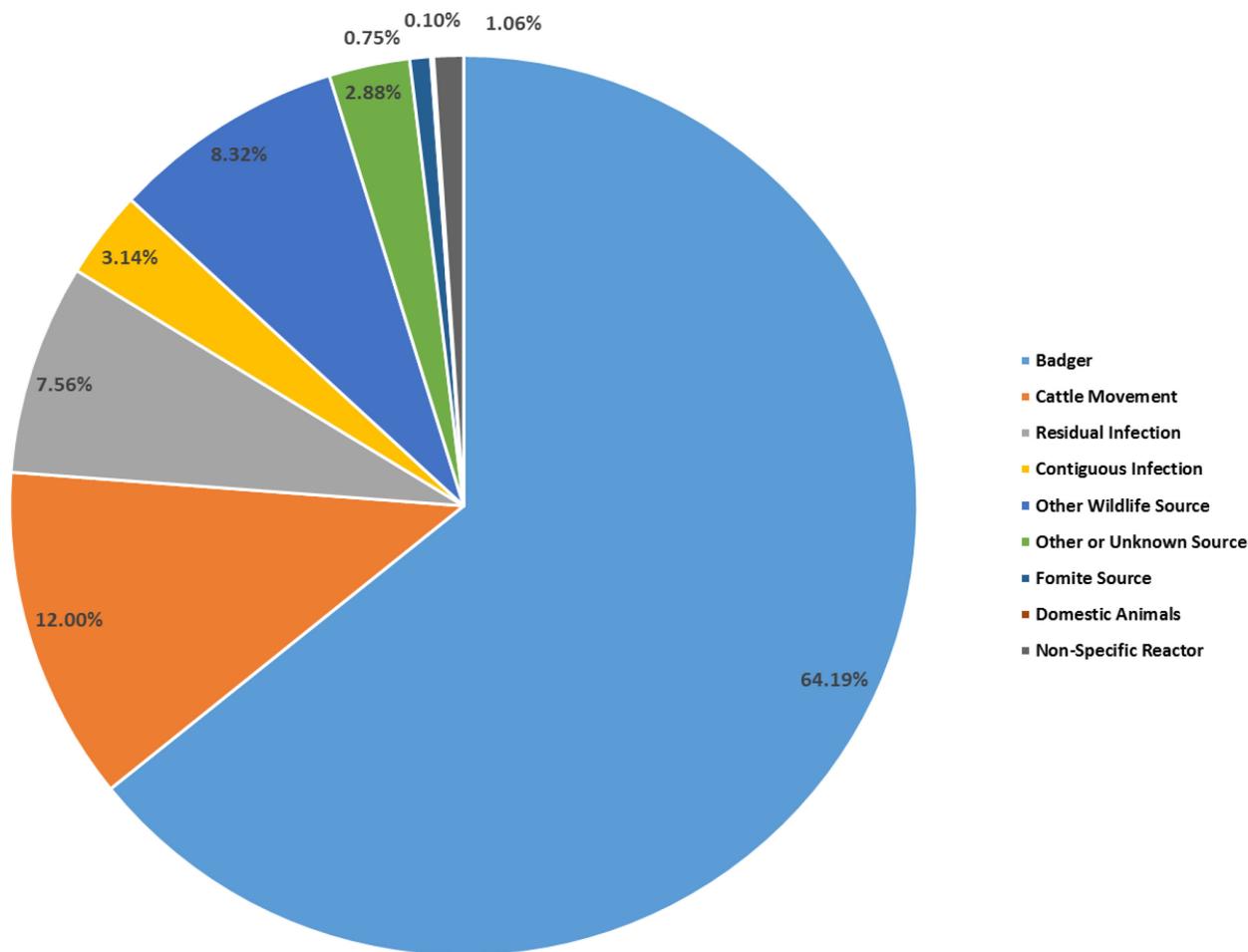


Figure 3.2.8 Summary of the weighted source of infection attributed for all incidents (both OTFW and OTFS) incidents that started in 2018, in the HRA (n=979)

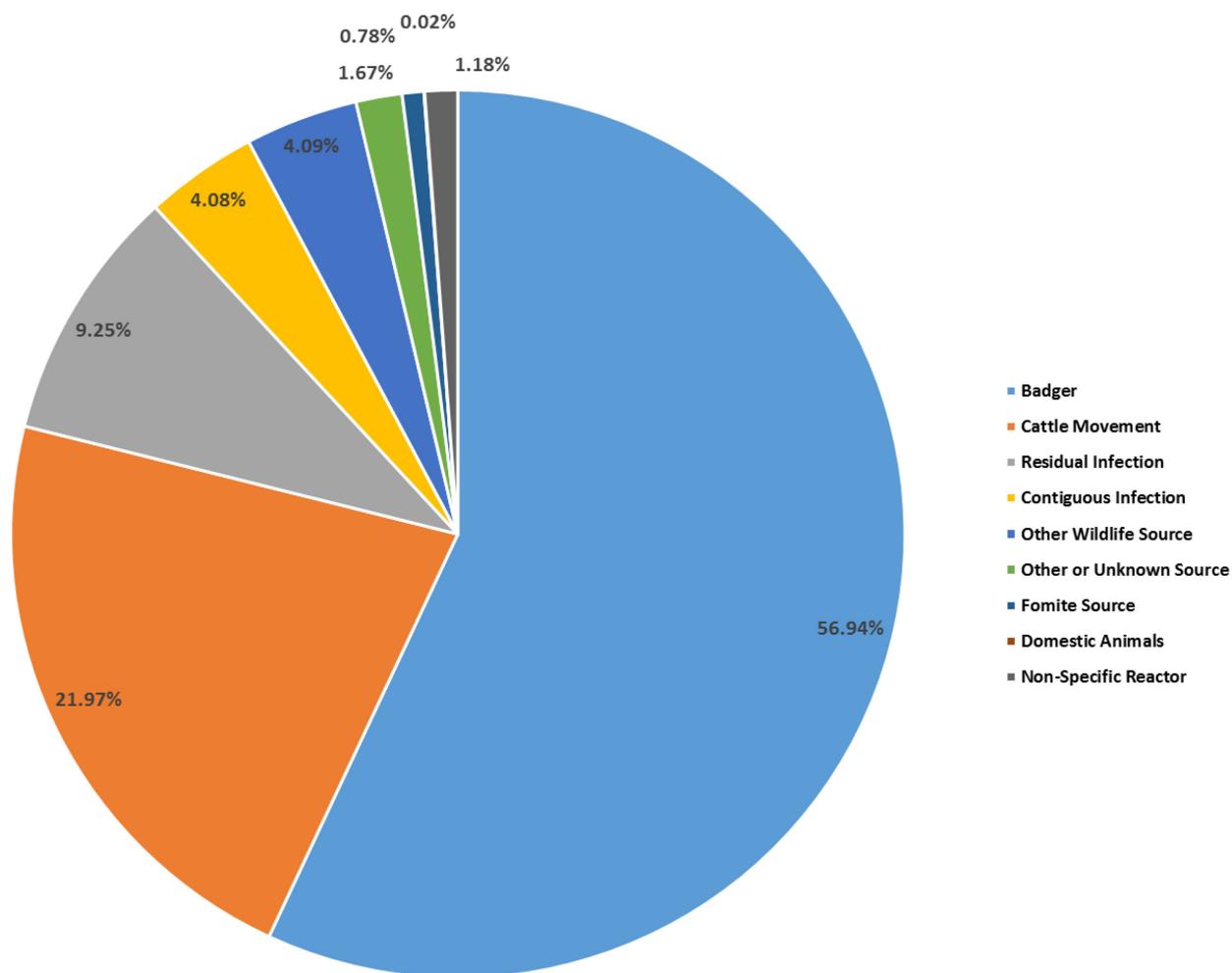


Figure 3.2.9 Summary of the weighted source of infection attributed for all incidents (both OTFW and OTFS) incidents that started in 2018, in the Edge Area (n=585)

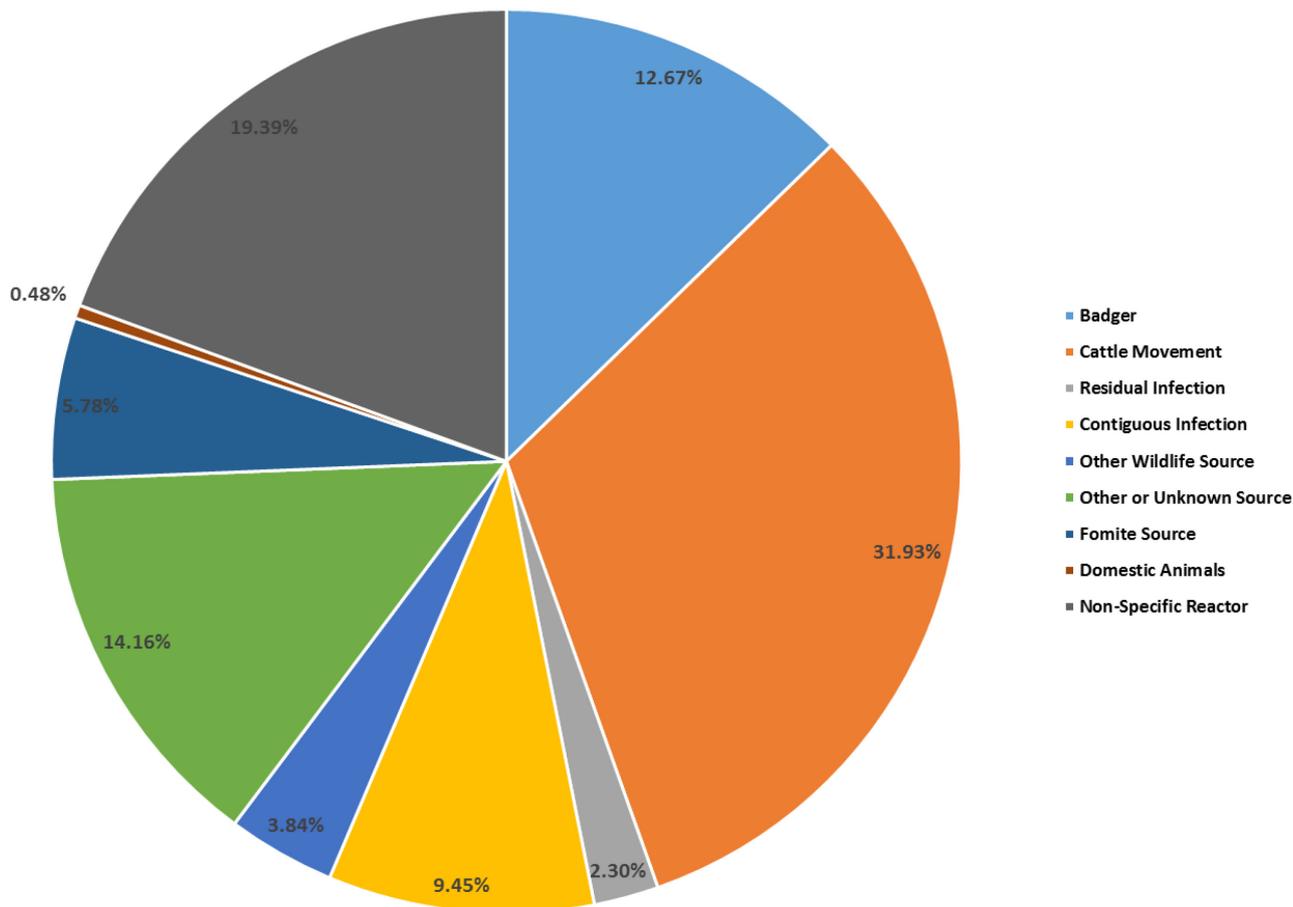


Figure 3.2.10 Summary of the weighted source of infection attributed for all incidents (both OTFW and OTFS) incidents that started in 2018, in the LRA (n=105)

The calculated contributions of each source of infection for TB incidents in the HRA, Edge Area and LRA are depicted in Figures 3.2.8 to 3.2.10 respectively. Within the HRA, badgers constituted 64% of the weighted opinion, while cattle movements accounted for 12% of the weighted opinion (Figure 3.2.8). For TB incidents in the Edge Area, the most frequently ascribed source of infection was badgers (57%), but cattle movements (22%) were also identified as posing a high risk of introduction (Figure 3.2.9). Conversely, in the LRA the contribution of badgers was much lower at only 13% (and limited to East Cumbria, where endemic *M. bovis* infection in badgers has been confirmed and is the object of special surveillance and control measures). Even so, in the LRA overall, TB incidents were most commonly attributed to cattle movements (32%). However, in the LRA sources other than cattle movement or badgers also played a greater role in the possible introduction of *M. bovis* infection (55% of incidents with an attributed source) compared to the HRA (24%) and the Edge Area (21%) (Figures 3.2.8 to 3.2.10).

Spatial differences in the source of infection identified with the highest level of certainty are examined in Figure 3.2.11. Incidents within the HRA were most often attributed to badgers, while cattle movements were the most significant source of infection within the LRA,

although in the LRA the proportion of incidents with an unclear source is high. Within the Edge Area, incidents bordering the HRA, and in the north of the area were more often ascribed to badgers, while those towards the LRA, and in the south and east were more commonly linked to the movement of cattle. Further details on the relevant risk pathways for each county within the Edge Area and LRA can be found in the 2018 Edge Area and LRA year-end county/regional reports²⁰.

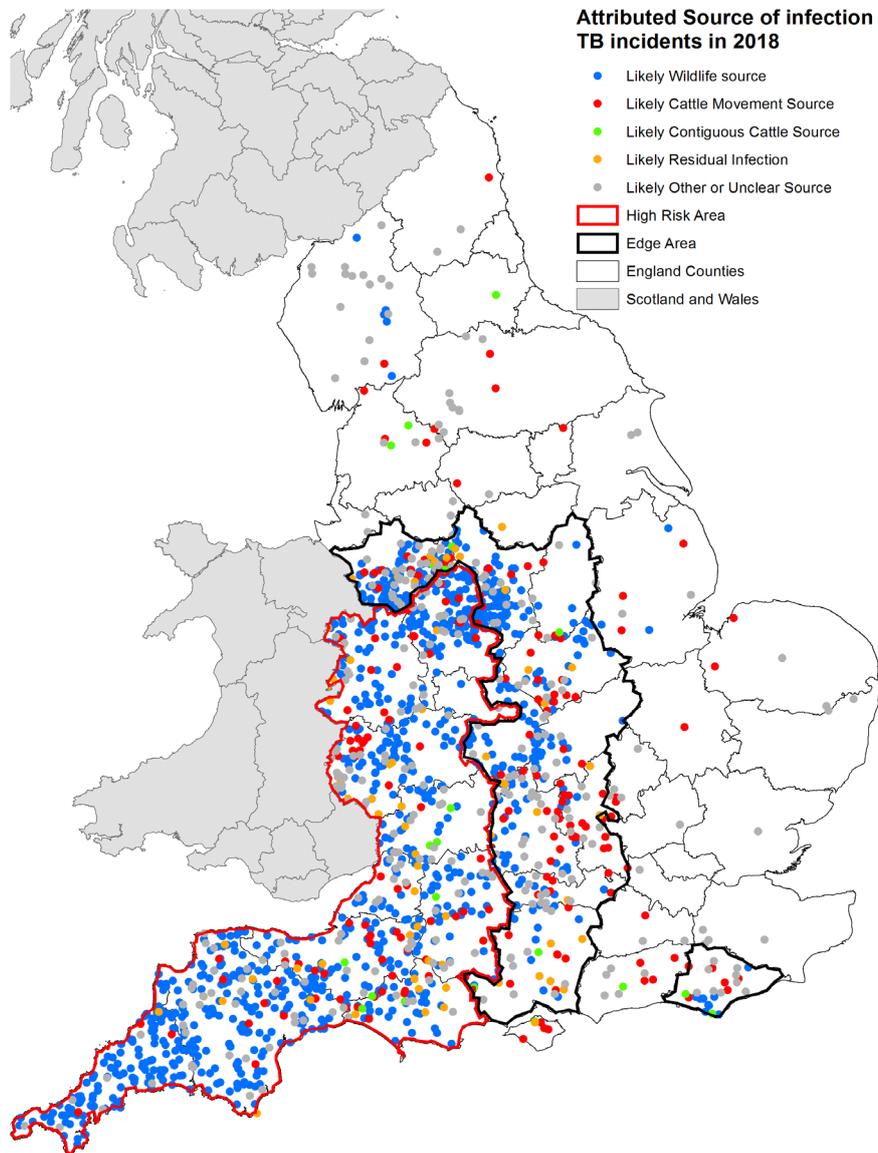


Figure 3.2.11. The source of infection recorded with the highest level of certainty, selected by informed veterinary opinion, for all incidents (both OTF-W and OTF-S) that started in 2018

- TB incidents were more commonly attributed to badgers in high incidence areas of the HRA and Edge Area.

²⁰Bovine TB: epidemiology reports, 2018 <https://www.gov.uk/government/publications/bovine-tb-epidemiology-reports-2018>

3.3 Finding Infected herds: Effectiveness of different TB surveillance streams

- In 2018, a total of 5.6 million TB tests were carried out; almost half of which were in the HRA (49%).
- In the HRA, TB incidents were most commonly detected through Area and Herd Risk Surveillance (46%), while in the Edge Area, Routine surveillance detected most new TB incidents (58%). In the LRA, a similar proportion of TB incidents were detected through Area and Risk surveillance and Routine surveillance (40% and 38% respectively).
- The proportion of TB incidents disclosed through slaughterhouse (SLH) surveillance was lower in the Edge Area and LRA in 2018 compared to 2017 (and 2016). In the HRA the proportion of TB incidents disclosed through SLH surveillance increased compared to 2017, but was still lower than 2016 and 2015. A decrease in the number of TB cases found at slaughter suggests that infected cattle are being detected earlier through live animal testing in the Edge Area.
- Higher proportions of TB incidents disclosed by SLH surveillance in the HRA probably reflects the fact that the background force of infection (and hence the risk of herds becoming infected between surveillance tests) is higher in this area, as well as the risk of residual cattle infection in herds that regain OTF status after a TB incident.
- Within the Area and Herd Risk surveillance stream, 70% and 71% of TB incidents in the HRA and Edge Area were detected by post-incident tests compared to six per cent in the LRA. This reflects the difficulty of clearing infection in the HRA and Edge Area and highlights the need for better understanding of the factors that lead to recrudescence and reinfection on farms.
- Within the LRA, radial tests detected proportionally more TB incidents than any other Area and Herd Risk Tests; detecting 77% of incidents. This suggests that controlling transmission through local cattle movements and shared grazing could reduce TB incidence in the LRA.
- Over 40% of Inconclusive Reactor-only test herds went on to have an incident within the following 15 months in the HRA, with a substantial proportion similarly affected in the Edge Area (38%). This indicates IRs are an important predictor of the presence of infection and supports the policy to restrict IRs in those areas to the herd in which they are disclosed for life.
- Trade and other surveillance testing disclosed less than 10% of the new TB incidents in the HRA and Edge Area (mainly pre-movement tests), but a higher proportion of incidents in the LRA (13% although representing only 17 TB incidents).
- Cattle in all risk areas are predominantly moved more within that risk area than between risk areas. A total of 257 TB incidents were detected in 2018 by pre-

movement tests. In the HRA 8% of TB incidents were detected by pre-movement tests, 6% in the Edge Area and 5% in the LRA, although an additional 7% of incidents in the LRA were detected by post-movement tests.

Surveillance Overview

Bovine tuberculosis (TB) is a slowly progressing disease. Infected individuals rarely display clinical symptoms, except in the advanced stages of infection. However, asymptomatic animals can be infectious and potentially spread the disease. Even in its advanced stages the signs of TB in cattle are non-specific, such as light fever and weight loss. Therefore, surveillance for TB is based on detecting the immunological response to the causative bacterium in infected live cattle and pathology characteristic of *M. bovis* infection at slaughter. The surveillance programme in the different TB risk areas (HRA, Edge Area and LRA) involves both active surveillance, where live animals are tested on farm, and passive surveillance, whereby non-reactor animals leaving the herd for slaughter undergo routine post-mortem meat inspection for TB and other notifiable diseases. Slaughterhouse inspection is carried out by the Food Standards Agency (FSA) meat inspectors and veterinarians. On-farm testing is generally carried out by an Official Veterinarian appointed by the APHA or, much more rarely, an APHA vet or suitably trained Animal Health Officer.

TB surveillance activities in England have been categorised into four different surveillance streams for the purposes of this report, since 2015 (see detailed description of the surveillance streams and associated tests is provided in the TB Explanatory Supplement²¹). In brief the four surveillance streams are:

- **Routine:** active surveillance through systematic field testing of OTF herds at a pre-defined interval of six months, one or four years.
- **Area and Herd risk:** active surveillance with additional field testing of herds or individual cattle because of evidence that they are at greater risk of being infected or of increasing the risk of disease spread such as contiguous herd tests, radial tests, hotspot tests, tracing tests and check tests after a TB incident.
- **Slaughterhouse:** passive surveillance through *post-mortem* inspection of all cattle slaughtered for human consumption.
- **Trade and other²²:** active surveillance through field tests generally conducted for the purposes of trade such as statutory (but privately funded) pre- and post-movement testing of individual cattle, voluntary private tests requested by farmers and tests at artificial insemination centres.

Over 5 million cattle were kept in nearly 50,000 active cattle holdings in England in 2018. A total of 5.6 million TB tests were carried out, almost half of which were in the HRA (49%).

²¹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

²² Referred to as Proactive testing in earlier reports

This equated to just under 82,000 herd tests, resulting in the detection of 3,607 new TB incidents. Table 3.3.1 displays the number of tests performed and incidents disclosed through surveillance of OTF herds.

Figure 3.3.1 and Table 3.3.1 show the relative proportions of individual cattle tests, herd tests, reactors and incidents for the four surveillance streams. The number of herds and animals tested and the type of tests employed reflects the current policies within each risk area. For the purposes of this analysis, each test has been recorded as a test in the herd, even if it was an animal-level test (e.g. Tracing tests (Area and Herd Risk surveillance stream) or pre-movement (Trade & other surveillance stream)).

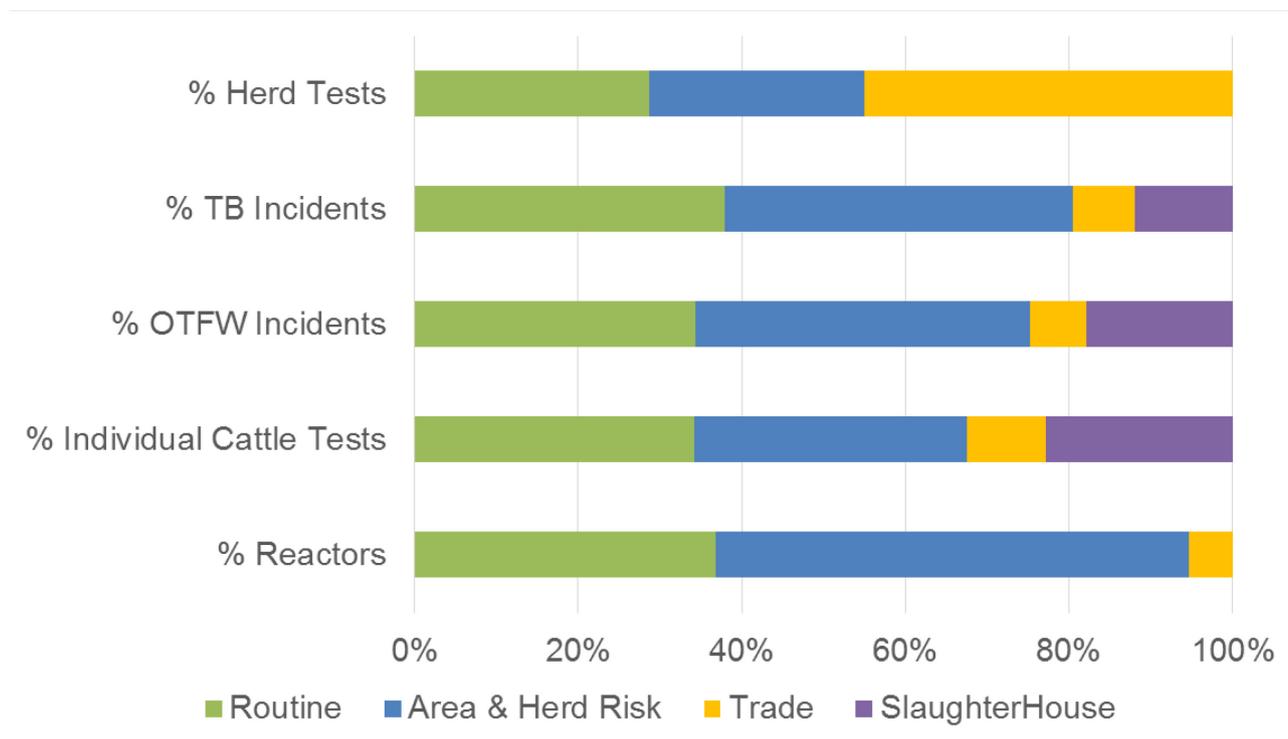


Figure 3.3.1. Proportion of herd and cattle tests, TB incidents in herds and individual reactors detected through each surveillance stream

In addition to the tests reported in Table 3.3.1, a further 2,641 herd tests were excluded from Tables 3.3.1-3.3.4 as they are not considered true disclosing test types. Excluded test types include short interval tests carried out within an infected herd (SI) to regain OTF herd status, inconclusive reactor tests (IR), supplementary interferon gamma tests (IFN) of infected herds, and tests occasionally used on a subset of a herd, often during a TB incident (ASG). Forty seven new TB incidents were disclosed by these test types, mostly through the implication of linked premises during SI testing (n=30).

Table 3.3.1 shows all tests and herd tests, whether they are herd-level and conducted on all or the majority of animals in a herd e.g. whole herd test (WHT) or routine herd tests (RHT) conducted as part of Routine Surveillance, or animal-level tests e.g. tracing tests conducted as part of Area and Herd Risk Surveillance, or pre-movement tests conducted as part of Trade & Other Surveillance.

Overall, tests conducted as part of the Area and Herd Risk surveillance stream detected more reactors, TB incidents (and OTF-W incidents) in 2018 than Routine surveillance. This highlights the value of targeting higher risk herds through specific tests, e.g. post-incident check tests. (Table 3.3.1). In the HRA, almost half of all incidents were detected by Area and Herd Risk surveillance and almost one third of incidents by Routine (annual) surveillance, in contrast to the Edge area, where most incidents were detected by Routine (annual or six-monthly) surveillance. In the LRA, a similar number of TB incidents (over a third) were detected by both Area and Herd risk surveillance and Routine surveillance, which is only conducted every four years in the majority of LRA herds because of the lower force of infection compared to elsewhere. The proportion of incidents detected through Trade & other surveillance in the LRA was around double the proportion detected in the other TB risk areas, this highlights the importance of post-movement testing for cattle being brought into the LRA from areas with a higher TB risk. The proportion of TB incidents disclosed by SLH was just under 10%, however SLH is more important in the LRA than in the other risk areas, because of the lower frequency of Routine surveillance. (Table 3.3.1).

Table 3.3.1.Total number of tests, reactors and TB incidents by risk area and surveillance stream in 2018

Area	Surveillance Stream	Herd Tests (%)	TB Incidents (%)	OTFW TB Incidents (%)	TB Incidents per 100 herd tests	Reactors per 1,000 cattle tested
HRA	Routine	10,352 (22.8)	890 (32.7)	546 (29.5)	8.6	2.7
	Area & Herd Risk	13,525 (30.6)	1,257 (46.1)	816 (44.2)	9.3	3.7
	Slaughterhouse	NA (0)	367 (13.5)	355 (19.2)	NA	NA
	Trade & other	20,311 (44.7)	211 (7.7)	131 (7.1)	1.0	1.2
HRA Total		44,188 (55.7)	2,725 (76.6)	1,848 (80.8)	(Average) 6.3	2.5
Edge	Routine	8,259 (41.6)	409 (58.0)	230 (57.1)	5.0	1.2
	Area & Herd Risk	3,650 (18.4)	208 (29.5)	108 (26.8)	5.7	0.2
	Slaughterhouse	NA (0)	46 (6.5)	44 (10.9)	NA	NA
	Trade & other	7,936 (40.0)	42 (6.0)	21 (5.2)	0.5	0.5
Edge Total		19,845 (25.0)	705 (19.8)	403 (17.6)	(Average) 3.7	0.7
LRA	Routine	4,102 (26.8)	49 (38.0)	9 (24.3)	1.2	0.2
	Area & Herd Risk	3,770 (24.6)	51 (39.5)	12 (32.4)	1.4	0.2
	Slaughterhouse	NA (0)	12 (9.3)	11 (29.7)	NA	NA
	Trade & other	7,433 (48.6)	17 (13.2)	5 (13.5)	0.2	0.4
LRA Total		15,305 (19.3)	129 (3.6)	37 (1.6)	(Average) 0.9	0.3
Grand Total		79,338	3,559	2,288	4.5	1.6

Over the past five years, the relative proportions of new TB incidents detected by different surveillance streams in the LRA and Edge Area have seen more variation than in the HRA. This is due in part to the relatively low number of TB incidents in these areas, but may also be due to the larger number of policy changes over time, compared to the HRA²³.

²³ <https://tbhub.co.uk/tb-policy/england/>

The proportion of new incidents detected by Routine surveillance in the Edge Area has increased since 2014, following the introduction of routine annual surveillance testing in this area in 2013, reinforced by six-monthly surveillance testing in most of Cheshire in 2014 and then rolled out to the western half of the Edge Area in 2018 .

The proportion of incidents detected through Trade & other surveillance in the LRA doubled between 2016 and 2017, before falling slightly in 2018. This may be an effect of post movement testing cattle from other risk areas, introduced in 2016.

In the Edge Area and LRA, the proportion of new TB incidents detected through SLH surveillance decreased in 2018 compared to 2017, continuing the downward trend since 2015. In England overall, the proportion of TB incidents detected by SLH surveillance has dropped by more than a quarter over the past five years (14.7% in 2014 vs 11.8% in 2018). This could be explained by infected cattle being detected at earlier stages of infection by more frequent TB field testing and more sensitive testing regimes for herds sustaining TB incidents.

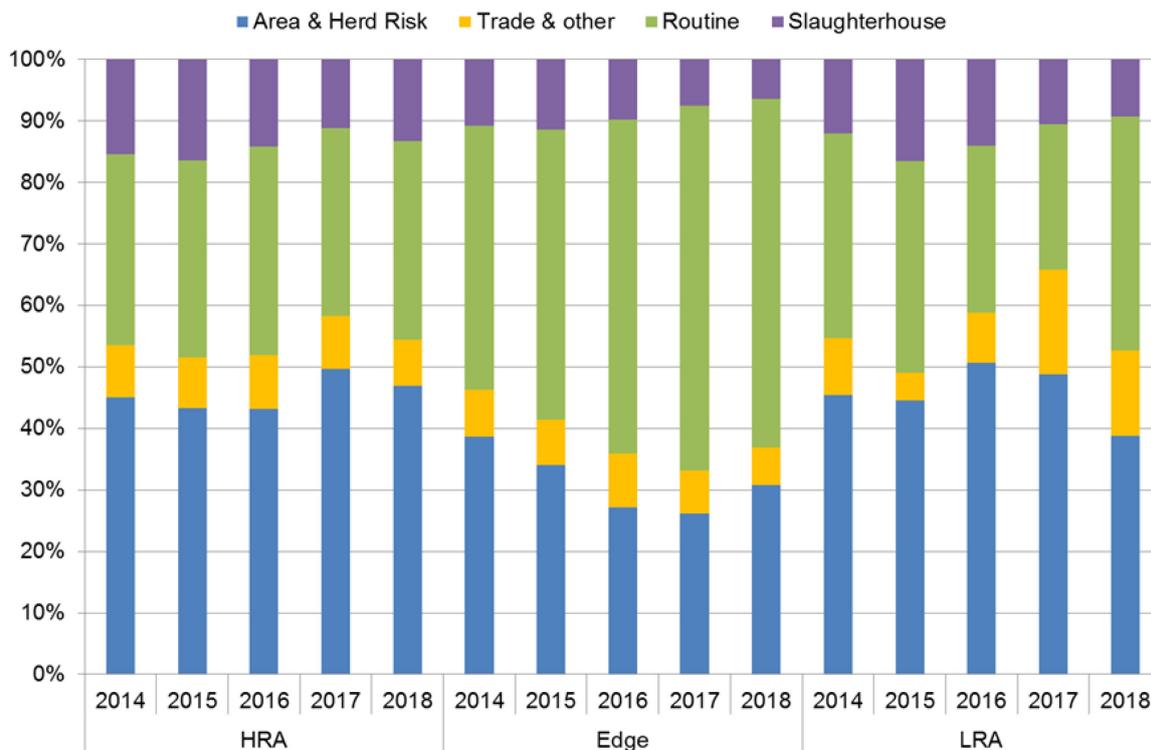


Figure 3.3.2 Annual proportions of new TB incidents detected by different surveillance streams within each risk area from 2014 to 2018 (data in GB Data Report²⁴)

²⁴ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739906/GBDataReport.ods

Routine Surveillance Stream

The Routine surveillance stream includes WHTs conducted in OTF herds at scheduled intervals of six months or one year (WHTs), and four yearly RHTs, as well as new herd tests (NH). WHTs are conducted in all cattle over six weeks old in the HRA, Edge Area and high risk herds in the LRA. The RHT in the LRA is conducted mainly in breeding stock.

Proportionally more reactors were disclosed per test in the HRA compared to the Edge Area (Table 3.3.1), which is likely to be due to a higher background force of infection in the HRA. However, this surveillance stream discloses proportionately more TB incidents in the Edge Area than in the HRA, where Area and Herd Risk surveillance is more important (Table 3.3.1). While almost all of the TB incidents within the Routine surveillance stream in the HRA and Edge Area were disclosed by WHT, and in the LRA, by RHTs, a greater number of reactors per 1,000 cattle tested were detected by NH in all three areas compared to WHT or RHT testing (Table 3.3.2).

Table 3.3.2. Performance of main test types¹ within the Routine surveillance stream by surveillance risk area in 2018

Area	Surveillance Stream	Herd Tests (%)	TB Incidents (%)	OTFW TB Incidents (%)	Reactors (%)	TB Incidents per 100 herd tests	Reactors per 1,000 cattle tested
HRA	New Herd Tests	459 (4.4)	26 (2.9)	12 (2.2)	75 (3.5)	5.7	5.3
	Whole Herd Tests	9,893 (95.6)	864 (97.1)	534 (97.8)	2,052 (96.5)	8.7	2.6
Edge Area	New Herd Tests	270 (3.3)	3 (0.7)	2 (0.9)	16 (1.6)	1.1	2.4
	Whole Herd Tests	7,989 (96.7)	406 (99.3)	228 (99.1)	990 (98.4)	5.1	1.2
LRA	New Herd Tests	577 (14.1)	4 (8.2)	1 (11.1)	2 (3)	0.7	19.4
	Whole Herd Tests	237 (5.8)	4 (8.2)	0 (0)	0 (0)	1.7	0.0
	Routine Herd Tests	3,288 (80.2)	41 (83.7)	8 (88.9)	65 (97)	1.2	0.3

1. Test types include: New Herd Tests (VE-CT-NH1, VE-CT-NH2), Whole Herd Tests (VE-WHT, VE-WHT2), Routine Herd Tests (VE-RHT24/36, VE-RHT48).

Area and Herd Risk Surveillance Stream

The Area and Herd Risk surveillance stream comprises tests carried out in higher risk situations. This surveillance stream includes tests that target areas of risk, for example contiguous, radial and hotspot tests; and tests that target herds at greater risk, for example tracings, AFU tests, check tests, and post incident tests. A higher proportion of incidents are disclosed by Area and Herd Risk surveillance in the HRA and LRA, compared to Routine surveillance (Table 3.3.1).

In the HRA, most Area and Herd Risk TB incidents were detected by post-incident tests, followed by contiguous tests (Table 3.3.3). Relatively few backward tracing tests were carried out in the HRA (less than one per cent of the Area and Herd risk surveillance stream), however in many cases other surveillance streams obviate the need for specific source trace check tests for herds, or the suspected source herd may already have been disclosed with disease and is subject to control testing. Backward tracing tests detected 17 TB incidents

per 100 herd tests, and had the highest detection rate for reactors, at four positive reactors disclosed for every 1,000 cattle tested (Table 3.3.3).

Similar test performance is seen in the Edge Area. Post-incident tests detected the highest proportion of incidents within this surveillance stream, followed by radial tests (Figure 3.3.3).

In the LRA, the best Area and Herd Risk performing tests were radial tests, which accounted for over half of the herd tests carried out in this area, and disclosed over three quarters of TB incidents. Only 21% of incidents disclosed in the LRA were OTF-W. They provide information for case management of the index case and also serve to demonstrate absence of endemic pockets of disease around OTF-W incidents in the LRA.

Post-incident tests, radial tests, contiguous tests and tracing tests will not be recorded as such if due at the same time as another scheduled herd test (e.g. a WHT), as only one test type is recorded in the system and Routine surveillance stream tests take precedence.

Potential TB Hotspot tests are used in low incidence areas, in response to an OTF-W incident (or cluster of incidents) of unclear origin in the LRA. These tests apply to herds identified in an area delineated by APHA, commonly within 3 km of the index incident herd. A total of 340 potential hotspot herd tests were carried out in the LRA in 2018 (totalling 61,678 cattle tests) with seven reactors disclosed from five TB incidents, three of which were OTF-W.

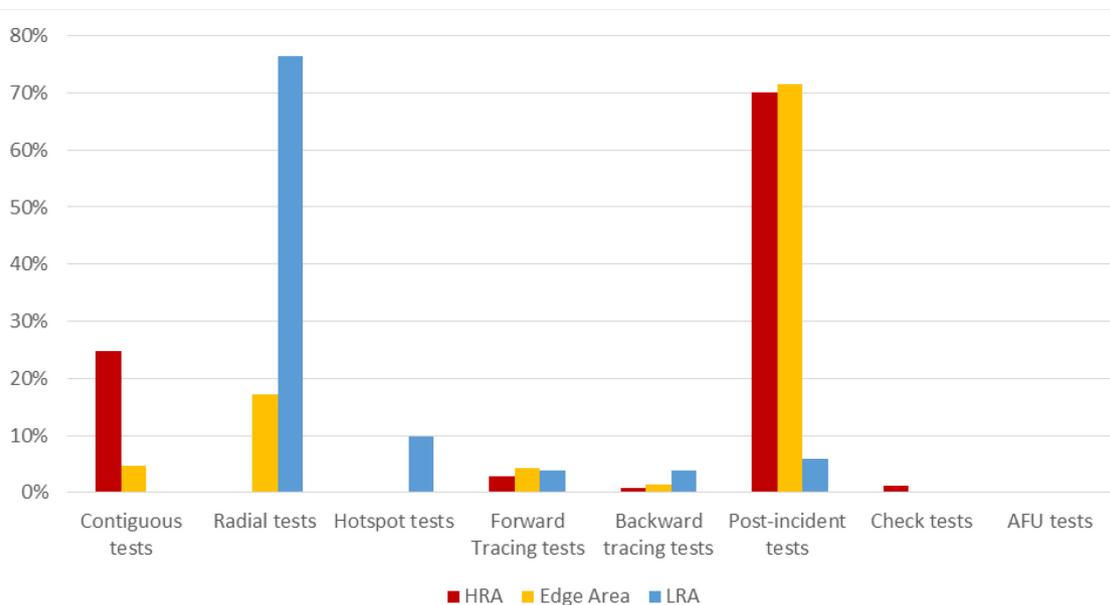


Figure 3.3.3 Percentage of main test types resulting in a TB incident within the Area and Herd Risk surveillance stream by surveillance risk area in 2018

- The majority of TB incidents were found by post-incident testing in the HRA and Edge Area, followed by contiguous testing in the HRA, and Radial testing in the Edge Area.

- Radial tests found most TB incidents within the LRA, with just 15% of TB incidents detected by another test type.

Table 3.3.3. Percentage of main test types¹ within the Area and Herd Risk surveillance stream by surveillance risk area in 2018

Area	Surveillance Stream	Herd Tests (%)	TB Incidents (%)	OTFW TB Incidents (%)	Reactors %	TB Incidents per 100 herd tests	Reactors per 1,000 cattle tested
HRA	Contiguous tests	2,329 (17.2)	312 (24.8)	212 (26.0)	976 (22.0)	13.4	3.5
	Radial tests	4 (0)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Forward Tracing tests	6,641 (49.1)	36 (2.9)	25 (3.1)	55 (1.2)	0.5	1.9
	Backward tracing tests	60 (0.4)	10 (0.8)	9 (1.1)	39 (0.9)	16.7	4.4
	Post-incident tests	4,329 (32.0)	882 (70.2)	557 (68.3)	3,207 (72.3)	20.4	3.9
	Check tests	121 (0.9)	15 (1.2)	12 (1.5)	41 (0.9)	12.4	1.9
	AFU tests	39 (0.3)	2 (0.2)	1 (0.1)	2 (0)	5.1	0.3
Edge Area	Contiguous tests	88 (2.4)	10 (4.8)	6 (5.5)	39 (6.0)	11.4	2.9
	Radial tests	757 (20.5)	36 (17.1)	16 (14.7)	67 (10.3)	4.8	0.7
	Hotspot tests	5 (0.1)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Forward Tracing tests	1,852 (50.2)	9 (4.3)	4 (3.7)	11 (1.7)	0.5	1.4
	Backward tracing tests	14 (0.4)	3 (1.4)	2 (1.8)	6 (0.9)	21.4	4.9
	Post-incident tests	907 (24.6)	150 (71.4)	80 (73.4)	500 (76.8)	16.5	2.9
	Check tests	547 (0.7)	0 (0)	0 (0)	0 (0)	0.0	0.0
LRA	Radial tests	2,019 (53.6)	39 (76.5)	8 (66.7)	52 (58.7)	1.9	0.2
	Hotspot tests	340 (9.0)	5 (9.8)	3 (25.0)	7 (9.3)	1.5	0.1
	Forward Tracing tests	1,245 (33.0)	2 (3.9)	0 (0)	3 (4.0)	0.2	0.6
	Backward tracing tests	15 (0.4)	2 (3.9)	0 (0)	1 (1.3)	13.3	0.5
	Post-incident tests	107 (2.8)	3 (5.9)	1 (8.3)	12 (16.0)	2.8	0.5
	Check tests	267 (1.2)	0 (0)	0 (0)	0 (0)	0.0	0.0

1. Test types include: Contiguous tests (VE-CON, VE-CON12), Radial tests (VE-RAD, VE-RAD6, VE-RAD12), Hotspot tests (VE-HS1, VE-HS2), Forward Tracing tests (VE-TR), Backward tracing tests (VE-CT(EM)), Post-incident tests (VE-6M, VE-12M), Check tests (VE-CT(I-I)), AFU tests (VE-TBU). 2 tests of unknown type removed from HRA.

Slaughterhouse Surveillance Stream

Slaughterhouse (SLH) surveillance utilises compulsory post-mortem inspection (meat inspection with palpation and incision of lymph nodes) of all cattle slaughtered for human consumption, followed by laboratory culture of tuberculous lesions to attempt the isolation of *M. bovis*. It is ongoing surveillance that may detect infected cattle missed by active on-farm surveillance through testing of live cattle.

The proportion of new TB incidents disclosed by SLH surveillance depends on the background force of infection and also on the frequency and efficacy of live animal surveillance and breakdown tests that take place in cattle herds²⁵. Herds are tested at least

²⁵ Further analysis of the efficacy of slaughterhouse surveillance and monitoring performance may be found in CDC slaughterhouse report: www.gov.uk

four times more frequently in the Edge and HRA compared to the LRA. Therefore a higher proportion (but lower number) of TB incidents might be expected to be detected at slaughter in the LRA compared to the other risk areas, although this was not the case in 2018.

As in previous years, the proportion of all TB incidents disclosed by SLH surveillance was highest in the HRA (13%), followed by the LRA (9%) and Edge Area (6%); likely reflecting that the higher background force of infection and number of herds in the HRA. The proportion of OTF-W incidents detected by SLH surveillance in 2018, however, was highest in the LRA (30%) compared to the HRA and Edge Area (19% and 11%, respectively).

Since 2009, the proportion of OTF-W TB incidents disclosed through SLH surveillance in the HRA has remained fairly consistent, but the trend in the Edge Area has been a declining one. There has been greater fluctuation in the LRA (Figure 3.3.4). The pronounced fall in Edge Area cases detected at slaughter in recent years is most likely due to the increased frequency of routine surveillance since 2013, with six monthly testing rolled out over a greater portion of the Edge Area in 2018 compared to 2017 (see Figure 2.1 for details).

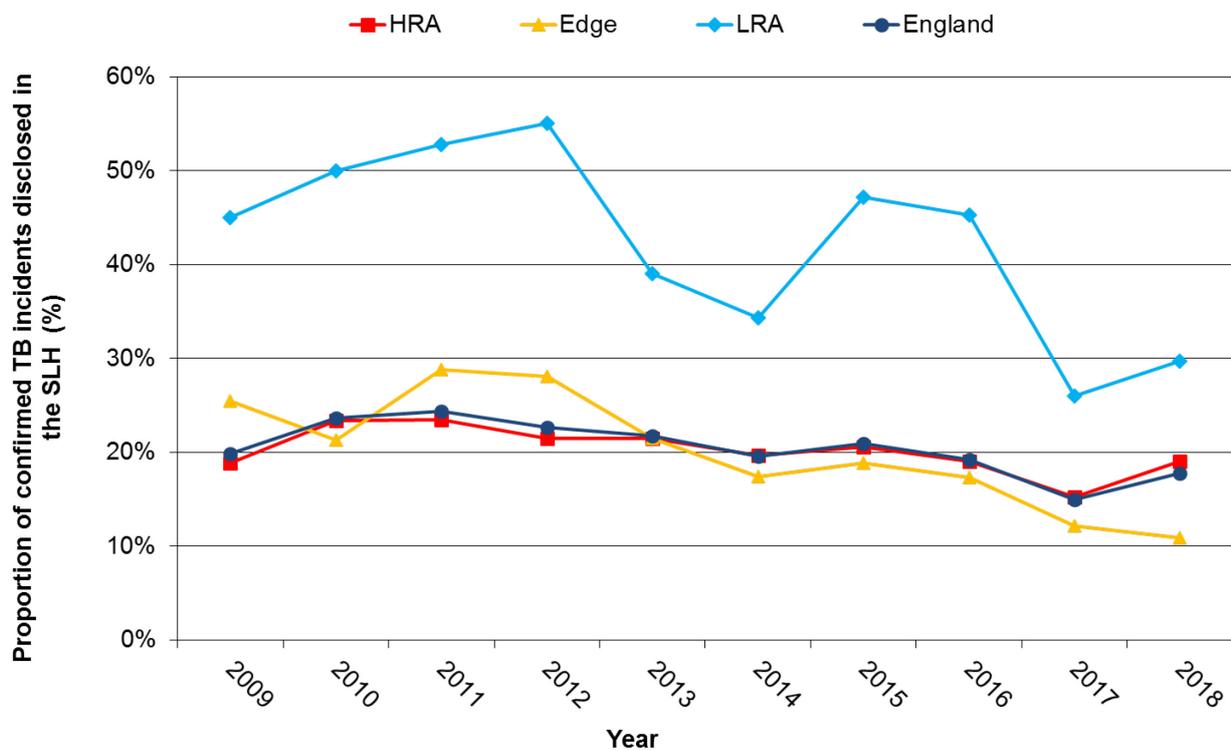


Figure 3.3.4 The proportion of new OTF-W TB incidents that were disclosed by slaughterhouse surveillance from 2009 to 2018, by risk area

Trade & other surveillance Stream

Trade surveillance includes international trade tests, private tests, tests at artificial insemination centres and pre- and post-movement testing of individual animals, rather than herd tests. Only single animals or a batch of animals are generally tested. Therefore, the proportion of the herds tested is usually much lower than for other herd tests.

Although there are large numbers of cattle movements across the country, cattle do not need to undergo bespoke pre-movement testing if the animal has already been subject to a government-funded herd test within the required timeframe for the animal test. This means animal tests, such as pre-movement tests (PrMTs), will be underreported within surveillance data. Trade & other tests detect the smallest proportion of TB incidents of all the surveillance streams (7.5%); however, this amounts to a relatively high rate of reactors detected per 1,000 tests (1.42 in the HRA, where most tests in this stream are conducted), and they play an important role in preventing disease spread between herds (e.g. into the LRA).

The majority of Trade & other surveillance cattle tests were conducted in the HRA (57%) compared to 21% in the Edge and 22% in the LRA (Table 3.3.1). In the HRA and Edge Area, virtually all Trade & other surveillance stream tests in 2018 were PrMTs (Table 3.3.4), whereas post-movement tests comprised the majority of Trade & other surveillance stream tests in the LRA. In April 2016, a change in policy made post-movement testing of cattle entering the LRA from annual or more frequent TB testing areas of GB compulsory.

Private tests represented 1% of cattle tests in 2018 (down from 5% in 2017 and 15% in 2016) and disclosed just two TB incidents (one OTF-W). International trade tests (pre-export and post-import tests from Ireland and elsewhere) and the voluntary pre-sale check test resulted in the disclosure of just one OTF-W incident, from post-import testing into the HRA (Table 3.3.4).

Table 3.3.4 Performance of main test types¹ within the Trade & other surveillance stream by surveillance risk area in 2018

Area	Surveillance Stream	Herd Tests (%)	TB Incidents (%)	OTFW TB Incidents (%)	Reactors %	TB Incidents per 100 herd tests	Reactors per 1,000 cattle tested
HRA	Pre-export	4 (0)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Post-import	64 (0.3)	1 (0.5)	1 (0.8)	2 (0.5)	1.6	1.1
	Post-movement	91 (0.4)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Pre-movement	20,106 (99.0)	209 (99.1)	130 (99.2)	362 (98.9)	1.0	1.2
	Private	46 (0.2)	1 (0.5)	0 (0)	2 (0.5)	2.2	2.3
Edge Area	Pre-export	7 (0.1)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Post-import	40 (0.5)	0 (0)	0 (0)	1 (1.7)	0.0	1.2
	Post-movement	75 (0.9)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Pre-movement	7,735 (97.5)	41 (97.6)	20 (95.2)	55 (93.2)	0.5	0.5
	Private	79 (1.0)	1 (2.4)	1 (4.8)	3 (5.1)	1.3	2.9
LRA	Pre-export	75 (1.0)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Post-import	129 (1.7)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Post-movement	3,046 (41.0)	9 (52.9)	3 (60.0)	34 (81.0)	0.3	0.6
	Pre-movement	3,895 (52.4)	7 (41.2)	2 (40.0)	7 (16.7)	0.2	0.1
	Pre-sale check LRA	2 (0)	0 (0)	0 (0)	0 (0)	0.0	0.0
	Private	286 (3.8)	1 (5.9)	0 (0)	1 (2.4)	0.3	0.3
England	Pre-export	86 (0.2)	0 (0)	0 (0)	0 (0)	0.0	0.0

Post-import	233 (0.7)	1 (0.4)	1 (0.6)	3 (0.6)	0.4	0.8
Post-movement	3212 (9.0)	9 (3.3)	3 (1.9)	34 (7.3)	0.3	0.2
Pre-movement	31,736 (89.0)	257 (95.5)	152 (97.4)	424 (90.8)	0.8	0.6
Pre-sale check LRA	2 (0)	0 (0)	0 (0)	0 (0)	0.0	0.0
Private	407 (1.1)	2 (0.7)	0 (0)	3 (5.2)	0.5	1.8

1. Test types include: Pre-export (VE-EX), Post-import (VE-PII, VE-PIO), Post-movement (VE-POSTMT, POSTMOVNC, VE-POSTMOVOV), Pre-movement (VE-PRMT, VE-AI), Pre-sale check LRA (VE-CT-LRA-SA), Private (VE-PR).

Pre-Movement Testing (PrMT)

There were just under 2.8 million cattle movements within Great Britain in 2018 (57,000 fewer than in 2017), excluding movements to a SLH directly and indirectly (e.g. via slaughter markets and authorised finishing units). Farms in all risk areas move more cattle within than outside their area and there is more cattle movement between areas closest in terms of TB risk (Table 3.3.5). In the HRA and LRA around 80% of cattle move within their area compared to 55% of Edge Area cattle.

Table 3.3.5 Summary of number of cattle movements¹ between risk areas and countries, 2018

Cattle movements in 2018	To HRA	To Edge Area	To LRA	To Scotland	To Wales	Total
From HRA	616,560	84,554	39,996	996	25,775	767,881
From Edge Area	55,418	209,724	48,289	762	20,692	334,885
From LRA	14,468	45,180	660,704	24,850	6,167	751,369
From Scotland	1,772	4,552	52,161	429,069	893	488,447
From Wales	89,941	37,414	27,191	535	291,853	446,934
Total	778,159	381,424	828,341	456,212	345,380	2,789,516

¹ Movements to slaughter houses that do not have grazing are excluded.

A total of 1.1 million of cattle in 2018 were moved out of the annual or six monthly-tested HRA and Edge Area (down 60,000 from 2017 and comparable with 2016). However, only 468,955 cattle tests were recorded as PrMT (around 43%), probably because herd tests were used to provide the same evidence of infection status prior to movement.

The proportion of TB incidents disclosed by PrMTs in the HRA has remained fairly stable since 2008; there has been more variability in the Edge Area and LRA (Figure 3.3.4). An increased proportion of TB incidents were detected by PrMTs in the Edge in 2013 following the increase in the number of eligible herds due to the introduction of annual testing. The proportion has continued to fall since then; likely due to herd-level tests (WHT or clearing SI tests) being conducted in place of PrMTs.

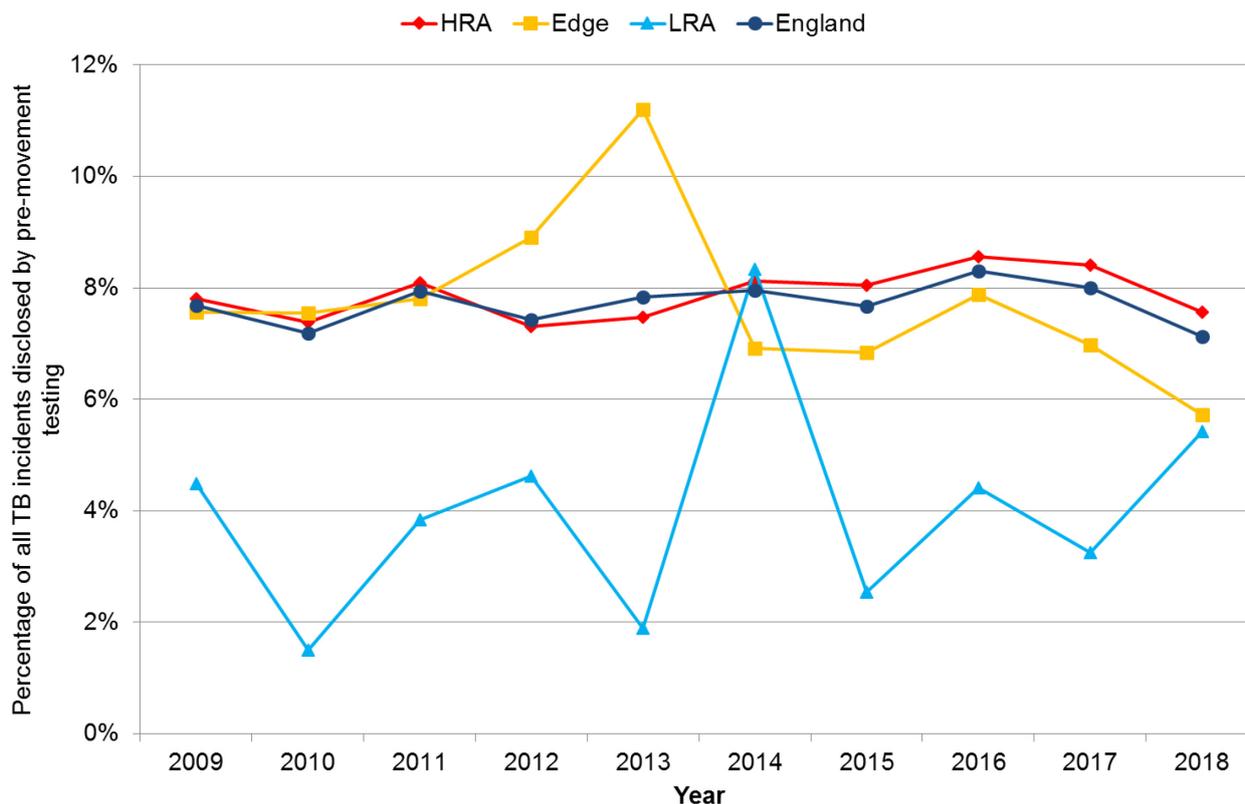


Figure 3.3.5 The proportion of total TB incidents disclosed by pre-movement testing* between 2009 and 2018, by risk area. *These data refer to tests categorised as PrMT, but does not include other tests that can be used as a PrMT.

Inconclusive Reactors (IRs)

Inconclusive reactors (IRs) are cattle that have a response to the TB skin test²⁶ that is not strong enough to classify them as reactors. These animals remain isolated from the herd pending a retest in 60 days' time with movement restrictions applied to the whole herd (i.e. whole herd restrictions²⁷) only if the herd has had an OTF-W incident in the previous three years (three-year rule). Otherwise only the IR animals are isolated and their movement restricted pending re-testing. If the IRs become reactors or IRs (i.e. 2x IRs) at the first retest, they are removed as reactors, thereby disclosing a TB incident in the herd (resulting in whole herd restrictions, reactor removal and additional incident testing imposed).

As expected, most IR-only tests (herds that had an IR disclosed and no reactors) are conducted and IRs identified in the HRA (69% and 73%, respectively) and the least in the LRA. Between 2017 and 2018, there was a decrease in the number of IR-only herds and IRs disclosed in the HRA, but increases in both the Edge Area and LRA (Table 3.3.6).

²⁶ Single Intradermal Comparative Cervical Tuberculin test or SICCT test.

²⁷ Whole herd restrictions apply to all temporary CPHs (tCPHs) and permanent CPHs (pCPHs) where no IRs have been disclosed and associated to the premises where the IR(s) was disclosed.

Table 3.3.6 Summary of number of IR-only tests and IRs disclosed, their percentages and percentage change between 2017 and 2018 by surveillance risk area.

Region	IR-only tests (% of all IR-only tests) (% change 2017-18)	IRs disclosed (% of all IRs disclosed) (% change 2017-18)
HRA	1,772 (69%) (-7%)	3,729 (73%) (-6%)
Edge Area	549 (21%) (+5%)	944 (19%) (+5%)
LRA	252 (10%) (+2%)	414 (8%) (+1%)

Over 40% of herds that had IRs disclosed without concurrent test reactors (IR-only herds) went on to have an incident within the following 15 months in the HRA (39% in the Edge and almost 20% in the LRA).

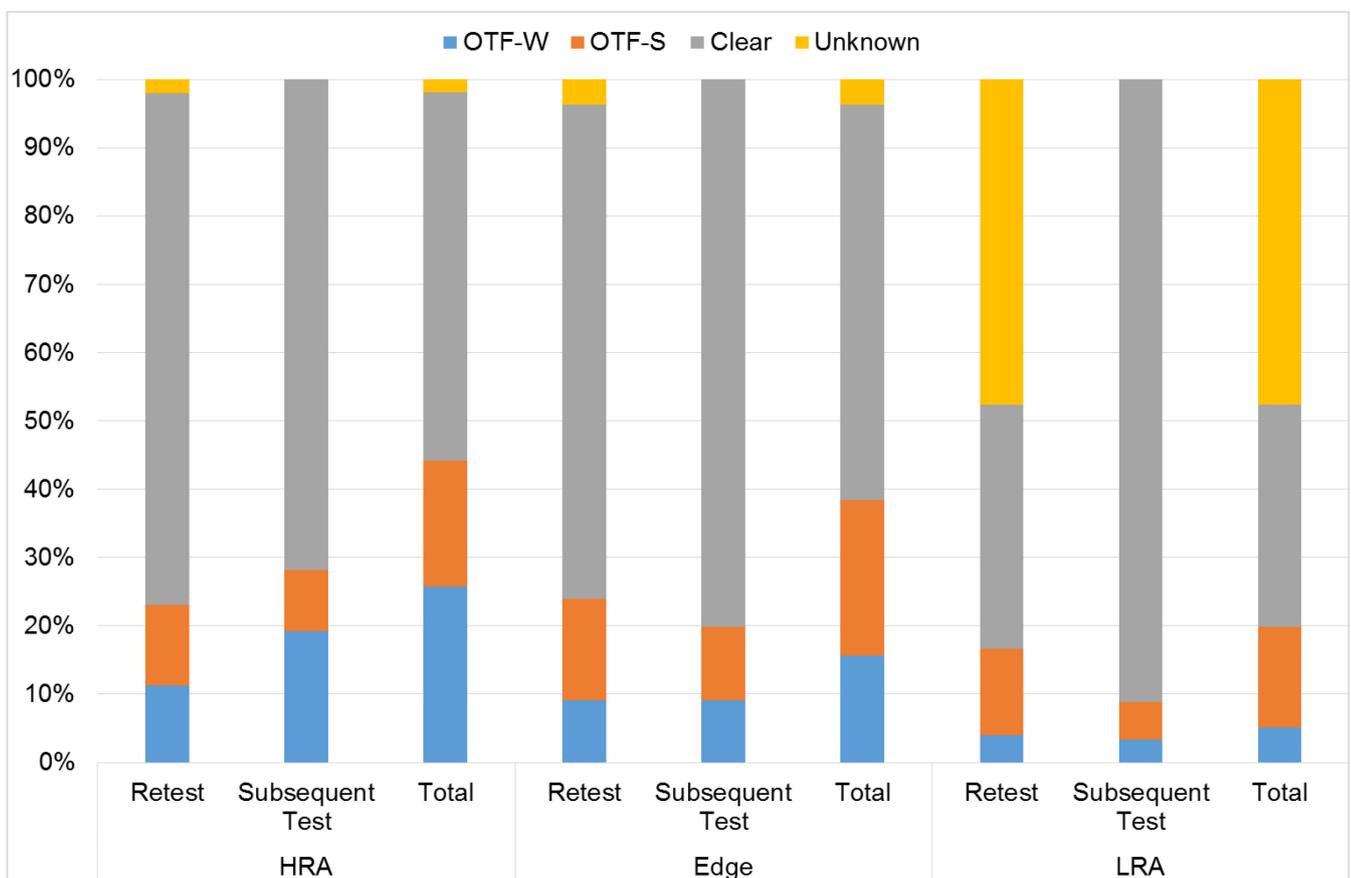


Figure 3.3.6 Fate of IR-only tests, following disclosure in 2018 by surveillance risk area. The fate of some herds is recorded as unknown due to reasons such as ceasing trading and not having a retest.

In the Edge Area and LRA, nearly all IR-only tests in 2018 took place in herds with no recent history of an OTF-W incident (89% and 96% respectively). The HRA had the lowest proportion of IR-only tests in herds with an OTF-W incident in the previous three years (67%). This follows from the higher incidence observed within this region. Around half of the

IRs in IR-only herds that went on develop TB (OTF-S or OTF-W) were detected by the IR-only herd retests in the HRA (52%). In the LRA and Edge Area most IRs that subsequently became reactors were detected at a retest (84% and 63%, respectively).

Figure 3.3.7 suggests that IR only herds in all risk areas have an increased risk of a TB incident at a subsequent test if they have a history of TB. A multivariable analysis by Brunton et al²⁸ shows that the risk from IRs in the HRA and Edge Area is substantially reduced by disclosure of reactors or 2xIRs at the first retest, but IRs that pass the retest can pose a TB risk for around 2.5 years from first disclosure. This indicates IRs are an important predictor of the presence of infection and although the retest eliminates most of the risk, the policy to restrict IRs to the herd in which they are disclosed for life should reduce the risk still further.

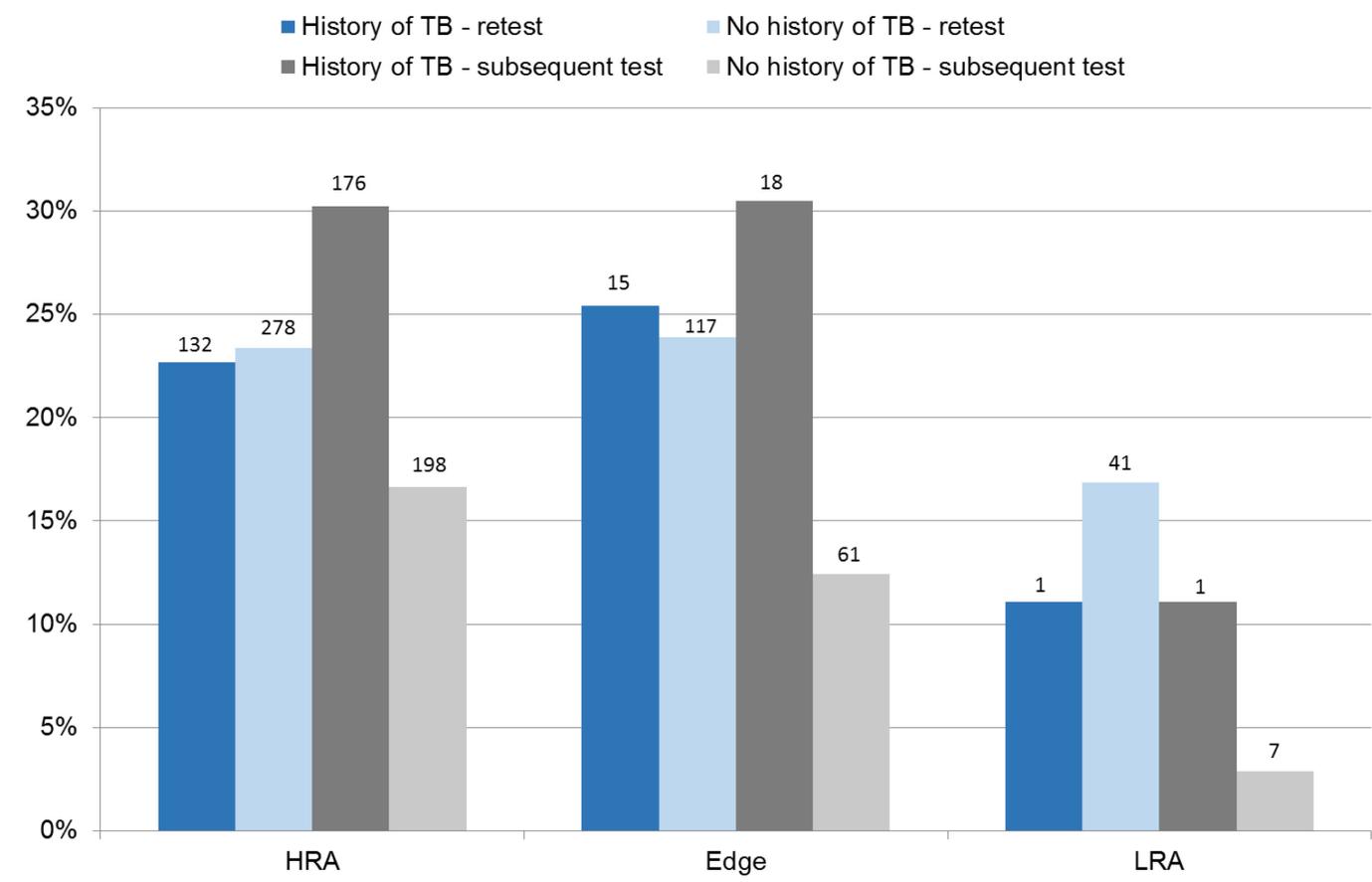


Figure 3.3.7 Proportion of IR-only herds going on to have a TB incident in 2018 at either the IR retest or a subsequent test (within 15 months after IR test), by surveillance risk area and TB history. Totals above each column represent the number of herds with a TB incident

²⁸ Brunton LA, Prosser A, Downs SH, Pfeiffer DU. Exploring the fate of cattle herds with inconclusive reactors to the tuberculin skin test. *Frontiers in veterinary science*. 2018;5:228.

Interferon gamma tests for detection of infected cattle within a TB incident

The IFN- γ ²⁹ blood test is used to increase the probability of detecting infected cattle that may not have been detected by the skin test due to imperfect sensitivity. Its main use is to complement the skin test within confirmed incidents (i.e. used in parallel). All herds suffering new fully confirmed (OTF-W) TB incidents in the LRA and Edge Area and in badger control areas (BCP Areas) of the HRA that have completed at least two culling seasons, must be subjected to supplementary IFN- γ blood testing, to enhance the detection of reactors. Mandatory IFN- γ tests are also used in persistent incidents where herds have been under restriction for more than 18 months, as well as in explosive or chronic breakdown herds considered for whole or partial slaughter. Outside of these scenarios, the deployment of the blood test in 2018 was discretionary.

Table 3.3.7 Animals (Herds) receiving an IFN- γ test in 2018 by surveillance risk area

Policy Categorisation ¹ – Animals tested ²							
Risk Area	Total	Chronic Breakdown Management	Miscellaneous	New OTF-W in BCP Areas	OTF-W outside HRA	Persistent OTF-W	Persistent OTF-W in BCP Areas
HRA	64,548 (540)	31 (4)	2,815 (45)	36,131 (338)	0 (0)	21,489 (125)	4,082 (28)
Edge Area	69,896 (590)	0 (0)	77 (4)	2,492 (10)	66,557 (571)	679 (4)	91 (1)
LRA	6,966 (59)	22 (2)	49 (2)	0 (0)	6,895 (55)	0 (0)	0 (0)
England	141,410 (1189)	53 (6)	2,941 (51)	38,623 (348)	73,452 (626)	22,168 (129)	4,173 (29)

1. Test types included: Chronic breakdown management (VE-IFN_SLHERD), Miscellaneous (VE-IFN, VE-IFN_ANOM, VE-IFN_BOV_OTH, VE-IFN_FLEX, VE-IFN_NSR, VE-IFN_OTH_SP, VE-IFN_PRI), New OTF-W in BCP Areas (VE-IFN_NBCP), OTF-W outside HRA (VE-IFN_LOW_IN), Persistent OTF-W (VE-IFN_PERSI), Persistent OTF-W in BCP Areas (VE-IFN_PBCP).
2. Number of herds tested in parentheses.

A total of 181,729 cattle underwent IFN- γ testing in England in 2018 and 9,619 (5.3%) were positive. A total of 1,452 herds were sampled and 1,015 had IFN- γ test positive animals disclosed (70%).

Since 2010 the overall IFN- γ test positive rate has varied between 4-6%. Historically there have been differences in the positive rate between risk areas with higher rates in HRA herds (19% in 2015, 8.1% in 2016 and 10.7% in 2017) although in 2018 this has dropped to 6.3% in comparison to 4.6% and 4.3% in the Edge Area and LRA respectively (Figure 3.3.8). This is likely due to the sharp increase in compulsory IFN- γ testing in BCP areas, which particularly affects the HRA. This trend is likely to continue in the next few years as more BCP areas become eligible for IFN- γ testing.

²⁹ Supplementary or ancillary test: Bovigam interferon- γ blood test (Prionics AG, Switzerland)

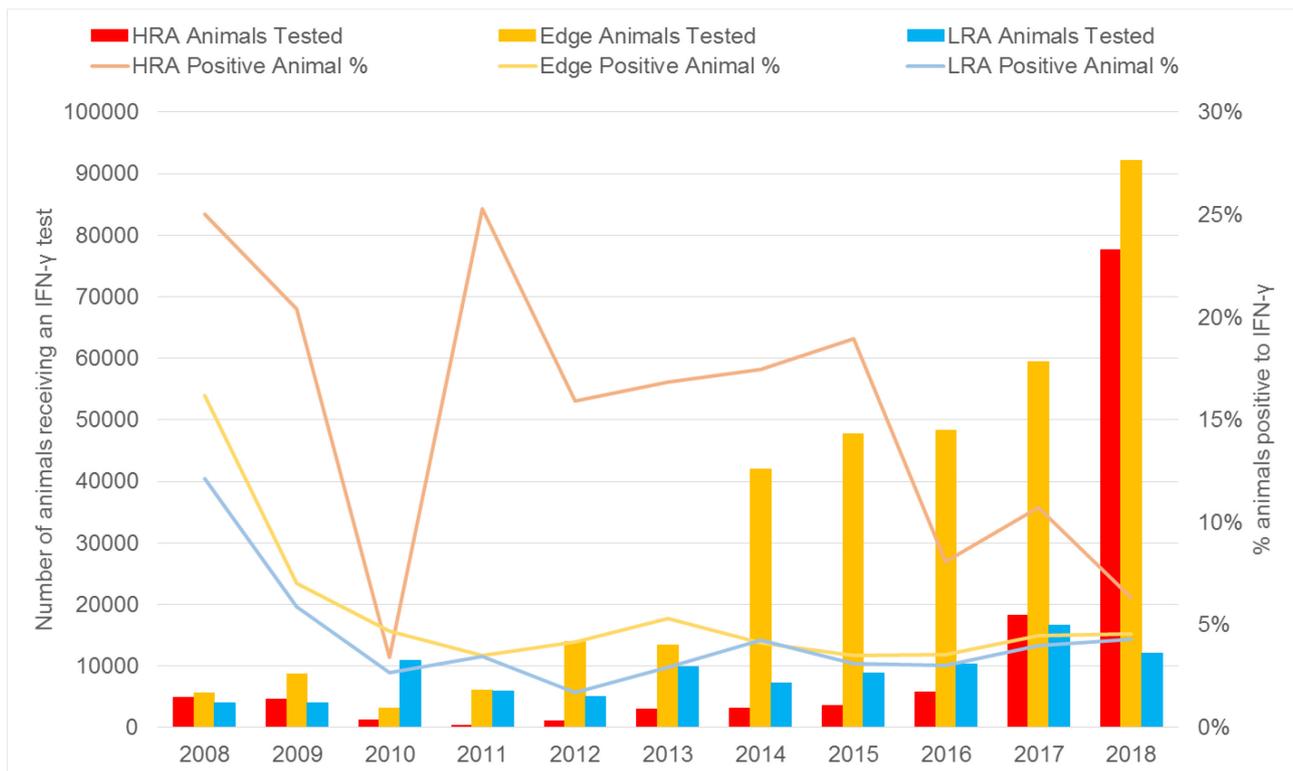


Figure 3.3.8. Number of animals tested and proportions of animals IFN-γ test positive by risk area, 2008 to 2018.

The use of IFN-γ tests at the herd level has evolved over time. In 2008-2009 the initial IFN-γ test deployment policy in England included IRs in herds where a TB incident was disclosed, so that many herds and relatively few animals within those herds were sampled. In 2018 the criteria for employing compulsory whole-herd IFN-γ testing was different in each of the three risk areas in England, discretionary use was also applied, with veterinary input, in particularly complex incidents. At herd level, the rate at which IFN-γ has detected positive animals, in addition to skin test reactors, has stayed broadly consistent across years and between risk areas at 60-80% (Figure 3.3.9).

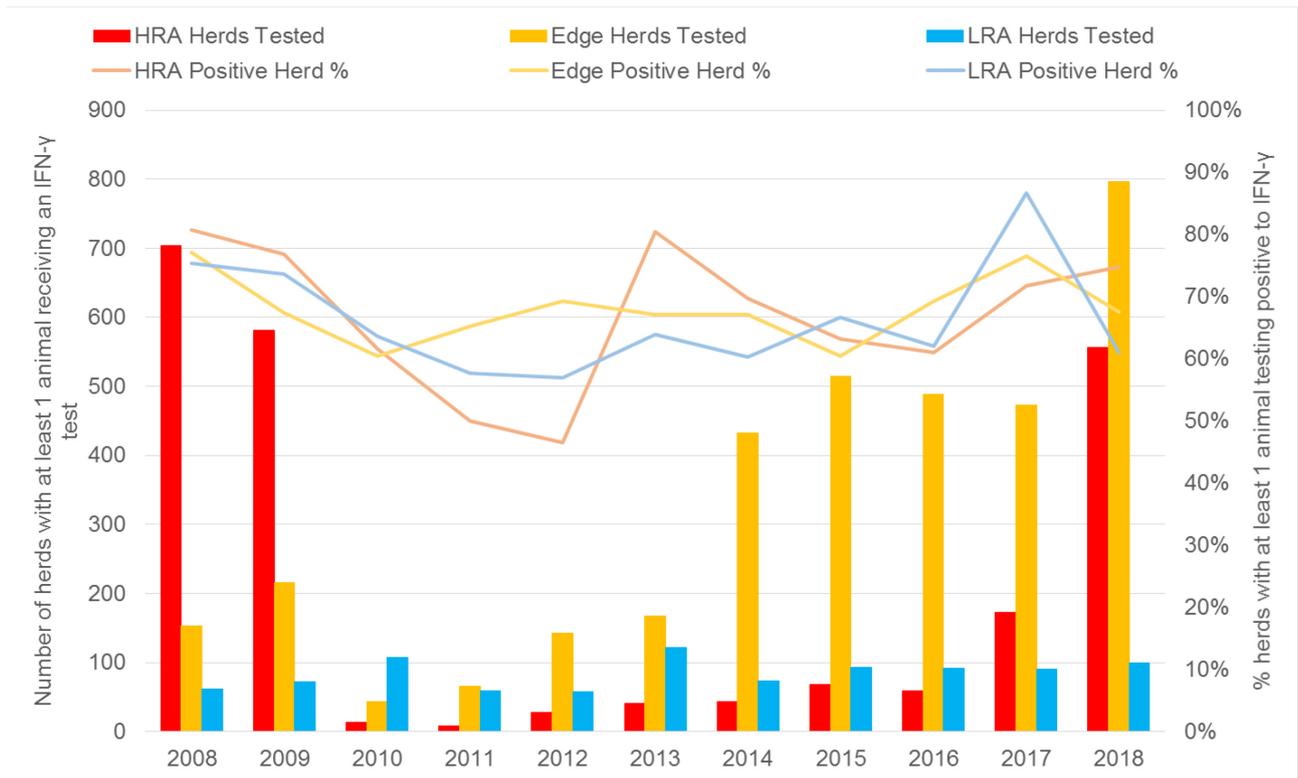


Figure 3.3.9. Number of herds tested and proportions of herds with at least one IFN- γ test positive by risk area, 2008 to 2018.

3.4 Impact of disease and control measures: prevalence, duration and persistence

- During 2018, at any point in time, about 2,900 herds (5.8% of the cattle herds in England), were under movement and other restrictions due to a TB incident. This national prevalence level is similar to previous years.
- Most of these herds were in the HRA. In 2018 the average herd level prevalence in the HRA decreased compared to 2017; however this level has been relatively stable since 2011. Prevalence in the HRA was highest in the counties of Wiltshire (13.6%), Devon (12.9%) and Avon (12.7%).
- Prevalence in the Edge Area has continued to increase since 2003, with a particular rise from 2013 since the introduction of a stricter regime for returning a herd to OTF status under the new bovine TB Government Strategy introduced in 2014. Prevalence averaged 6.7% during 2018 and was highest in the counties of Oxfordshire (14.1%) and Berkshire (13.0%).
- TB infected herds remained under restriction for a median of around six and a half months in the HRA and Edge Area, and just under five months in the LRA. However, the range was wide. TB incident duration was higher compared to 2017, when herds were under restriction for approximately six months in the HRA and Edge Area and just over four months in the LRA. Unsurprisingly, herds were under movement restrictions for longer periods in larger herds (>200 animals) and in TB incidents with more than one reactor.
- The number of TB incidents classed as 'persistent' (movement restrictions lasting for 18 months or longer) that closed in 2018 increased in all risk areas compared to the number that closed in 2017. Overall, 276 persistent TB incidents were resolved in England during 2018, 88% of which were located in the HRA.
- At the end of December 2018, 396 herds had a persistent TB incident that was ongoing ('open'), the majority of which were located in the HRA (n=348).
- In 2018, 33,265 cattle were slaughtered for TB control reasons, with a median of two reactors removed per incident. The mean number of reactors removed varied between risk areas, with an average of eight and a half in the HRA, ten in the Edge area and seven in the LRA in 2018. The high numbers of reactors in some incidents will mean the loss is much greater for some farmers.

Level of disease: Herd prevalence

Herd prevalence shows the proportion of herds classified as infected with TB at a given point in time and is measured by counting the number of herds under restrictions due to a TB incident at the mid-point of each month, divided by the number of active herds. This measurement is therefore affected by both the occurrence of new TB incidents and the incident control strategies in place. The latter determines the risk of leaving residual infection in the affected herds if the incident controls are removed too soon. The extent of testing needed to provide sufficient evidence to declare a herd officially free of TB also affects the duration of restrictions (see next sub-section). As the prevalence of TB depends on both how many herds are newly infected with TB (incidence) and how long restrictions are maintained (duration), it gives an indication of how much impact the epidemic is having on the cattle farming sector.

During 2018, an average of 5.8% of herds in England overall were restricted at any one time, equating to around 2,900 herds. However, this overall figure masks substantial differences between risk areas as shown in Figure 3.4.1. This figure also shows a seasonal cycle, likely related to the time a test is undertaken (which is planned to fit with the farming calendar when possible). Herd prevalence in the HRA decreased slightly compared to 2017. In the Edge Area, herd prevalence has increased steadily since 2009 with a marked upward trend since testing was increased in this area in 2013, reflecting the earlier detection achieved and the more stringent controls deployed in the following years. In the LRA, prevalence has remained consistently low for the past ten years.

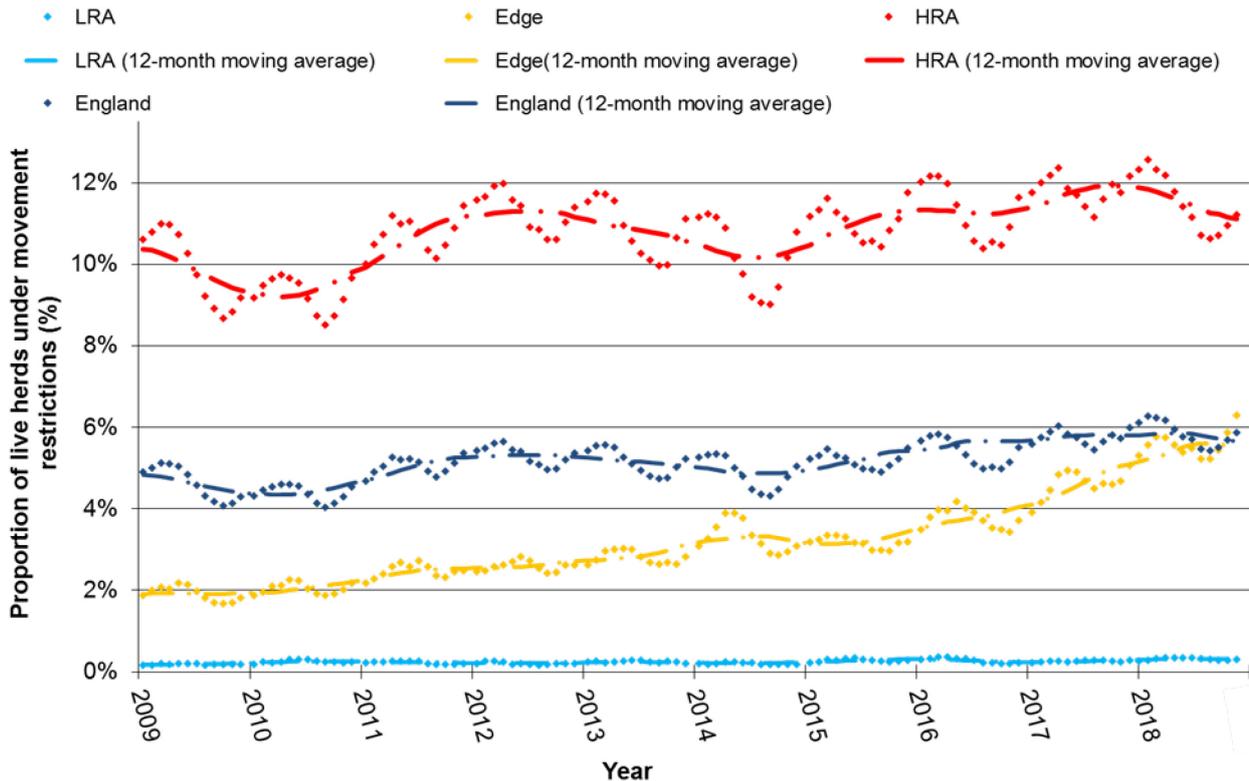


Figure 3.4.1 Proportion of live English herds under TB movement restrictions (prevalence) as a result of any TB incident, by month, between January 2009 and December 2018

- Prevalence in the HRA has generally plateaued since 2011, but risen over time in the Edge Area and has remained consistently low in the LRA.

In 2018, as in previous years, there was a wide variation in county-level prevalence of TB incidents (Figure 3.4.2), with the highest prevalence seen in Oxfordshire (14%), and the lowest in counties in the LRA. Further details about prevalence at county level within the HRA are presented in Section 4.1, while prevalence in individual counties of the Edge Area and LRA are presented in the Year End Descriptive Epidemiology Reports³⁰.

³⁰ <https://www.gov.uk/government/publications/bovine-tb-epidemiology-reports-2018>

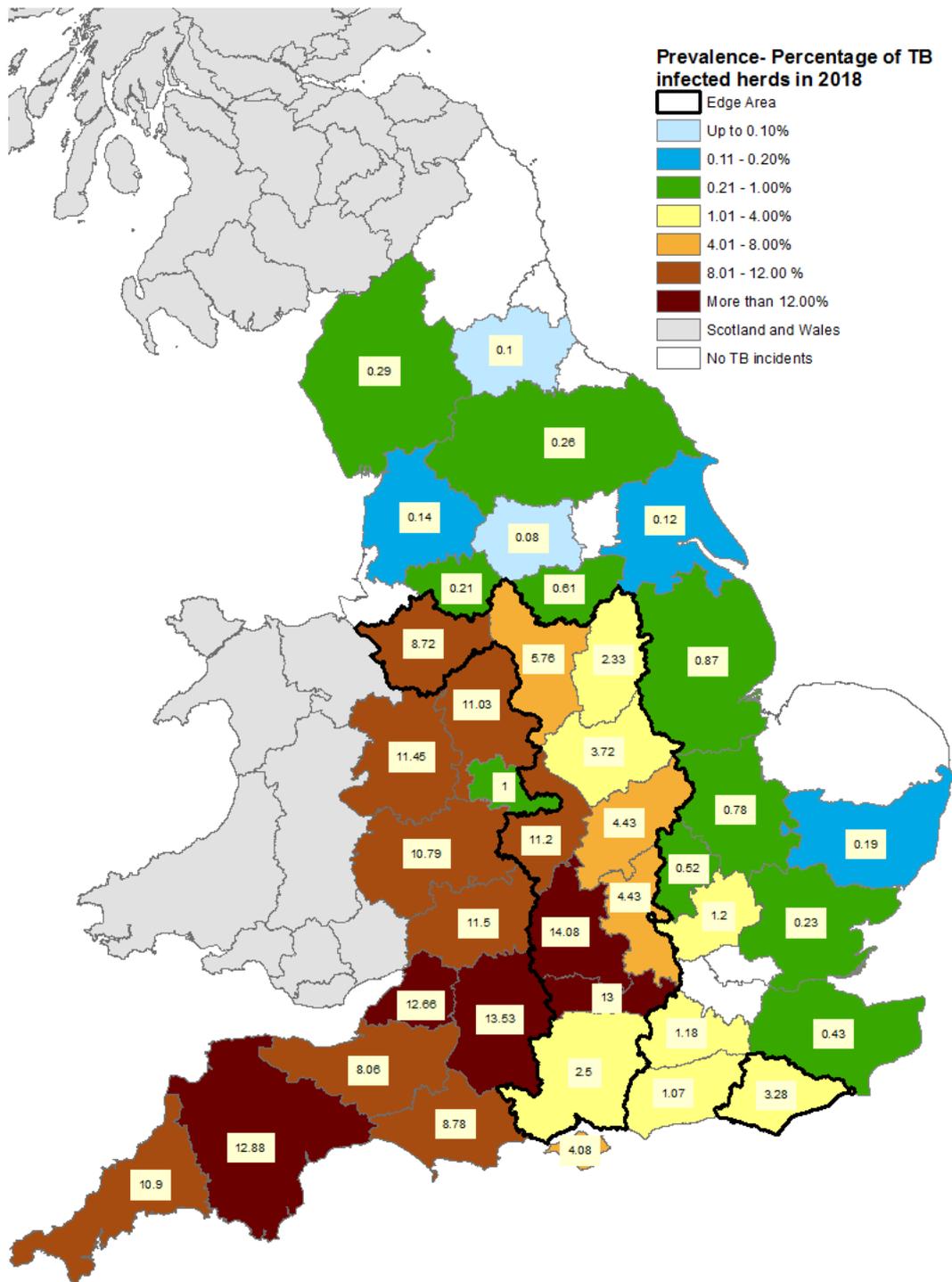


Figure 3.4.2 County herd prevalence: percentage of herds in each county that were under restrictions due to a TB incident at the end of 2018 (15th December)

- Prevalence is generally greatest in the HRA. However, as in previous years, high levels of herd prevalence were also found in some Edge Area counties, including Oxfordshire, Berkshire, Warwickshire and Cheshire.

Duration of TB incidents (period of movement restrictions)

Herds infected with TB are prevented from moving cattle while infection is being removed, to limit the risk of spreading TB (with the exception of direct movements to slaughter, to dedicated slaughter markets or finishing units approved by APHA, all under licence). The duration of these movement restrictions affects farmers because restrictions constrain the management of the herd. Longer durations are generally associated with more tests and thus greater costs to both farmers and taxpayers. Shorter periods of restrictions enable a farmer to get back to business as usual more quickly, so minimising their economic impact. However, this must be balanced against the risk of leaving infection in the herd (and further spread of disease) if restrictions are removed too early.

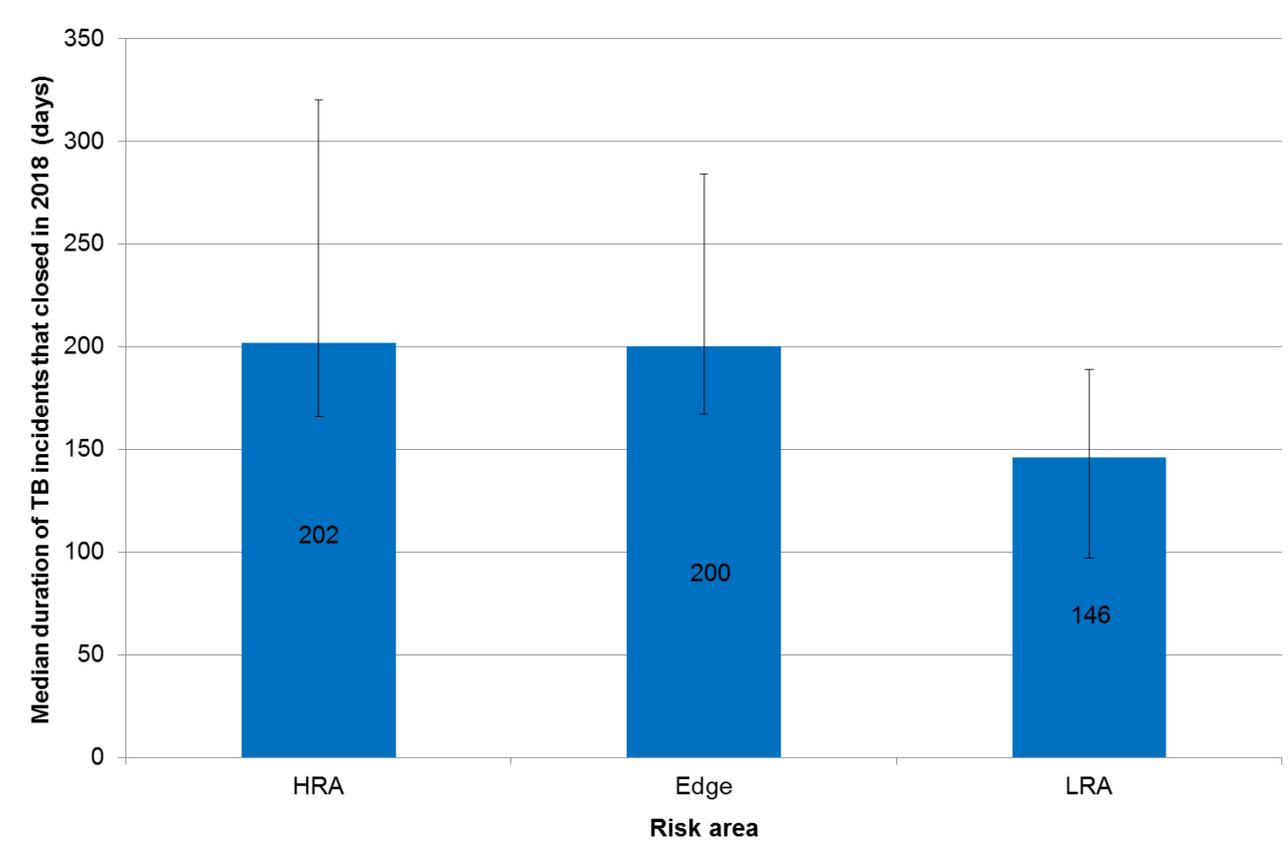


Figure 3.4.3 Median duration (and ‘interquartile range’, IQR) of all TB incidents that closed in 2018 by risk area

- Herds were under restriction due to TB for similar lengths of time (median) in the HRA and Edge Area, but the duration was much shorter in the LRA, however there is wide variation within each risk area.

In the HRA and Edge Area, herds were under restriction for longer compared to the LRA, with a median duration in the HRA and Edge Area of six-and-a-half months. Additionally, the interquartile range (IQR) indicates that half of herds in the HRA were under restriction for between five and ten-and-a-half months; however in the LRA, the median duration of TB

incidents was notably shorter at just under five months (IQR ~ 3 - 6 months), reflecting the higher proportion of TB incident herds with OTF status suspended (OTF-S), which require only a single short interval test (SIT) to demonstrate freedom from infection.

Factors that are associated with a significant increase in duration include large herd size and number of reactors found.

The duration of herd movement restrictions was associated with herd size in all risk areas (Figure 3.4.4). It took longer for restrictions to be lifted in herds with more than 200 animals, as can be seen by the increasing proportion of such herds (green shading) in the longer duration categories. A greater proportion of medium and small herds are restricted for shorter periods in all risk areas (movement restrictions of less than 150 days and 151-240 days in the HRA and Edge area). As duration of incidents increases, the proportion of small herds affected decreases.

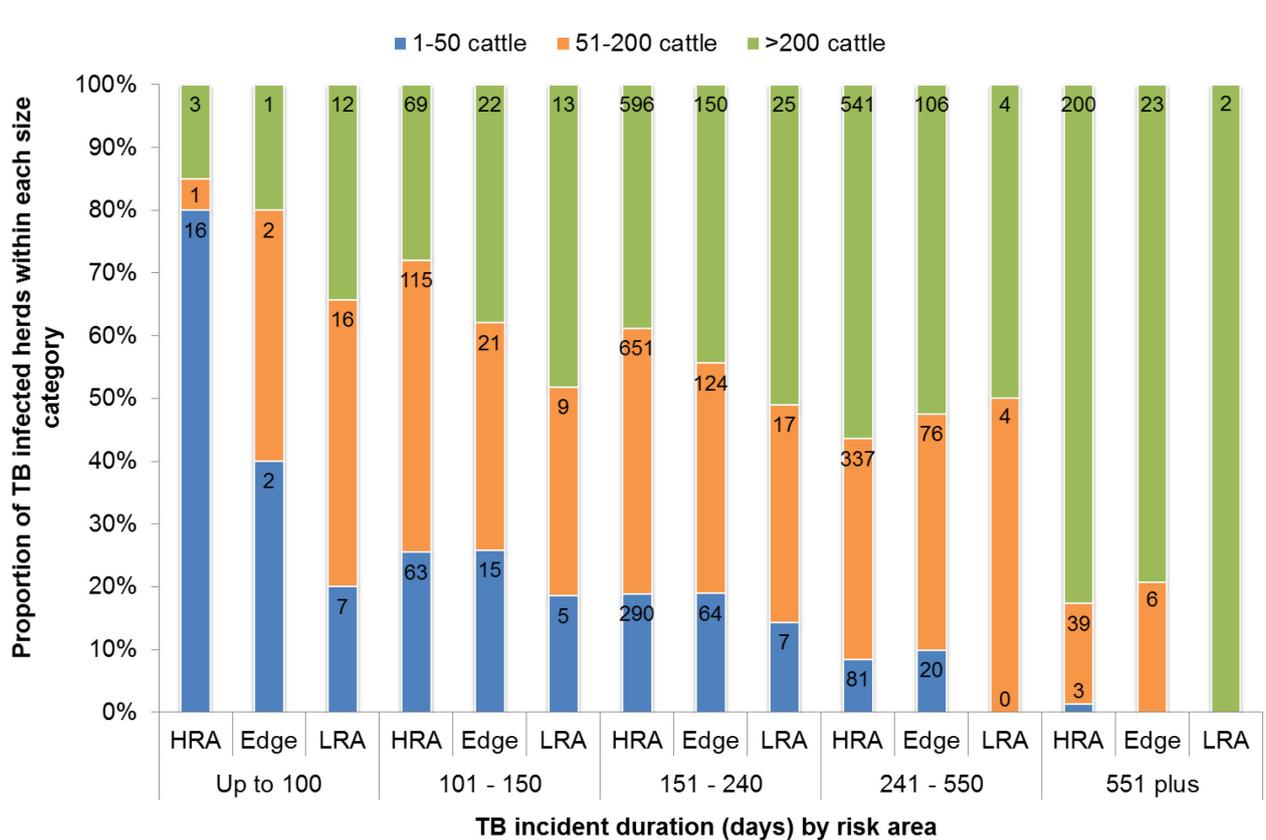


Figure 3.4.4 Comparative duration of TB incidents that closed in 2018, by risk area and herd size (values show number of herds in each size category)

- Smaller herds of up to 50 animals came off movement restrictions more quickly than herds with 51-200 animals, which also resolved more quickly than those with over 200 animals, regardless of risk area.

Long movement restrictions are the result of challenges in removing infection, or in demonstrating freedom from infection. They may result from a number of factors that can interfere with efforts to remove infection, such as a poor response of one or more infected

animals to the skin test, intense cattle-to-cattle transmission, continued re-infection (e.g. from wildlife or contiguous herds), or less commonly, the potential for uninfected animals to show non-specific reactions to tests.

A total of 3,737 herds in England had movement restrictions lifted in 2018 (TB incidents closing at the end of 2018). Figure 3.4.5 shows the number of Short Interval Tests (SITs) it took to regain OTF herd status after a TB incident, comparing risk area and herd size. Overall in England, 50% of herds (with TB incidents that closed in 2018) took two SITs to resolve, and 85% of all herds underwent fewer than five SITs to regain OTF herd status.

In the HRA and Edge Area, most TB incidents took two or three SITs to resolve; for the LRA this was one or two. The HRA had herds under restriction for longer, with 16% of herds receiving more than five SITs in 2018; in the Edge Area only 11% of herds received more than five SITs and in the LRA just four per cent (five herds).

In the HRA, around two thirds (65%) of small herds (1-50 cattle) with TB incidents required two SITs to regain OTF status, with 30% of small herds requiring three or more SITs; fewer medium size herds (51-200 cattle) cleared a TB incident with two SITs (57%) and just under half required three or more SITs (43%). Most large herds (>200 cattle) required three or more SITs (61%).

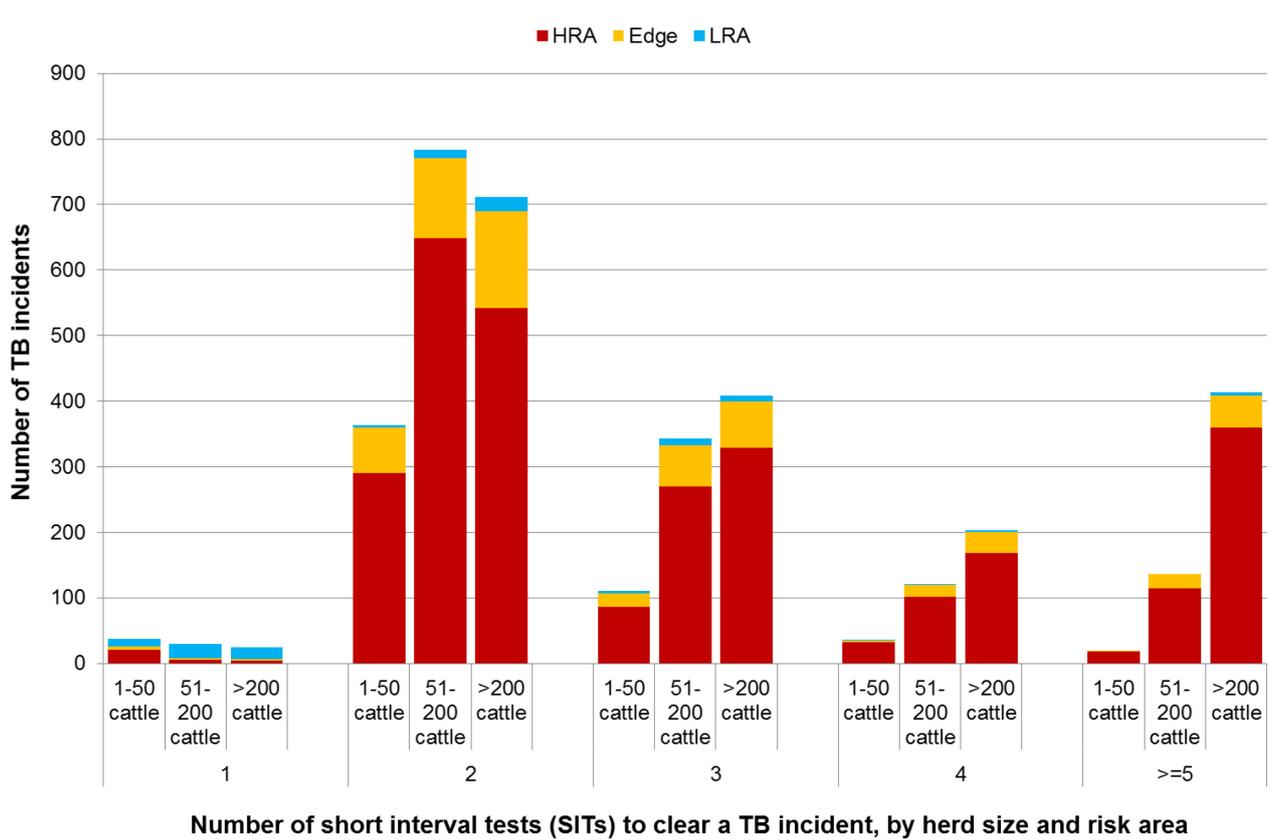


Figure 3.4.5 Number of short interval tests (SITs) necessary to regain OTF herd status after a TB incident, by risk area and herd size (for TB incidents ending in 2018). Note: three herds were missing information on SITs)

- In the HRA and Edge Area, most herds required two or three SITs to regain OTF status after a TB incident. In the LRA, most herds required one or two SITs.

Changes in TB herd incident duration over time

Since 2008, TB incidents with more than one reactor have consistently been under restriction for longer, in all risk areas, compared to incidents with one reactor only (Figure 3.4.6). Herds in the HRA generally had a longer duration of movement restrictions in both categories, although the Edge Area has had a similar duration for TB incidents with 0-1 reactors since 2014. The duration of TB incidents for single reactor herds is largely driven by the required number of SITs, which for the LRA is often only one as the majority of cases are strongly suspected but not fully confirmed by post-mortem examination or bacteriological culture, hence the lower duration for such herds in this area.

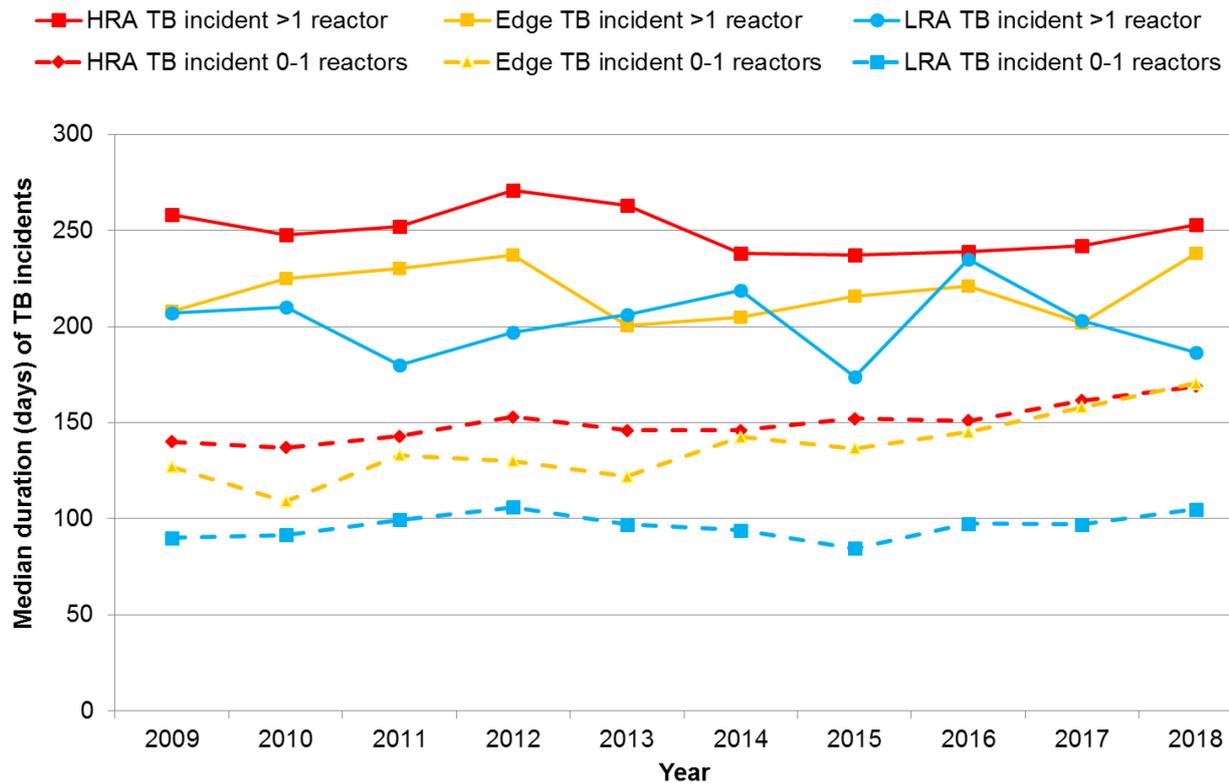


Figure 3.4.6 Median duration of TB incidents that closed in each year, between 2009 and 2018

- Since 2008, herds with TB incidents in the HRA and those with more than one reactor have consistently been under restriction for longer, compared to those with incidents in the Edge Area or LRA.
- In the HRA and Edge Area the median duration of all TB incidents increased in 2018 compared to 2017. This may be related to changes in the timing of SITs, which came into effect in April 2017. New policy requires SITs to be applied 60 days following the removal of reactors, rather than 60 days after the initial date of detection.
- Since 2013 in the Edge Area and 2016 in the HRA, most single reactor herds have required two SITs to clear a TB incident, leading to a similar duration (170 days in 2018).

Persistent TB incidents

If a TB infected herd is under movement restrictions for over 550 days (about 18 months), the incident is considered to be 'persistent'. These affected herds are eligible for enhanced management procedures, based on a series of prioritisation criteria.

Figure 3.4.7 shows the proportion of TB incidents resolved in each year since 2009 that were persistent incidents, by risk area; the vast majority were in the HRA, where the proportion of persistent incidents was also higher than in the Edge Area or LRA. A greater proportion of persistent TB incidents were resolved in each of the risk areas in 2018

compared to 2017, and in the HRA the proportion of persistent incidents resolved in each year has been increasing since 2015 (Figure 3.4.7).

In 2018, there were 276 persistent TB incidents resolved in England overall, with 88% located in the HRA (244, compared to 204 in 2017), and 11% in the Edge Area (30, compared to 11 in 2017). Two persistent TB incidents closed in 2018 in the LRA (none in 2017).

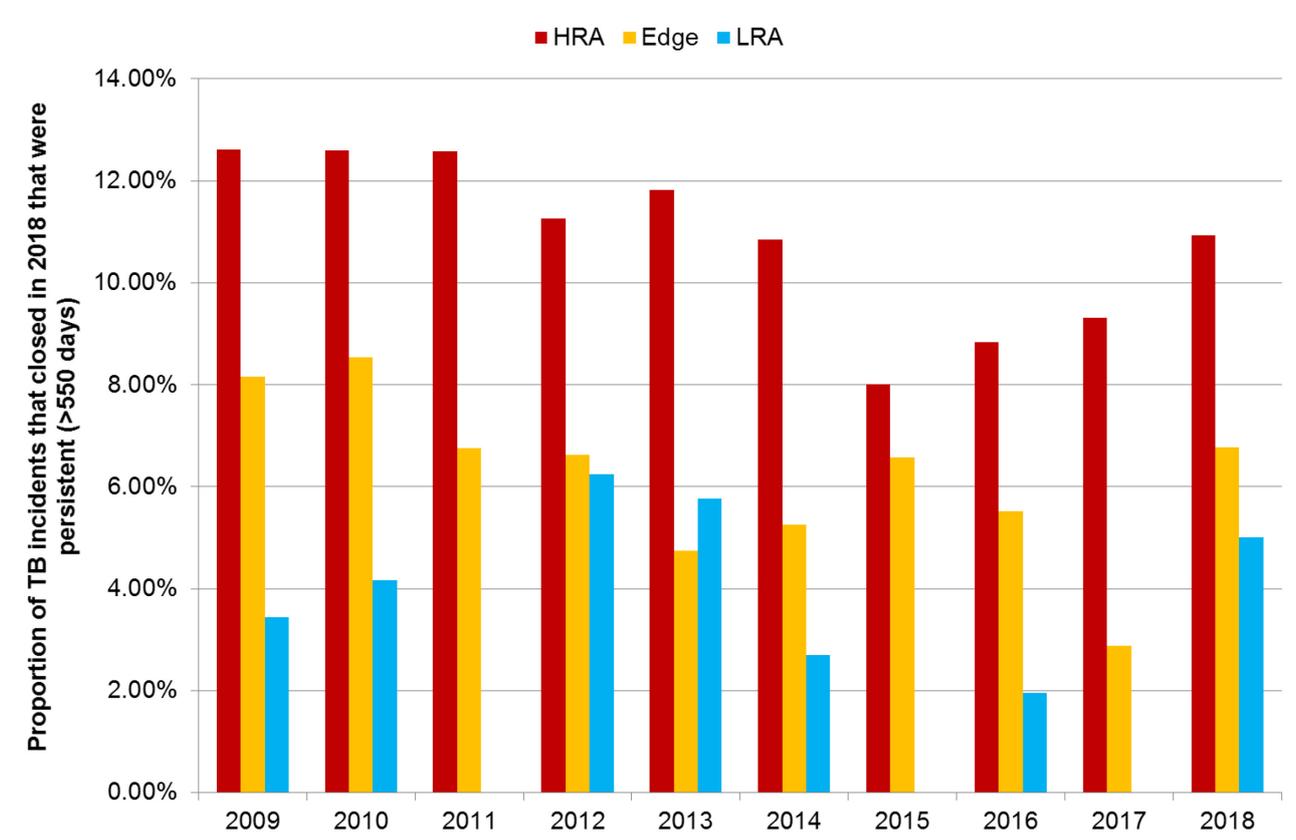


Figure 3.4.7 Proportion of TB incidents that ended in each year that lasted more than 550 days ('persistent' TB incidents)

- The proportion of persistent TB incidents resolved in the HRA is higher than the other risk areas, reflecting the greater burden persistent incidents pose in this area.
- In the Edge Area, the proportion of persistent incidents has been fluctuating in recent years, but was higher in 2018 than any year since 2010.

At the end of 2018, there were 396 herds that had a persistent TB incident that had not been resolved ('open'), most of which were located in the HRA (348), 45 in the Edge Area and three in the LRA. This is ten more persistent incidents open at the end of 2018 compared to the end of 2017 (386 incidents), showing that although more persistent incidents were resolved in 2018 compared to 2017, more TB incidents also became persistent during 2018.

Persistent TB incidents have a variety of causes including:

- The limitations of the existing test in finding all infected animals, particularly in large herds, due to presence of infected animals that fail to react to the test, potentially leading to continued spread within the herd.
- Repeated re-infection from an unidentified source, possibly driven by management factors, for example the need to use particular fields with known badger activity.
- New infection unknowingly introduced with purchased animals (under licence), or new exposure in the environment, including contiguous herd breakdowns or changes in management.

Most herds that have prolonged infection with TB are located in the HRA. Within the HRA for persistent breakdowns that closed in 2018, the proportion was highest in Cornwall (10.7%), followed by Devon (9.1%) (Figure 3.4.8).

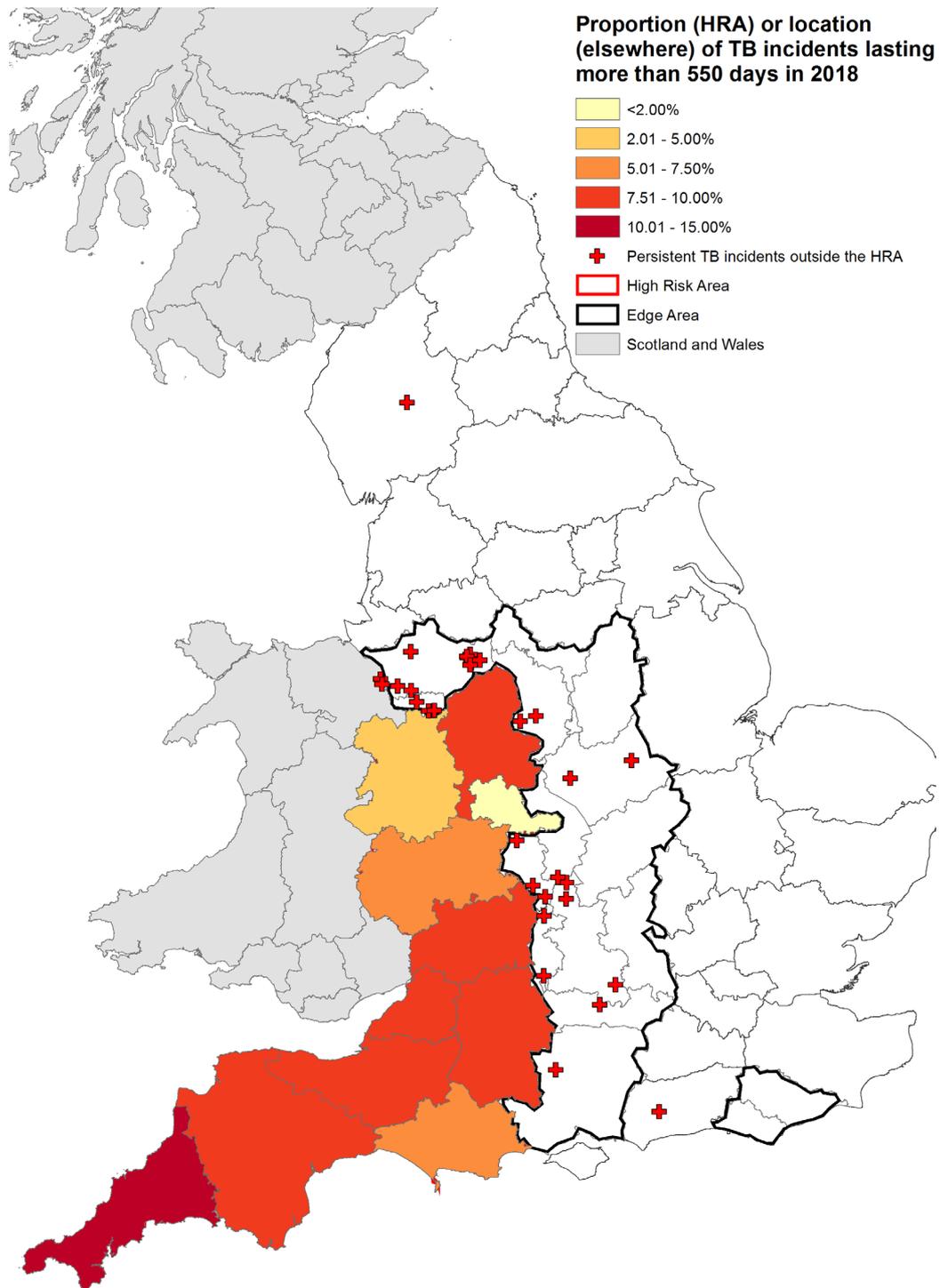


Figure 3.4.8 Proportion (HRA) and location (elsewhere) of all TB incidents that ended in 2018 that had lasted more than 550 days (persistent incidents)

- Most herds that have prolonged infection with TB (that closed in 2018) were located in the HRA, with the highest proportions observed in Cornwall (10.7%) and Devon (9.1%).
- Very few TB incidents that ended in 2018 in the Edge Area or LRA had lasted longer than 18 months, therefore are shown by their location rather than as a proportion of all incidents.

Number of animals removed

In 2018, a total of 33,265 cattle were slaughtered for TB disease control (Figure 3.4.9a). The vast majority of those animals were TB test reactors (94.3%, Figure 3.4.9a); 54% of which were standard-interpretation reactors³¹; 17% severe-interpretation reactors³² and 28% IFN- γ test positives (Figure 3.4.9b). The remaining 5.7% were removed as inconclusive reactors (IRs) 3.6% before re-testing or as direct contacts 2.1%.

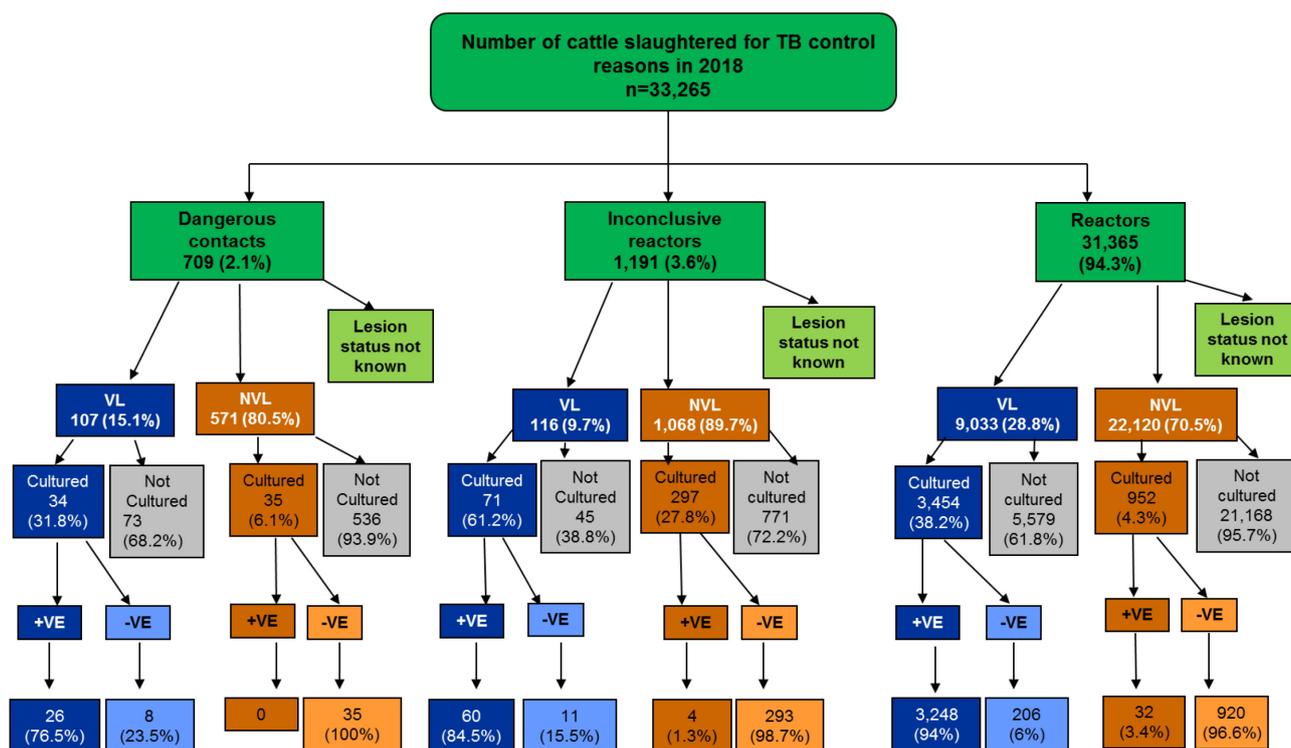
Confirmation of *M. bovis* infection means the detection of typical gross lesions of TB at post mortem (PM) examination or meat inspection (visibly-lesioned [VL] animals) in a slaughtered test reactor, or identification of the bacterium in laboratory culture. Virtually all cattle slaughtered for TB control purposes undergo post mortem meat inspection, usually in an abattoir³³, but not every TB-affected animal is sampled for laboratory culture and molecular typing of *M. bovis*.

In line with previous years, 94% of VL cattle that were sampled yielded a positive culture result, whereas only 3.4% of non-visibly-lesioned (NVL) sampled cattle did so (Figure 3.4.9a).

³¹ Reactors whose readings of increases in skinfold thickness for bovine site are over 4 mm bigger than those on the avian site (irrespective of whether the avian site reading is positive or negative)

³² Reactors whose readings of increases in skinfold thickness for bovine site are >3 mm bigger than those on the avian site or those with a positive bovine reading and negative avian reading.

³³ Missing PM examination in 0.8% of reactors and 0.7% of IRs and DCs slaughtered.



KEY: VL = visible lesions; NVL = non-visible lesions; +VE = *M. bovis* positive; -VE = *M. bovis* negative; NC = not cultured

Figure 3.4.9a Diagram showing the number of cattle that were slaughtered for TB control reasons in 2018 across England, and the number in which infection with *M. bovis* was confirmed.

IFN- γ tests are compulsory in OTF-W incidents in the Edge Area and LRA, but discretionary in the HRA. However, from April 1st 2017 compulsory use of IFN- γ blood testing was implemented in specific areas in the HRA³⁴. IFN- γ test positive animals represent just 19% per cent of all cattle slaughtered for TB control reasons in the HRA, but 50% in the Edge Area and 55% in the LRA (Figure 3.4.9b).

Over 90% of confirmed cattle slaughtered in OTF-W incidents (in Figure 3.4.9b defined as any VL animal or NVL *M. bovis* positive animal) were standard-interpretation reactors to the SCCIT skin test.

³⁴<https://tbhub.co.uk/guidance/testing-and-compensation/cattle-interferon-gamma-ifny-testing-bovine-tuberculosis/?-testing-bovine-tuberculosis/>

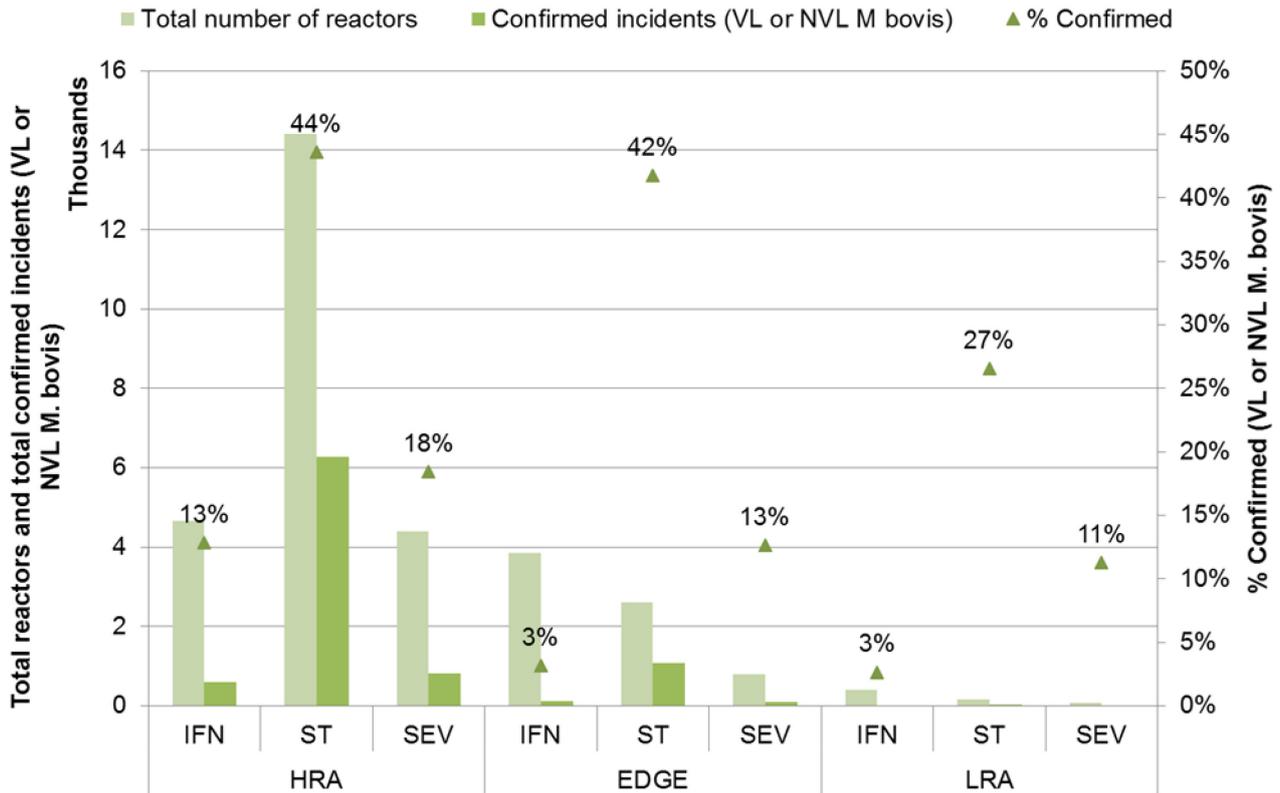


Figure 3.4.9b Number of reactors (IFN- γ , standard and severe interpretation) and total (and %) of VL or NVL (but *M. bovis* positive) animals, by risk area

The median number of reactors removed per incident has remained at two for several years; however some incidents have large numbers which inflates the mean. The mean total number of test reactors removed (including IFN- γ test positive animals) in the HRA per TB incident was around six from 2009 to 2014 and has since fluctuated between six and eight, increasing to nine towards the end of 2018. Figure 3.4.10 reflects the moving average (mean) number of reactors removed. There has been greater fluctuation in the Edge Area which showed a peak in 2015 and again in 2017. There are very few incidents in the LRA so the mean shows greater variability.

Sixty-six per cent of TB incidents closing in 2018 in England had two or more reactors, largely driven by the HRA, but also the Edge Area (67% and 70% respectively). In the LRA, the proportion of TB incidents with two or more reactors was 45% in 2018. The proportion of TB incidents with two or more reactors increased in all individual risk areas and England overall in 2018 compared to 2017. This is likely to be driven by the increased application of INF- γ testing during TB control.

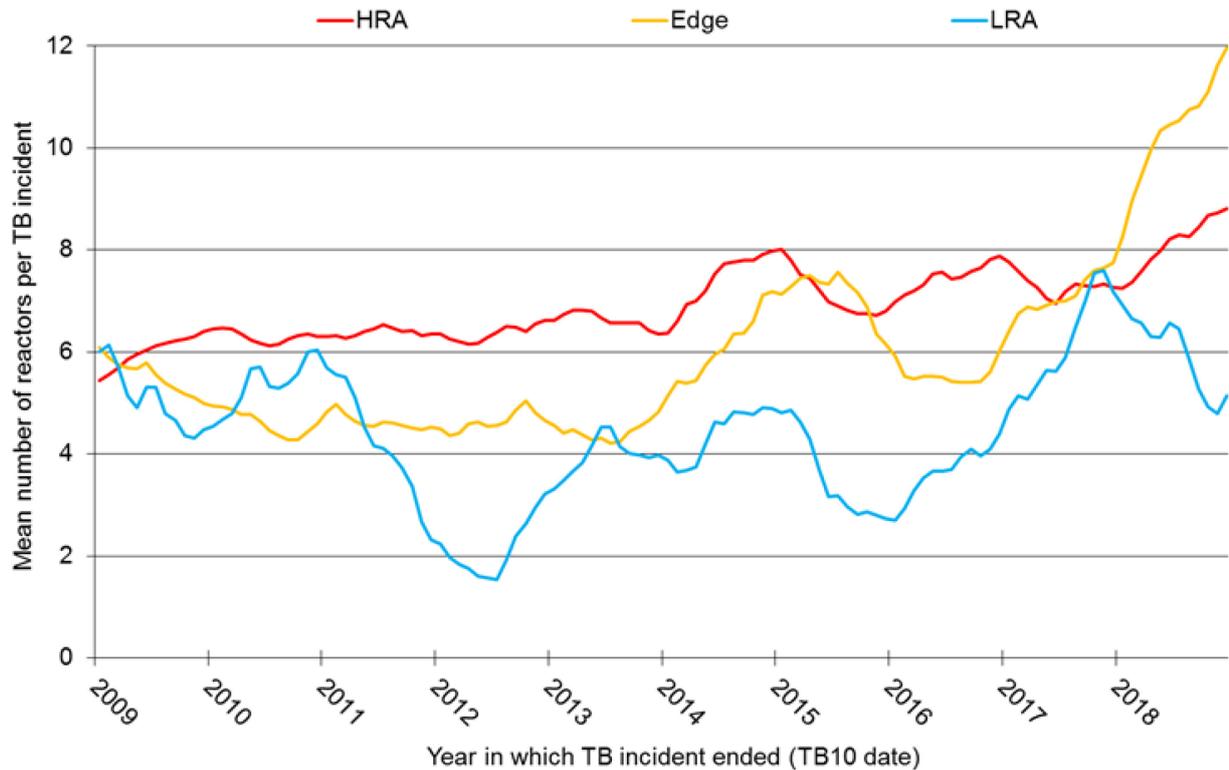


Figure 3.4.10a Rolling mean total number of test reactors (including IFN-γ test positive animals) taken per TB incident that closed between Jan 2009 and Dec 2018, by risk area (12-month moving average)

- The mean total number of test reactors removed in the HRA per TB incident was around six from 2009 to 2014 and has since fluctuated between 6-9 reactors.
- There has been greater fluctuation in the Edge Area, which showed a peak in 2015 and again in 2018. There are very few incidents in the LRA, so the mean shows greater variability (between 4 and 8 in 2018).

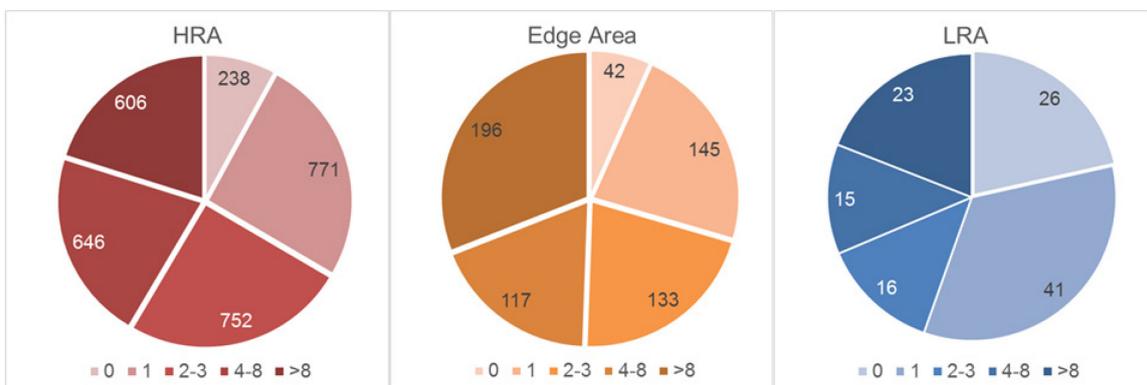


Figure 3.4.10b Number of reactors per TB incident that closed in 2018, by risk area

The frequency of TB incidents for each category of reactor numbers is specified in each pie

- This figure shows the variation between the number of reactors found in each TB incident closing at the end of 2018. Most incidents in the HRA had between 1 and 3

reactors per TB incidents, in the Edge Area the number of TB incidents was higher where there was either 1 reactor or >8 reactors. In the LRA, most TB incidents had 1 reactor.

In 2018, there was a 0.5% decrease in the number of cattle removed from herds for TB control purposes across England compared to 2017. The majority of the 33,265 cattle removed from herds were reactors taken from the HRA (n=23,465, 71%), which has been the pattern over the last ten years (Figure 3.4.11). However, substantial numbers are also taken as inconclusive reactors (IRs, 843 in the HRA) and direct contacts (DCs, 479 in the HRA). There has also been a steep increase in the number of reactors removed from herds in the Edge Area, jumping from 2,609 in 2013 to 7,252 in 2018, reflecting the impact of more stringent controls introduced since 2013, and the rollout of Edge Area controls in previously HRA parts of the Edge Area counties in 2018.

The measure requiring two skin herd tests with negative results at severe interpretation for restoring OTF herd status after a TB incident has applied since April 2016 in the HRA and since 2013 in the Edge Area. This means that IRs disclosed at standard interpretation may be removed as reactors when reinterpreted at severe is applied, increasing the number of reactors and reducing the risk of leaving residual infection in the herd. Furthermore, compulsory application of IFN- γ test in all OTF-W TB incidents in the Edge Area was rolled out from 2014, and applied to the former HRA parts of the five previously split Edge Area counties in 2018.

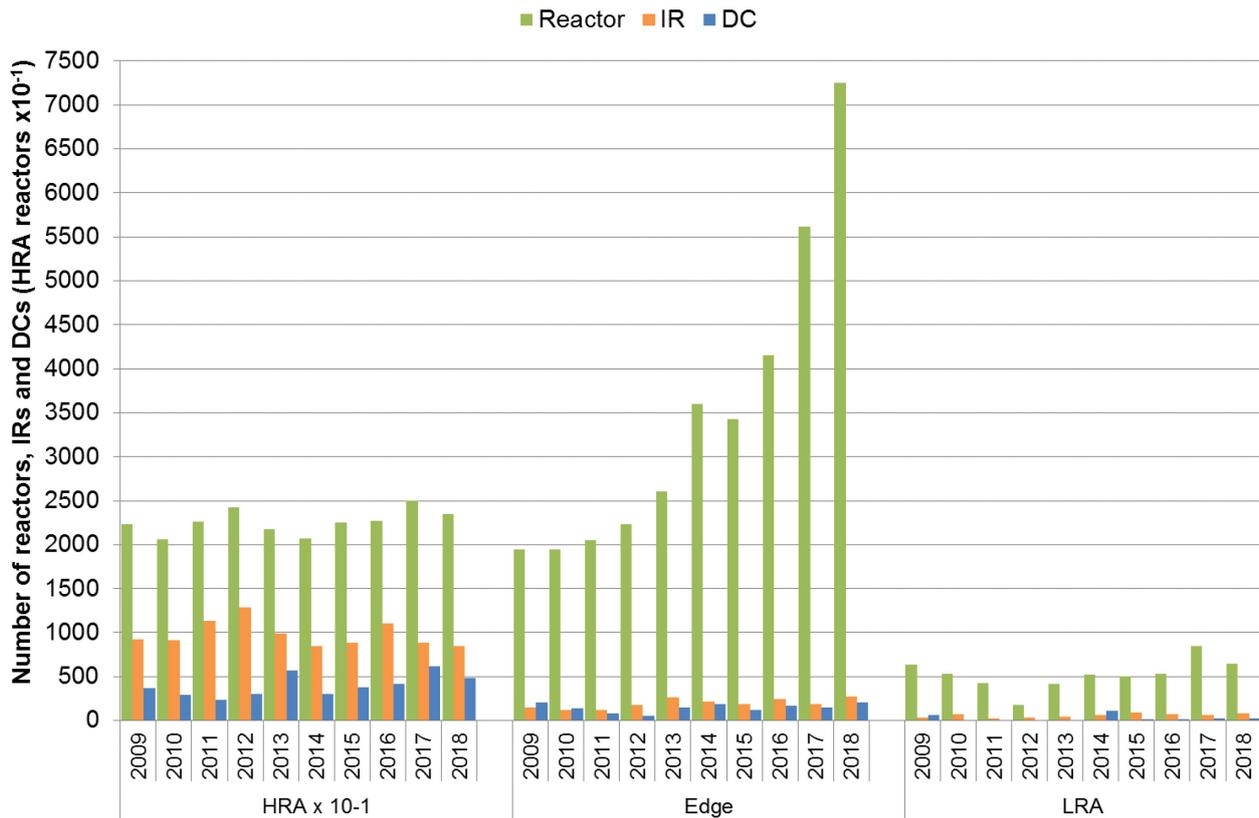


Figure 3.4.11 Number of reactors, inconclusive reactors and direct contacts removed from herds between 2009 and 2018, by risk area (note HRA reactors presented as a tenth of their true value)

- Most cattle removed over the past ten years are reactors taken from the HRA, with substantial numbers also removed as dangerous contacts or inconclusive reactors.
- The number of cattle removed as reactors in the Edge Area has increased substantially since 2013, when more stringent controls were introduced.

4.1 Epidemiology of TB in the High Risk Area

- Within the HRA, there was a significant reduction in the bovine TB herd incidence rate in 2018 compared to 2017 (18.5 TB incidents per 100 herd-years at risk in 2018, compared to 19.8 in the same area in 2017, $p=0.009$).
- The total number of new herd incidents in 2018 (2,761) also decreased significantly compared to 2017 (3,033, $p=0.009$).
- TB incidence per 100 herd-years at risk decreased in almost all HRA counties in 2018. As in previous years, the incidence rates varied considerably between counties. Wiltshire and Devon had the highest incidence of 22 and 21 incidents per 100 herd years at risk, respectively. The lowest incidence rates were observed in Dorset, Somerset and the West Midlands.
- The overall average monthly herd prevalence for the HRA decreased from 11.8% in 2017 to 11.5% in 2018, although this change was not statistically significant ($p=0.343$). As with incidence rates, prevalence varied between counties. The highest herd prevalence rate in 2018 was seen in Wiltshire and Devon, with 14% and 13% of herds restricted due to a TB incident at the end of the year, respectively. The lowest prevalence rate was seen in the West Midlands (1%).
- Devon and Cornwall had the highest number of cattle herds in the HRA and accounted for around 38% of TB incidents.
- Counties experiencing TB incidents with the longest duration of movement restrictions (for TB incidents that ended in 2018) included Dorset (median duration of 231 days), Avon (225 days) and Cornwall (214 days).
- For TB incidents closing in 2018, the majority of herds sustaining a persistent breakdown (i.e. those with movement restrictions lasting >550 days) were located in Devon and Cornwall.
- The HRA accounted for 43% of all IFN- γ tests carried out in England in 2018, an increase from 22% on 2017. Over 67% of these IFN- γ tests were carried out in Devon, Dorset and Somerset and most of these were mandatory tests carried out in new OTFW breakdown herds within Badger Control Plan (BCP) areas following two annual rounds of successful culling.
- Ten new BCP areas were authorised in 2018 in the HRA, bringing the total number of areas licensed for badger control in eight of the twelve HRA counties to thirty. Two additional BCP areas are operative in the Edge and LRA.

Geographical coverage of the HRA

The HRA extends from the western areas of the Midlands to the South and West of England (excluding the Isles of Scilly). In January 2018 the boundary of the HRA was redefined to exclude five counties that were previously divided between the HRA and Edge Area. All of these counties (Cheshire, Derbyshire, East Sussex, Oxfordshire and Warwickshire) were moved fully into the Edge Area, reducing the size of the HRA. Data reported in this chapter is for the 12 remaining counties that constitute the HRA in 2018, unless otherwise stated. For consistency, TB trends over time compare TB incidents in the 2018 HRA counties only, and do not include incidents from part-counties that are now fully within the Edge Area. Defra's overall objective for the HRA is to initially stabilise incidence and then to start to reduce it. Local and national bovine TB control measures are being implemented in the HRA; with challenges coming from the high volume of cases and finite resources available to tackle them.

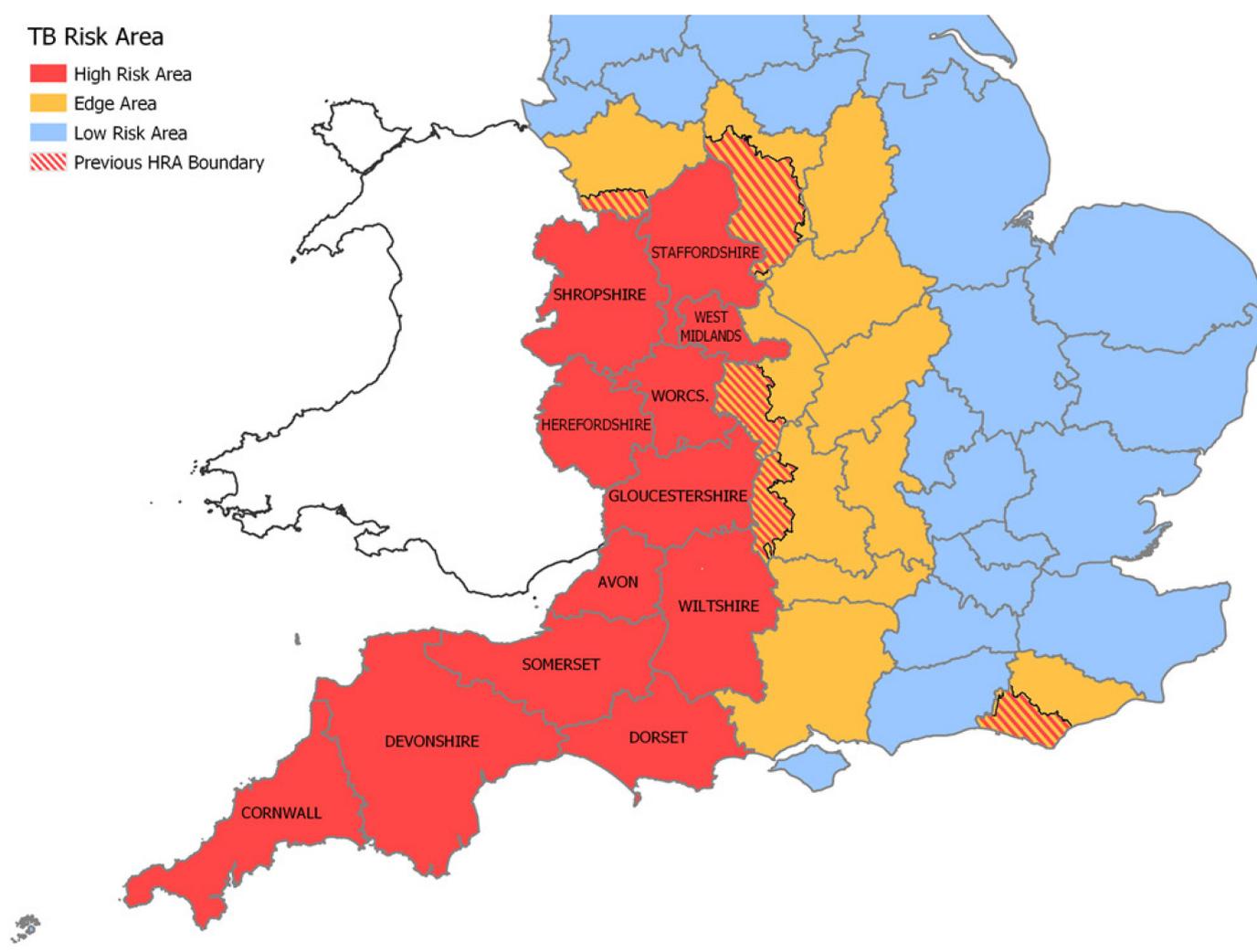


Figure 4.1 HRA county map (also showing the old HRA sections of five counties with 'split' status between 2013 and 2017)

In this chapter, TB herd incidents are mostly reported with no distinction between status (Official TB Freedom Withdrawn (OTF-W) or Official TB Freedom Suspended (OTF-S)), due to the high positive predictive value³⁵ of the skin test in the HRA, meaning that we would expect over 90% of all TB test positive animals to be infected³⁶.

The herd incidence rate in the HRA in 2018 was 18.5 TB incidents per 100 herd years at risk. The incidence rate decreased significantly by 6.7% (p=0009) in 2018, compared to the incident rate for the same spatial area in 2017, Table 4.1). This is further reflected when looking at the rate of new breakdowns in section 3.1 (no significant change since 2011 so disease levels are plateauing, particularly in the HRA).

Table 4.1 Table of headline figures for the High Risk Area for TB in England

Year	Total number of new TB infected herds (TB incidents) ¹	Incidence rate ²	Median duration of TB incident (days) (interquartile range) ³	Prevalence (average monthly) ⁴
2018	2,761	18.5	202 (166 to 320)	11.5
2017 (2018 boundaries)	3,033	19.8	193 (155 to 293)	11.8
Change (%)	-9.0	-6.6	+4.7%	-9.0
Statistical significance	p=0.009	p=0.009	p<0.001	p=0.343
2017 (pre-2018 boundaries)	3,259	19.2	172 (131 to 272)	11.4

¹The change in total number of breakdowns was compared using a chi-squared test.

² New TB infected herds per 100 herd-years at risk (100HYR). The incidence rate ratio was used to compare the difference between 100HYR incidence in 2017 and 2018 for HRA herds according to 2018 boundaries.

³The change in the median duration of TB incident (days) was tested with the K sample equality-of-means test.

⁴The z-test was used to compare average monthly prevalence between 2017 and 2018 for HRA herds according to the 2018 boundaries.

County-level risk for new infection with TB

The preferred measure of disease occurrence is the incidence rate per 100 herd-years at risk (100 HYR), which reflects the likelihood of an unrestricted herd suffering a TB incident during each 12 month period. Figure 4.2 ranks counties in the HRA by their incidence rate since 2013. End of year prevalence figures for 2018 are also provided in Figure 4.3.

³⁵ See Explanatory Supplement for description of PPV

³⁶ PPV in high incidence areas if severe interpretation used only in confirmed incidents: 92.3% (95% CI 91.1-93.7%). Goodchild, A. V., et al. (2015). "Specificity of the comparative skin test for bovine tuberculosis in Great Britain." 177(10): 258

Prevalence reflects the proportion of herds that are infected with TB at a given point in time, and differences in prevalence are affected by variation in incidence, the duration of TB incidents, and the timing of the start of the incident. Thus, prevalence gives an indication of the burden of disease. Further notes on the methodology of incidence and prevalence measures are described in the Explanatory Supplement³⁷.

TB herd incidence decreased (between 1 and 22%) in nine of the twelve HRA counties from 2017 to 2018. The highest incidence was observed in Wiltshire and Devon (22 and 21 TB incidents per 100 HYR respectively). The greatest reduction in TB incidence in 2018 compared to 2017 was in Gloucestershire, where incidence spiked in 2017, despite a downward trend in the preceding four years, then fell significantly by 22% ($p=0.020$), to 19 TB incidents per 100 HYR in 2018. When considering the difference in incidence between 2018 and the preceding five years (2013-2017), a statistically significant decrease was observed in Gloucestershire ($p=0.026$) and Devon (0.042) only.

The only two counties of the HRA showing an increase in incidence in 2018 compared to 2017 were Shropshire (+7%) and West Midlands (+147% although only five TB incidents in total). The West Midlands contains large urban and peri-urban areas and has a low cattle density, and as such has a reduced burden of bovine TB than other counties in the HRA. This is observed across all of the measures explored in this chapter. The incidence rate in Hereford & Worcester did not change in 2018 compared to 2017 (Figure 4.2).

As with incidence, Wiltshire and Devon had the highest prevalence in 2018 (14% and 13%, respectively). The lowest prevalence in 2018 was seen in West Midlands (1%).

³⁷ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

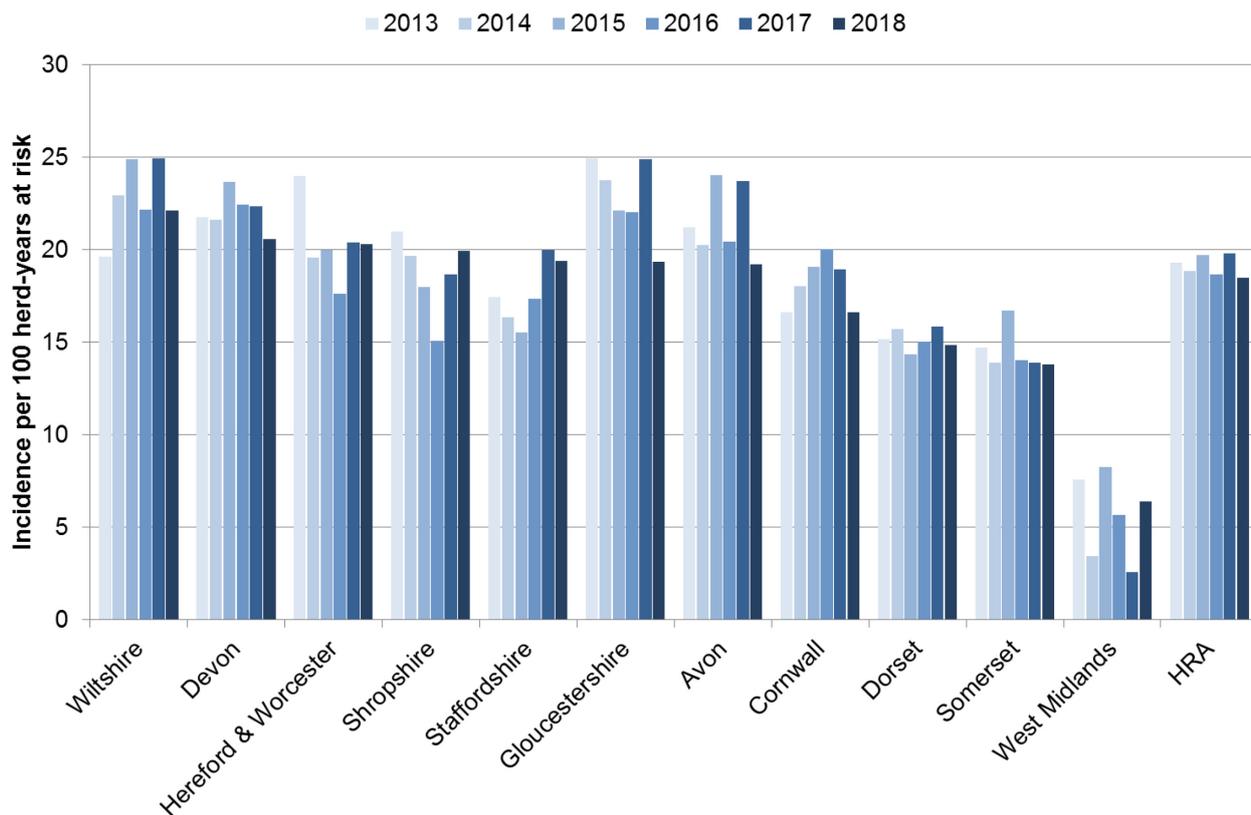


Figure 4.2 Herd incidence rate (per 100 herd-years at risk) from 2013-2018, by HRA county ranked by decreasing order of incidence in 2018.

- With the exception of Shropshire and the West Midlands, the incidence rate fell in all HRA counties in 2018, compared to 2017.
- TB herd incidence has increased over the past three years in Shropshire.
- Devon, Cornwall and Somerset have all experienced a falling TB incidence rate since 2016.

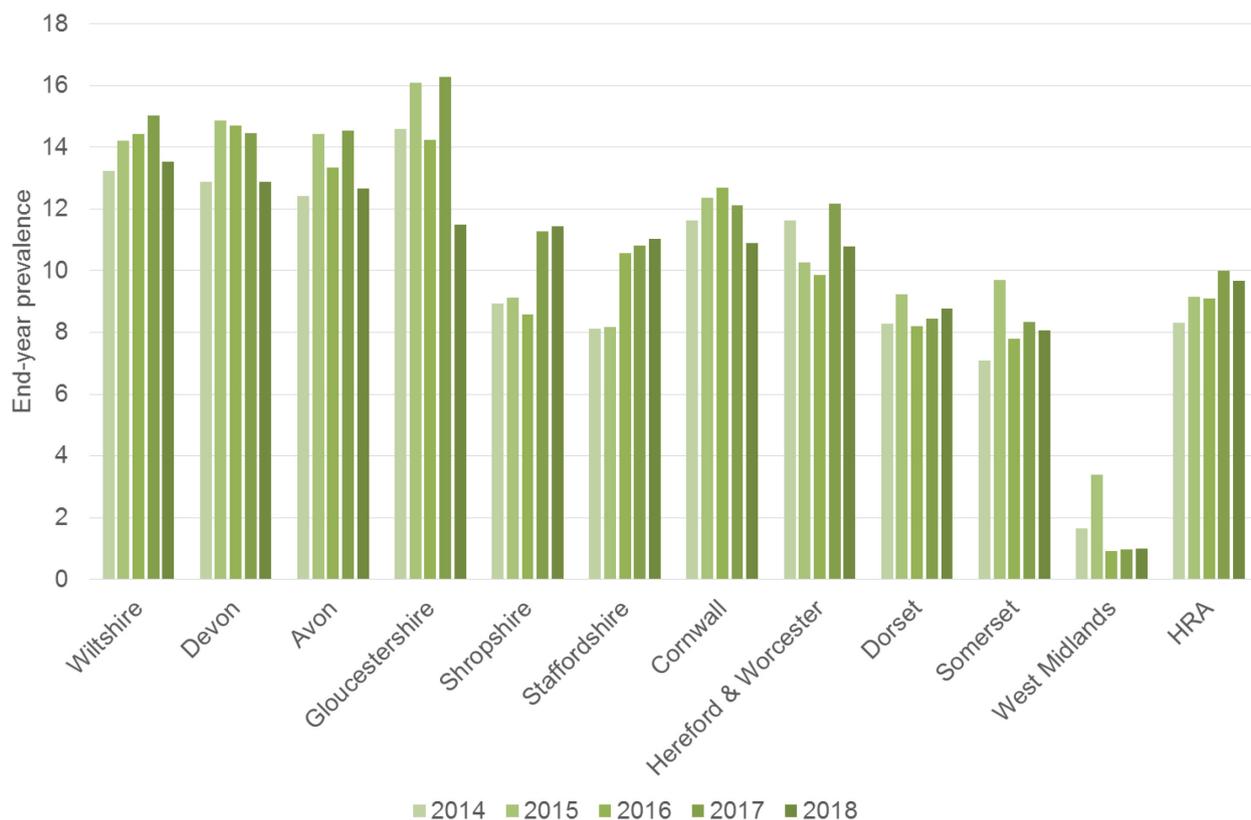


Figure 4.3 End of year prevalence from 2013-2018, by HRA county ranked by decreasing order of prevalence in 2018.

- With the exception of Shropshire, Staffordshire and Dorset, end of year prevalence fell in all HRA counties in 2018, compared to 2017.
- The highest herd prevalence was observed in Wiltshire, followed by Devon and Avon.
- End of year prevalence has been falling in Devon and Cornwall for the past three years.

Number of new TB infected herds

The number of TB infected herds is important in terms of resource planning and number of businesses impacted. Figure 4.4 shows the total number of TB incidents and the number of OTF-W incidents in each county in 2018. The greatest number of incidents were disclosed in Devon (which has by far the largest number of herds), where 25% of HRA TB incidents occurred in 2018. The highest percentage of OTF-W incidents as a proportion of total new incidents was disclosed in Gloucestershire (78%), followed by Wiltshire (76%).

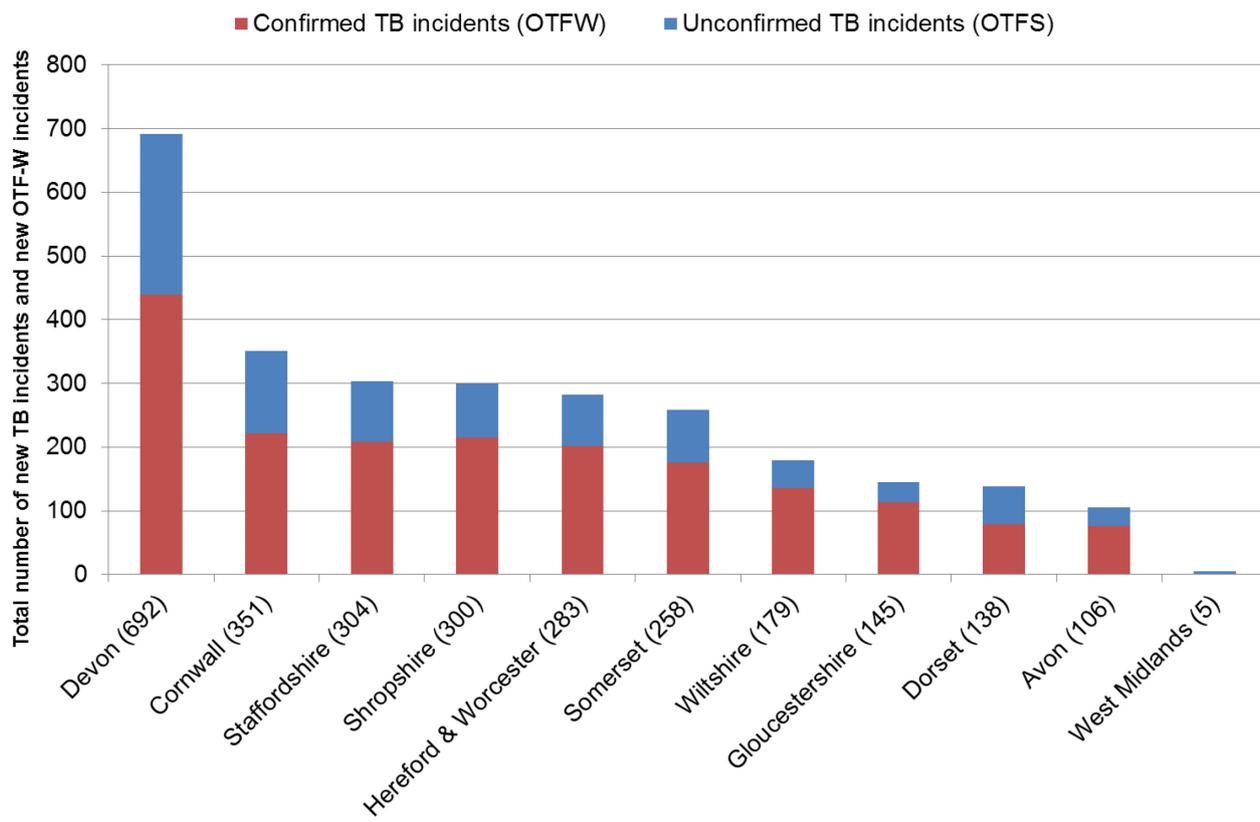


Figure 4.4 Number of new TB incidents (split by OTF-W and OTF-S status) in HRA counties in 2018, ranked by decreasing total number of TB incidents

- The proportion of TB incidents with OTF-W status ranged from 57% in Dorset to 78% in Gloucestershire (0% in West Midlands, n=5)

Demographics and influence on TB

The risk of TB has consistently been shown to increase with the number of cattle in a herd and other factors, like the level of fragmentation of the farm land (Broughan et al., 2016³⁸). The total number of cattle is a crude demographic measure, as the cattle distribution and management within herds can influence the risk of disease. The larger the herd, the higher the risk of suffering a TB incident, but the extent of the proportional relationship varies between areas (Figure 4.5, also see 3.2.1a and b (maps showing herd density and herd-level incidence)).

Counties with a greater proportion of TB incidents in the HRA tended to have a higher percentage of cattle and herds. This is most evident in Devon, where 25% of TB incidents in the HRA were found, and 25% of cattle (and 23% of herds) are also located. This was followed by Cornwall, with 13% of TB incidents (and 13% of cattle and 14% of herds). In contrast to this pattern, despite Somerset having 12% of HRA herds and 13% of cattle, only 9% of the TB incidents were disclosed in this county.

³⁸ Broughan, J. M., et al. (2016). "A review of risk factors for bovine tuberculosis infection in cattle in the UK and Ireland." *Epidemiol Infect* 144 (14): 2899-2926.

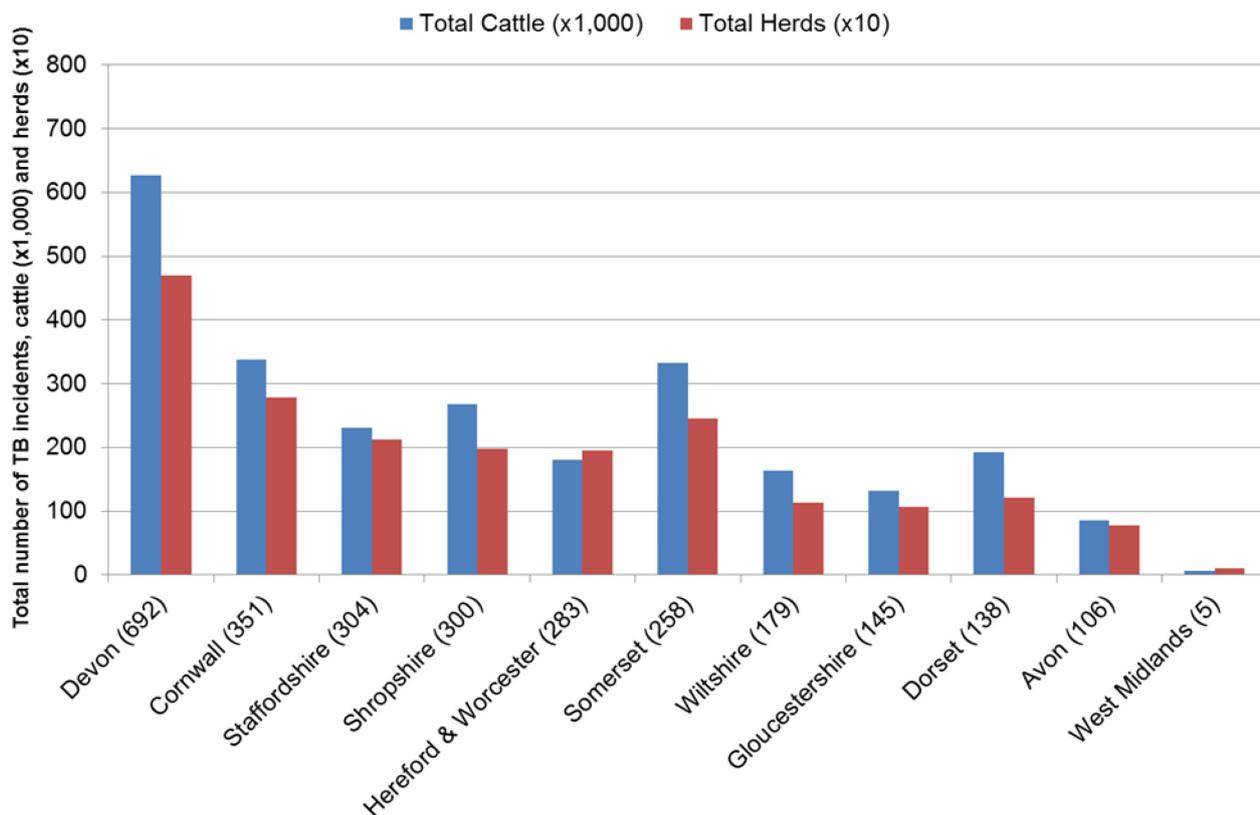


Figure 4.5 Total Number of new TB incidents, cattle (x1000) and herds (x10) in HRA counties in 2018 Counties ranked by total TB incidents

- As expected, counties with larger numbers of cattle and herds, tended to have a greater number of TB incidents.
- Somerset and Dorset appear to have fewer TB incidents than expected, when considering the number of cattle and herds in those counties.

Figure 4.6 shows the relative numbers of herds, and proportions of large herds in the different areas of the HRA in 2018, ranked by the proportion of large herds (>300 cattle). Although analyses confirm that larger herds are more at risk of disease, the presence of more large herds alone cannot explain a county's incidence rate. Many areas with a high proportion of large herds have a relatively low incidence rate.

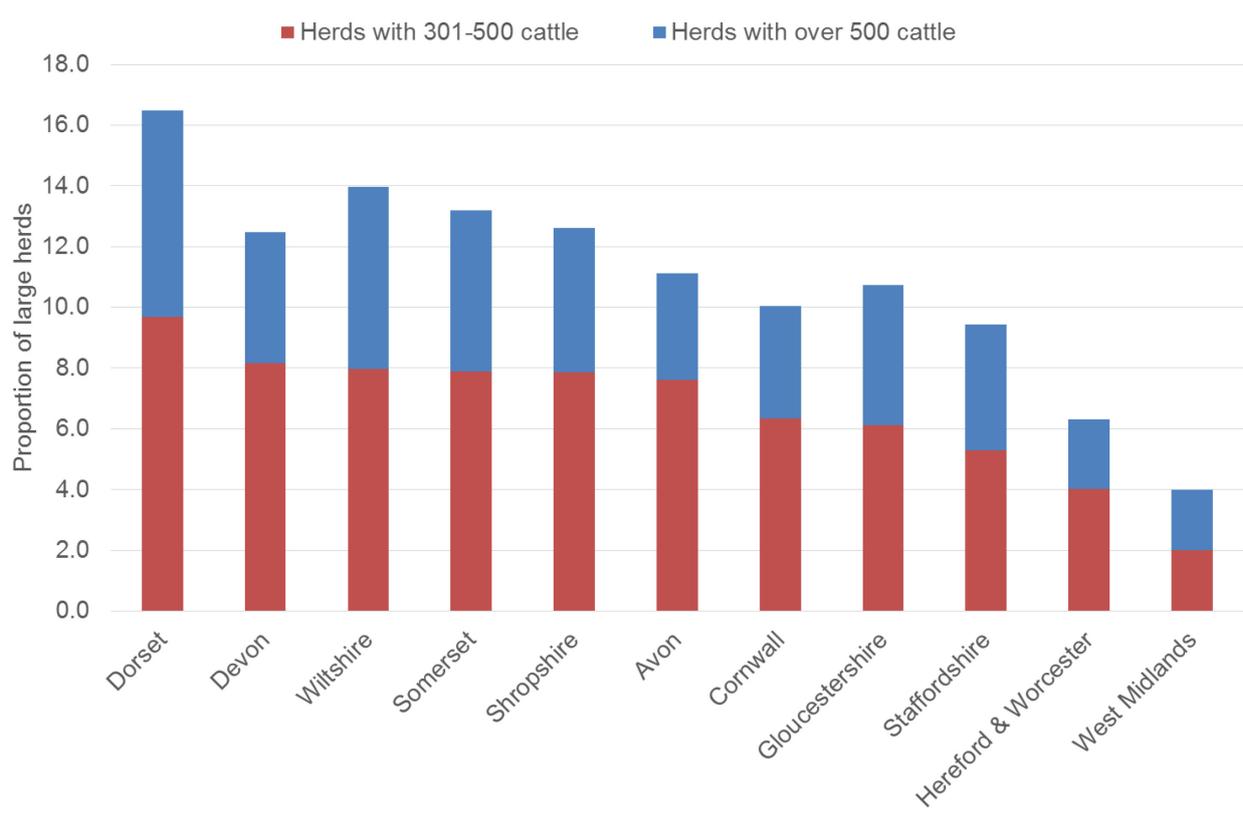


Figure 4.6 Proportion of large herds, by HRA county Counties ranked by decreasing order of herds with 301-500 animals

- Dorset had the highest proportion of herds with greater than 300 cattle (16%) followed by Wiltshire (14%).
- Hereford and Worcester (6%, 123 herds) and West Midlands (4%, 4 herds) had the lowest proportion of herds with over 300 animals.

TB incident duration and persistence

A total of 3,013 TB incidents in the HRA ended during 2018. The median duration of TB incidents was longest for herds in Dorset (231 days), Avon (225 days) and Cornwall (214 days).

The median duration of OTF-W incidents was longer compared to the median for all TB incidents in all HRA counties (Figure 4.7). This was despite the requirement (from April 2016) for two successive short interval tests (SITs) with negative results at severe interpretation in all new incidents in the HRA.

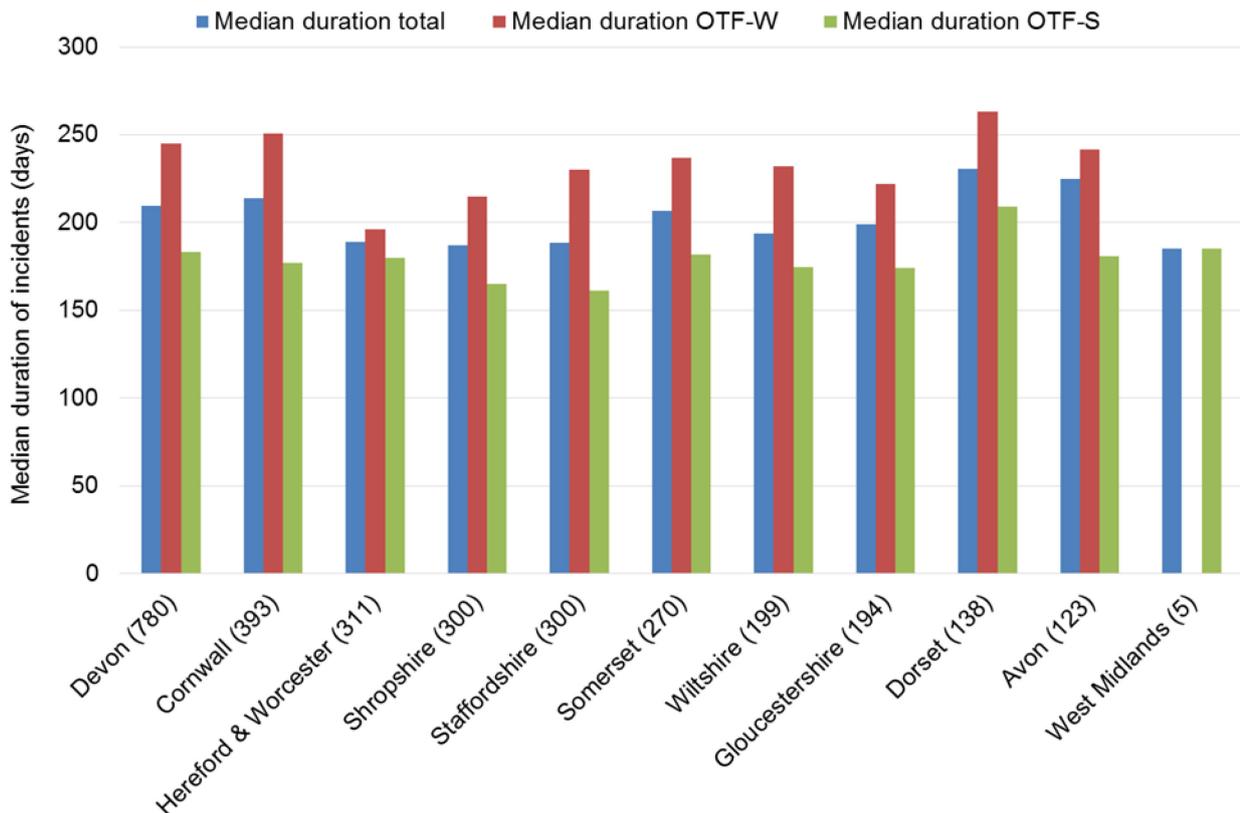


Figure 4.7 Median duration (days) of incidents that closed in 2018, by HRA county ranked by decreasing number of incidents (in parenthesis)

- In all counties duration of herds under movement restrictions was higher in confirmed (OTF-W) incidents compared to total TB incidents.
- Median duration was highest in Dorset (231 days for confirmed TB incidents)

In 2018 58% of TB incidents in the HRA occurred in herds that had experienced at least one TB incident in the previous three years. This recurrence rate was higher than in the other risk areas in England (Edge Area - 38% and LRA - 6%). Within the HRA, recurrence was highest in Avon and Gloucestershire (66%), and lowest in the West Midlands (40%, two of five TB incidents) (Figure 4.8).

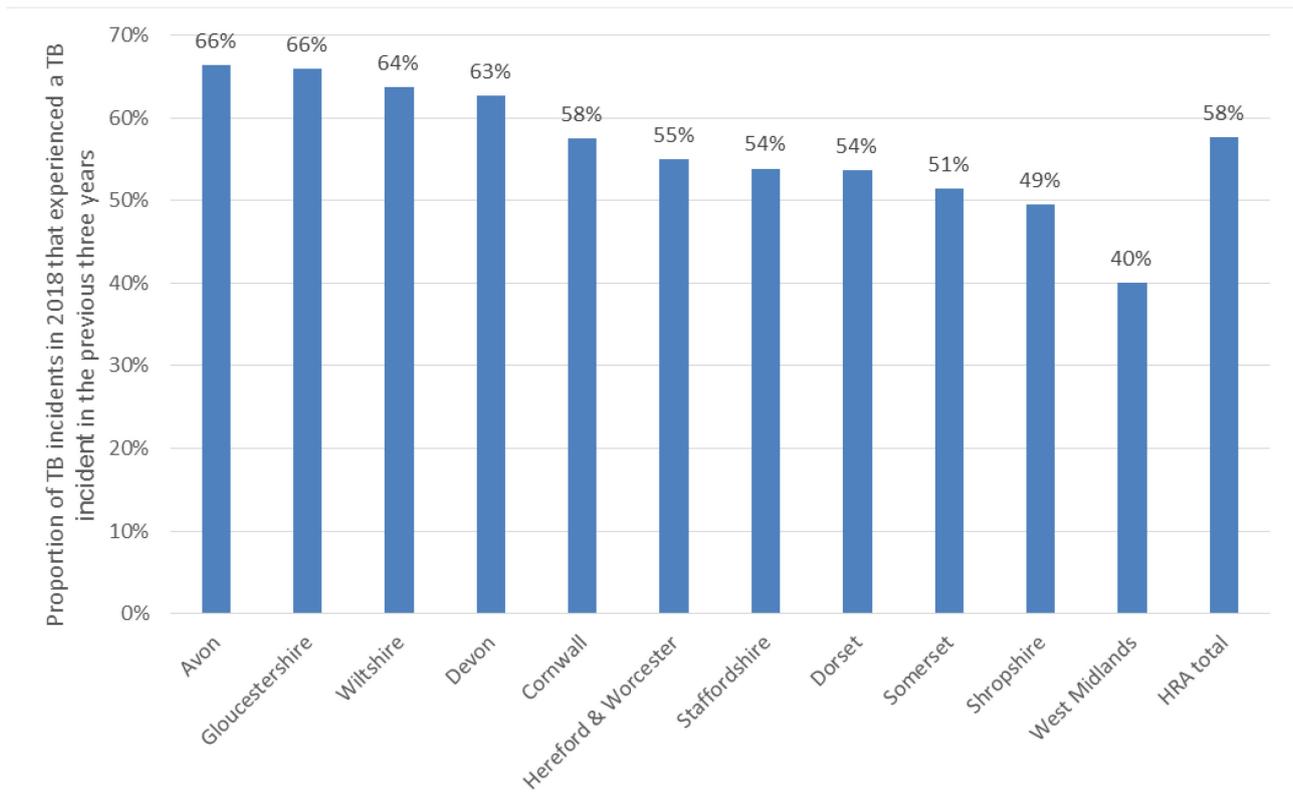


Figure 4.8 Proportion of TB incidents in 2018 in herds that experienced any TB incident in the previous three years, by HRA county

The high positive predictive value of the skin test in the HRA³⁹ together with the need to intensify the efforts to tackle disease in this area and reduce recurrence, justifies the need for all TB incident herds in the HRA to pass two successive short interval tests (SITs) at severe interpretation in order to regain OTF status. This policy, introduced in 2016, along with the increased use of the interferon-gamma (IFN- γ) blood test in the HRA since April 2017, should help reduce recurrence due to recrudescence and may also reduce the severity and length of incidents. Other measures implemented in the HRA may also contribute to reducing recurrence, for example encouraging good biosecurity and safer buying practices using advice from initiatives such as the TB Hub and TBAS (TB Advisory Service) and badger culling to reduce recurrence due to reinfection from wildlife.

Herds under movement restrictions for more than 550 days are deemed to be persistent and are eligible for enhanced management procedures from APHA (Figure 4.9). At the end of 2018, 348 persistent incidents were still ongoing ('open') in the HRA.

³⁹ PPV in high incidence areas if severe interpretation used only in confirmed incidents (95%CI): 92.3% (91.1-93.7%). Goodchild, A. V., et al. (2015). "Specificity of the comparative skin test for bovine tuberculosis in Great Britain." 177(10): 258

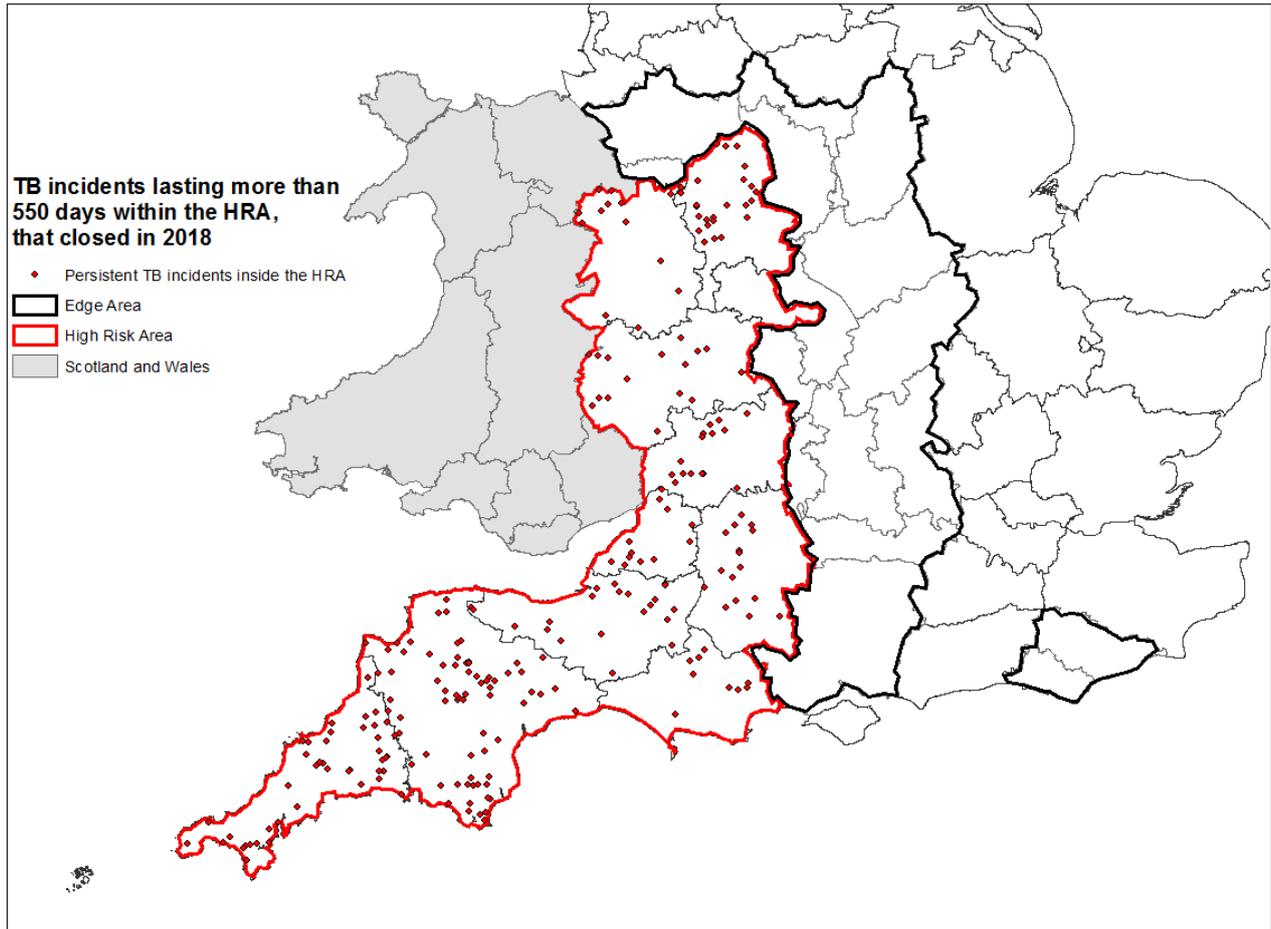


Figure 4.9 Distribution of persistent TB incidents (duration over 550 days) that ended in 2018 in the HRA

- None of the TB incidents that closed in 2018 were persistent in the West Midlands.
- A large number of persistent TB incidents that closed were located in Devon and Cornwall, where most TB incidents are also found.

TB surveillance and incident detection

For a detailed description of the test types included in each of the four TB surveillance streams explored in this chapter, see chapter 3.3 (Surveillance). Figure 4.10 shows the proportion of TB infected herds disclosed by each surveillance stream and county. In the HRA overall, the highest proportion of TB incidents were disclosed by Area & Herd Risk tests (47%). This was the case in all counties, with the exception of Somerset, where an equal number of TB incidents were disclosed by both Area & Herd Risk and Routine surveillance testing (99 each).

Routine surveillance found the next highest proportion of TB incidents in the HRA overall (32%), with the highest proportion of incidents disclosed in West Midlands (4 out of 5 TB incidents, 80%), followed by Somerset (38%). Trade & other surveillance testing led to the fewest detections of TB in the HRA in 2018, with under nine per cent of TB incidents in all HRA counties, with the exception of Dorset (12%) detected in this way (Figure 4.10).

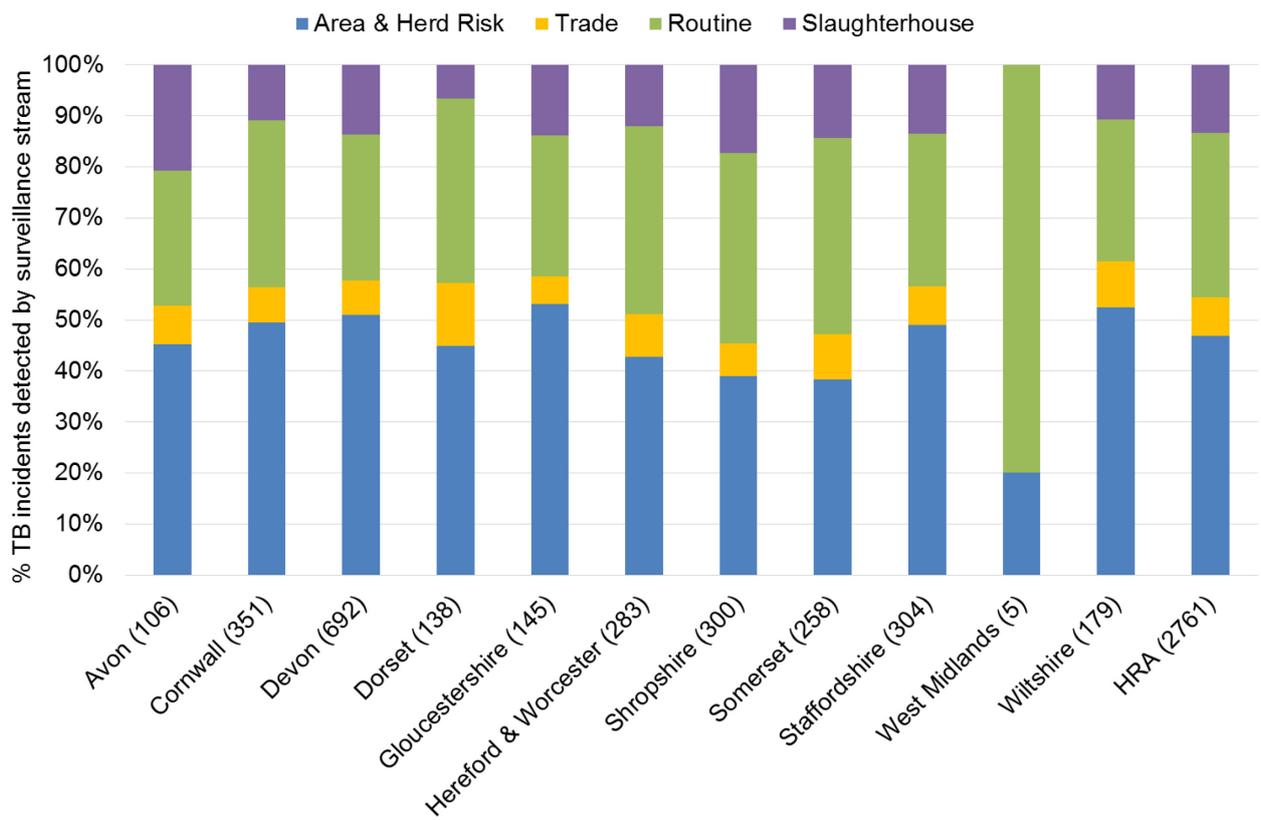


Figure 4.10 Proportion of new TB infected herds in 2018 detected by each surveillance stream, by HRA county

In the HRA overall, 13% of all new TB incidents were disclosed through slaughterhouse (SLH) surveillance, with variation between counties, from 0% in the West Midlands to 21% in Avon in 2018 (Figure 4.11). Excluding the West Midlands, all HRA counties detected a greater proportion of OTF-W TB incidents by SLH surveillance in 2018 compared to 2017. Trends over longer periods of time, however, show a decrease in 2018 compared to 2013-2016 for many counties, including Cornwall, Dorset, Gloucestershire, Somerset and Wiltshire.

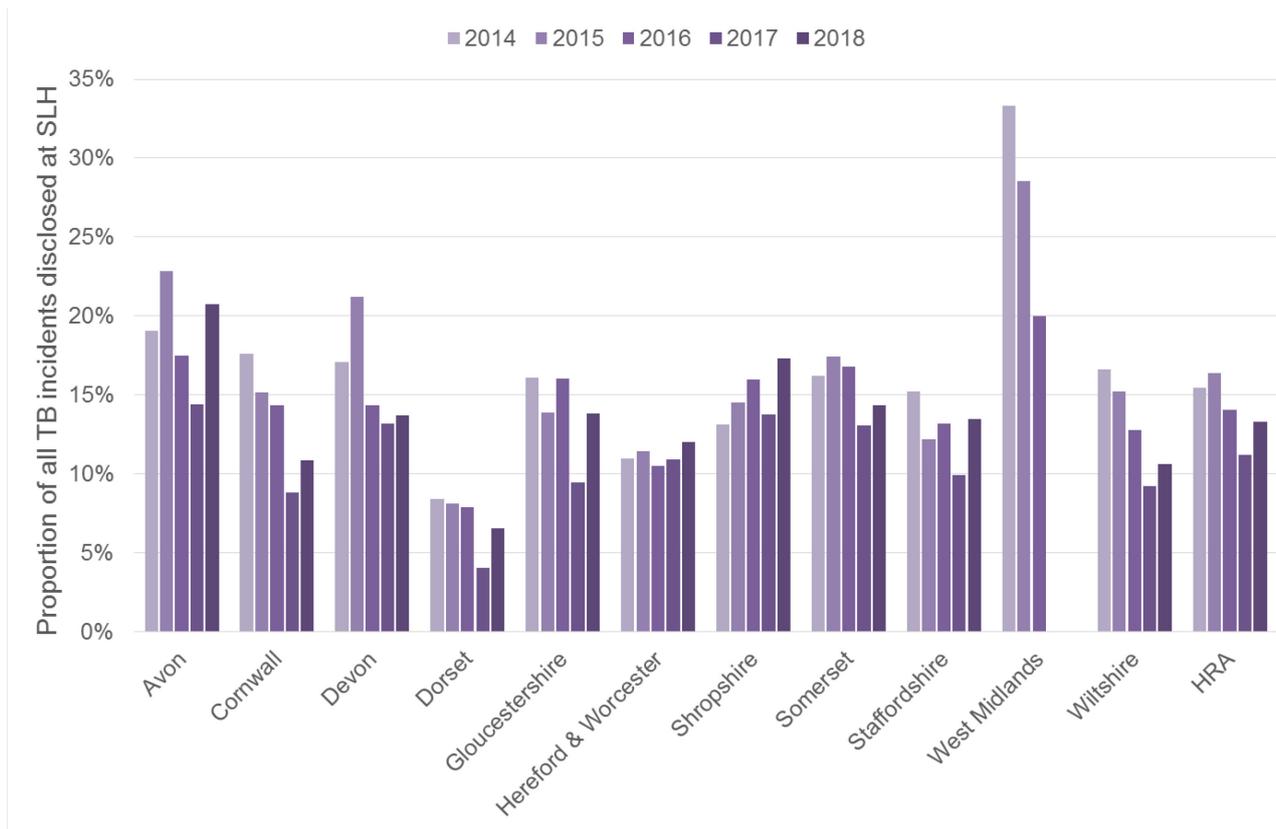


Figure 4. 11 Percentage of all TB incidents disclosed by slaughterhouse surveillance (post-mortem meat inspection) in 2018, by HRA county

Dealing with infected herds in the HRA

Since April 2016, all herds with incidents in the HRA require two consecutive severe interpretation skin tests with negative results before restrictions can be lifted. The most efficient tests at detecting incidents within the Area and Herd Risk surveillance stream in the HRA were post-incident check tests carried out 6 and 12 months after the restoration of OTF herd status. These tests disclosed 20 TB incidents per 100 herds tested in 2018.

Number of reactors removed

Overall, 23,465 skin test (SICCT) reactors or interferon gamma blood test (INF- γ) positive animals were slaughtered for TB control purposes in the HRA in 2018. The total number of animals removed, and the proportion that were detected by INF- γ testing varied by county. Most cattle were removed from herds in Devon (6,702 animals), where 24% of reactors were detected by INF- γ testing. The county with the highest proportion of reactors detected by INF- γ testing by far, was Dorset (50%) followed by Gloucestershire and Devon (24% each) (Figure 4.12).

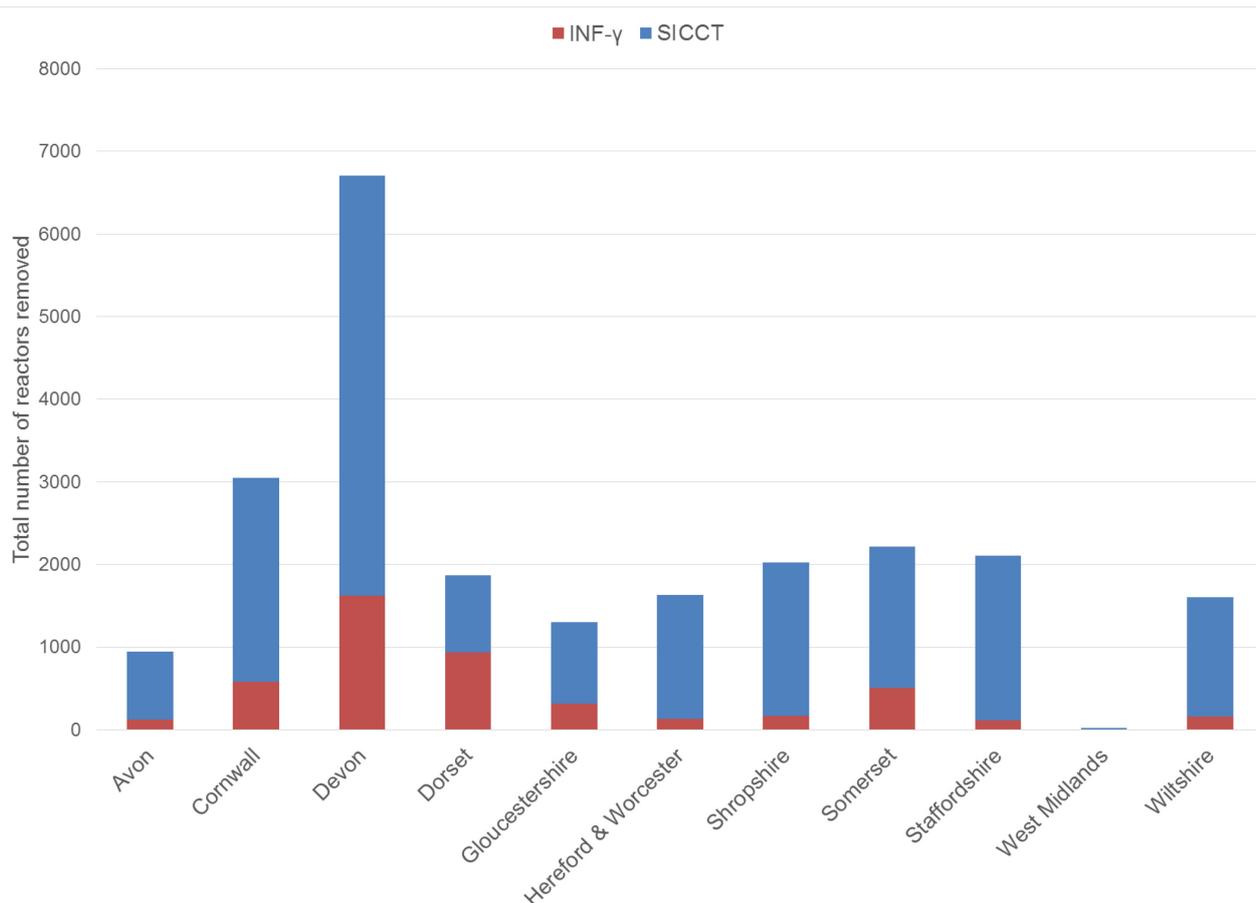


Figure 4.12 Number of reactors removed in 2018 due to SICCT and INF- γ testing, by HRA county

Use of the IFN- γ test in the HRA

The IFN- γ blood test is used as a supplementary test to the tuberculin skin test, which is the primary screening test, during some lesion or culture positive (OTFW) TB incidents. The total number of IFN- γ tests carried out in the HRA counties during 2018 has rapidly increased in recent years, from just under 6000 in 2016, to 19,000 in 2017, increasing four fold to 80,000 in 2018.

The application of IFN- γ testing is mandatory for all new OTF-W TB incidents that occur in BCP Areas that have successfully completed two or more rounds of culling. In 2018 this applied to parts of Gloucestershire, Somerset, Dorset, Cornwall, Devon and Herefordshire. Discretionary IFN- γ tests are also used in the enhanced management of persistent incidents where herds have been under restriction for more than 18 months, as well as in explosive or chronic breakdown herds considered for whole or partial slaughter.

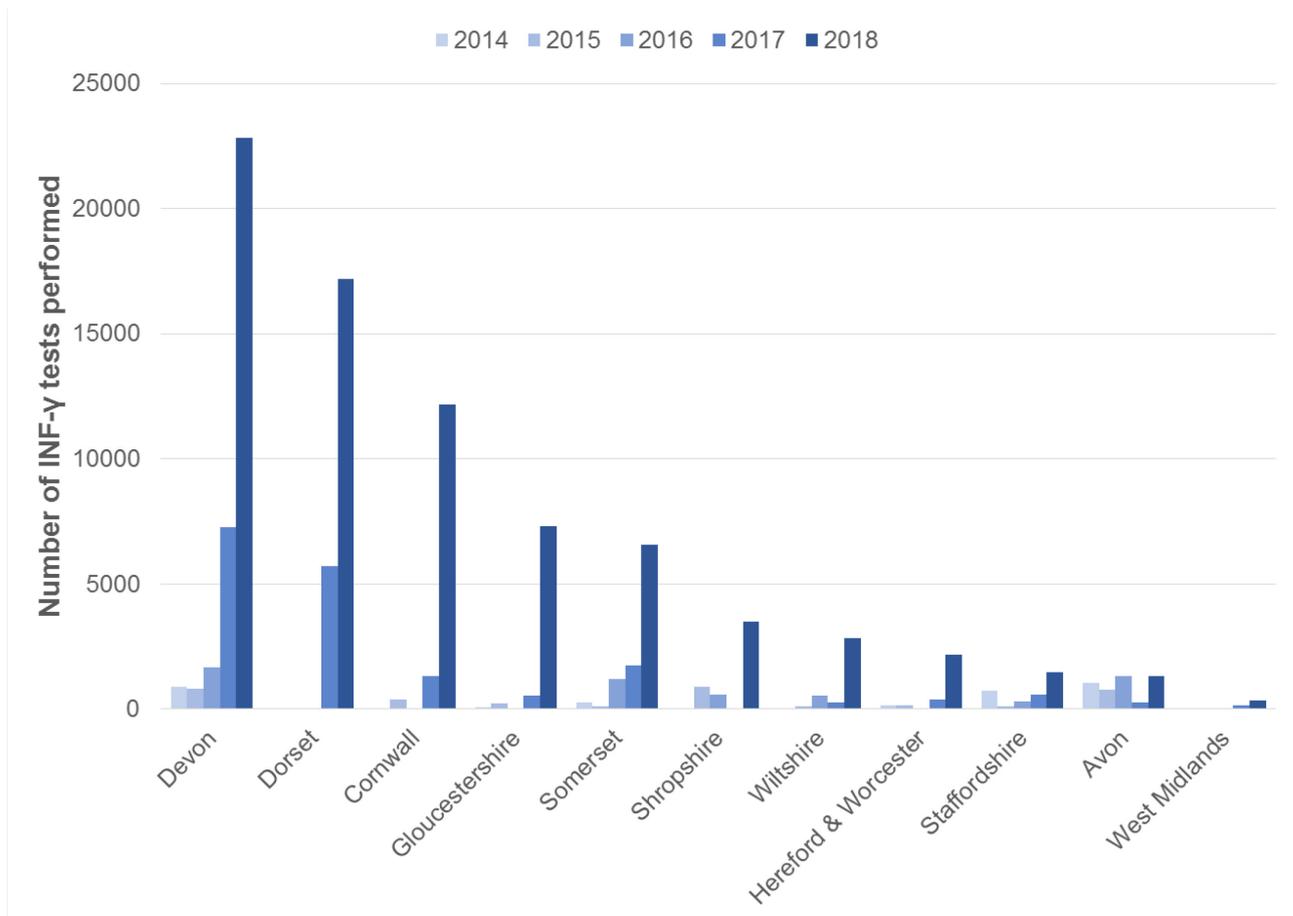


Figure 4.12 Number of IFN-γ tests performed in HRA counties, 2014-2018

There is great variability in the number of IFN-γ blood tests completed by county and year, not only due to the discretionary and now sometimes mandatory application of the tests, but also to the fact that the number of samples taken in each eligible herd depends on the number of cattle over six months old present in the herd. In addition, in some cases only specific high risk epidemiological groups are tested rather than the whole herd over six months of age.

TB control in wildlife

Although any warm-blooded mammal is susceptible to infection with *Mycobacterium bovis* to a variable degree, the main wildlife reservoir and true maintenance host of infection in England is the Eurasian badger (*Meles meles*). In the HRA of England, where the influence of badgers in the epidemic is suspected to be stronger, licensed badger culling has been in progress for six years, within designated badger control plan areas (BCP).

In 2018 ten new badger control areas were authorised in the HRA and one in the LRA (Area 32 – in East Cumbria), giving a total of 32 licensed badger control areas as of the end of 2018 (including Area 1 and Area 2 in the HRA that had completed four annual culling seasons and entered into a period of supplementary culls in 2017).

Badger removal results from 2018 indicate that 29 badger control areas undergoing intensive culling (excluding Areas 1 and 2) achieved the minimum level of badger removal required. No area exceeded the maximum number based on badger abundance. Area 32-Cumbria had no maximum or minimum targets set. Further information can be found at the Summary of badger control monitoring during 2018⁴⁰.

The evolution of OTF-W incidence and prevalence of TB in cattle located within the licensed badger control areas can be found in the Bovine TB in cattle: badger control areas monitoring report⁴¹. The licensed use of injectable BCG vaccine is also permitted in the HRA and Edge areas for TB control purposes

⁴⁰https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765439/badger-control-monitoring-2018.pdf

⁴¹ <https://www.gov.uk/government/publications/bovine-tb-incidence-of-tb-in-cattle-in-licenced-badger-control-areas-in-2013-to-2017>

4.2 Epidemiology of TB in the Edge Area

- The following bullet points summarise key findings from the individual descriptive year-end reports on the epidemiology of bovine TB in the Edge Area.⁴²
- Two key policy changes affected the Edge Area in 2018. Firstly, the Edge Area expanded to the west to fully include five counties previously partially located in the HRA (Cheshire, Derbyshire, East Sussex, Oxfordshire, and Warwickshire). Secondly, six-monthly routine herd surveillance testing was introduced in the endemic portion of the Edge Area (Figure 2.1, Preface), with compulsory radial testing for herds located within 3km of any OTF-W cattle herd complementing routine testing in the remainder of the Edge Area. These policy changes increased the sensitivity of surveillance, with the intention of detecting disease earlier and reducing the opportunity for undisclosed disease to spread.
- Overall there was a slight non-significant increase in TB herd incidence in the Edge Area in 2018, compared to 2017 (9.2 TB incidents per 100 herd years at risk in 2018, up from 9.1 in the same spatial area in 2017, $p=0.758$). At county level, all changes in incidence between 2017 and 2018 were non-significant; incidence increased in six counties, and decreased in the remaining five counties.
- As in previous years, there was wide variation in the burden of TB across the Edge Area in 2018. Incidence ranged from 16.6 herds per 100 herd years at risk infected in Oxfordshire, down to just 3.9 in Nottinghamshire; while the greatest number of incidents were detected in Cheshire (179 cases disclosed in 2018).
- In the Edge Area the source of infection was highly variable between counties. Incidents bordering the HRA are more frequently ascribed to badgers, while those closer to the LRA are more commonly linked to cattle movements. Badgers were identified as the primary weighted source of TB infection in eight Edge Area counties, most prominently in Derbyshire (77%), Cheshire (66%), Northamptonshire (63%) and Warwickshire (60%). Cattle movements were identified as the primary weighted source in Buckinghamshire (57%), Hampshire (37%) and Nottinghamshire (36%).
- In several counties there are new areas of endemic infection and new clusters emerging, with anecdotal evidence that the infection is maintained by local wildlife (badger) populations. Areas of significance include:
 - Leicestershire, a cluster in the north east presents a risk to south Nottinghamshire and the LRA in Lincolnshire.
 - Northamptonshire, a new area of potential endemicity continues to emerge in the west of the county.

⁴² <https://www.gov.uk/government/publications/bovine-tb-epidemiology-reports-2018>

- Oxfordshire has a number of persistent clusters and spread to neighbouring Edge Area counties is a risk.
- Areas of concern identified in previous years showed some signs of improvement in 2018. These include:
 - Derbyshire, a cluster in the north-west has been spreading north and causing concern for the LRA in recent years. In 2018 there were fewer new cases disclosed in this area than in 2017, however the area is not fully resolved.
 - Cheshire, fewer new detections were made in the north of the county compared to 2017. More time needs to pass to assess if this temporary improvement will be sustained.

4.3 Epidemiology of TB in the Low Risk Area

- The following bullet points summarise key findings from the year-end descriptive reports on the epidemiology of TB in the Low Risk Area Year End⁴³.
- Overall, the incidence rate in the LRA is very low and stable (less than one incident per 100 herd years at risk). There were 129 incidents in 2018, a slight increase from 123 in 2017.
- There was a higher degree of uncertainty around the source of TB in cases detected in the LRA compared to the HRA and Edge Area, in part related to the smaller proportion of OTF-W incidents detected, where genotype results can provide key evidence in tracing the most likely source of infection.
- Movement into the LRA of cattle from herds with undetected infection was the most common source of TB for new incidents in 2018. There were frequent movements of cattle from higher risk areas onto finishing units inside the LRA where cattle are fed on arable by-products. Compulsory post-movement testing for such cattle movements goes some way to mitigating the risks associated with sourcing cattle from outside the LRA.
- In the LRA, hotspot procedures are initiated around OTF-W incidents of undetermined origin. Enhanced testing is applied to cattle herds located within 3 km of the index herd and a concurrent wildlife survey is implemented. Four potential TB hotspots were active in the LRA in 2018. These were located in Cumbria, Lincolnshire, Norfolk and West Sussex, with a total of five new TB incidents disclosed in cattle herds as a result of enhanced testing in these areas in 2018.
- As well as cattle movements, spread of disease from endemic areas of infection in the Edge Area pose a risk to the LRA. Areas identified as being at particular risk of such infection creep include:
 - Greater Manchester, incidence in the neighbouring Edge Area county of Cheshire is high and there are concerns there could be disease spillover into the area around Stockport.
 - Lincolnshire, a potential hotspot was initiated in 2018 close to the border of Leicestershire where TB appears to be endemic.

⁴³ <https://www.gov.uk/government/publications/bovine-tb-epidemiology-reports-2018>