



Animal &
Plant Health
Agency

Bovine tuberculosis in England in 2017

Epidemiological analysis of the 2017 data and historical trends

September 2018



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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.

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Analyses were conducted in this report at county level and by risk area for England. Wales continue to report [surveillance](#)¹ separately. [TB data](#)² for all GB administrations for 2017 is published separately.

¹<http://gov.wales/topics/environmentcountryside/ahw/disease/bovinetuberculosis/bovinetberadication/?lang=en>

²https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739906/GBDataReport.ods

1. Executive summary

1. This Executive Summary introduces this report about the bovine tuberculosis (TB) epidemic in England and provides an overview.
2. The report describes the England control strategy and then presents separate chapters, with summary bullets, supported by detailed text on (i) the level of TB in England and changes over time, (ii) the characteristics of infected herds, (iii) the effectiveness of surveillance, (iv) the impact of TB and of the control measures, (v) the effectiveness of controls, and (vi) the detailed epidemiology of disease in each risk area. A glossary is also provided within an Explanatory Supplement. The data that support this report are presented separately on line in the GB TB Data Report, and a link is provided.
3. Bovine TB in England is subject to a statutory eradication programme based on the strategy published in 2014, which among other things divides the country into three 'risk' areas determined by their level of disease. The High Risk Area (HRA), mainly in the west and south-west, had the great majority of new TB incidents in 2017. As in previous years, the Low Risk Area (LRA) in the north, east and south-east had very few TB incidents in 2017 and just over a third of which were lesion and/or bacteriologically positive. The Edge Area, which lies between the HRA and LRA, had 11% of the new TB incidents in 2017.
4. Eradication of TB is based on systematic testing of herds to quickly identify and remove infected cattle, with movement restrictions and additional interventions applied during the incident management process to prevent the spread of disease and reduce the risk of disease persistence. A range of new controls have been introduced in 2017 including new licensed badger control areas, wider deployment of interferon-gamma (IFN- γ) blood testing in the HRA and the lifelong restriction of animals which pass a re-test following identification as an inconclusive reactor (IR) on the farm of detection.
5. The incidence of TB in England increased steadily from 1986 to 2010 and has since plateaued. This plateau hides a significant increase in incidence between 2016 and 2017 in the Edge Area. In 2017 TB incidence in the HRA increased slightly; the level of TB in the LRA remains very low.
6. Although the rate of new infections is not increasing significantly in the HRA, over half the herds with new incidents in the HRA in 2017 had suffered another TB incident in the previous three years, confirming that recurrent infection is an important driver of the epidemic here. This is also highlighted by the frequency with which TB infection is revealed by check tests carried out 6 or 12 months after an incident has been resolved. Such 'risk-based' testing was more successful at finding infected herds in the HRA in 2017 than routine testing.
7. In the Edge Area the epidemic continues to propagate, driven mainly by the introduction of purchased cattle that have undisclosed TB infection, but also by the development of local areas of endemic infection that in some cases may be driven by infection in the local badger population.
8. In 2017, 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 TB infection that could not fully be explained by their size or location.

9. Key data for 2017 are presented in Table 1.1.

Table 1.1 Key bovine TB parameters in 2017 (selected 2016 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 herd incidents detected	3,259 (3,229)	434 (387)	123 ¹ (137 ¹)	3,816 (3,753)
Number of open incidents at the end of 2017	2,667 (2,536)	312 (207)	56 (45)	3,035 (2,788)
Herd incidence per 100 herd-years at risk	19.2 (17.9)	7.7 (6.7)	1.0 ² (1.0)	11.0 (10.2)
Average monthly prevalence (%)	11.4 (10.7)	3.9 (3.3)	0.3 (0.3)	5.8 (5.4)
Duration				
Median duration of restrictions for all incidents ³ (days) (25-75 th percentile) 2017	172 (131-272)	152 (103-220)	126 (77-234)	168 (127-267)
Median duration of restrictions for all incidents ³ (days) (25-75 th percentile)	185 (146-289)	166 (140-238)	126 (80-201)	179 (135-283)
% persistently infected herds ⁴	6.7 (6.6)	2.1 (4.3)	0.0 (0.7)	6.1 (6.2)
Number of open cases at the end of 2017 with duration >550 days	360 (334)	25 (13)	1 (0)	386 (347)
Recurrence				
% incidents involving previously infected herds, within last 36 months	56.6 (58.2)	26.4 (29.2)	13.9 (13.1)	51.6 (53.4)

¹ 47 (38%) of TB cattle incidents in the LRA were lesion- and/or culture-positive (OTF herd status withdrawn)

² Includes all suspect and OTF-W incidents

³ That closed in 2017.

⁴ Incidents that had lasted >550 days that closed in 2017

2. Preface

This report is published concurrently with a data report titled 'Bovine tuberculosis in Great Britain. Surveillance data for 2017 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 regime³, such as pre-movement testing and TB in non-bovine species. However due to the timing of this report the data presented here are more complete for 2017, as results from investigations and testing that were completed in the first months of 2018 are included. This additional time has been used to good effect to remove duplication and correct other transactional errors, so data in this report will not exactly match those in the statistics notices.

This epidemiology report describes the TB epidemic in cattle in England in 2017 and includes commentary and analyses in light of the associated intervention policies. The report has sections that separately present and discuss the level of disease and changes over time, our success in finding cases (surveillance), the impact of the disease and of control measures, and the effectiveness of controls in reducing transmission. Later sections describe the epidemic in each of the England risk areas.

Bovine TB surveillance and control are complex processes and a wealth of jargon has developed, which has become common parlance to those closely engaged with the control 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 Supplement⁴ which is published concurrently with additional explanation about the disease, the data and methodologies used and the approach to control.

³ <https://www.gov.uk/government/publications/bovine-tb-epidemiology-and-surveillance-in-great-britain-2017>

⁴ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

3. Control 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 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, Defra published its [strategy](#)⁵ for achieving Officially Bovine Tuberculosis Free Status (OTF) for England (Figure 3.1⁶).

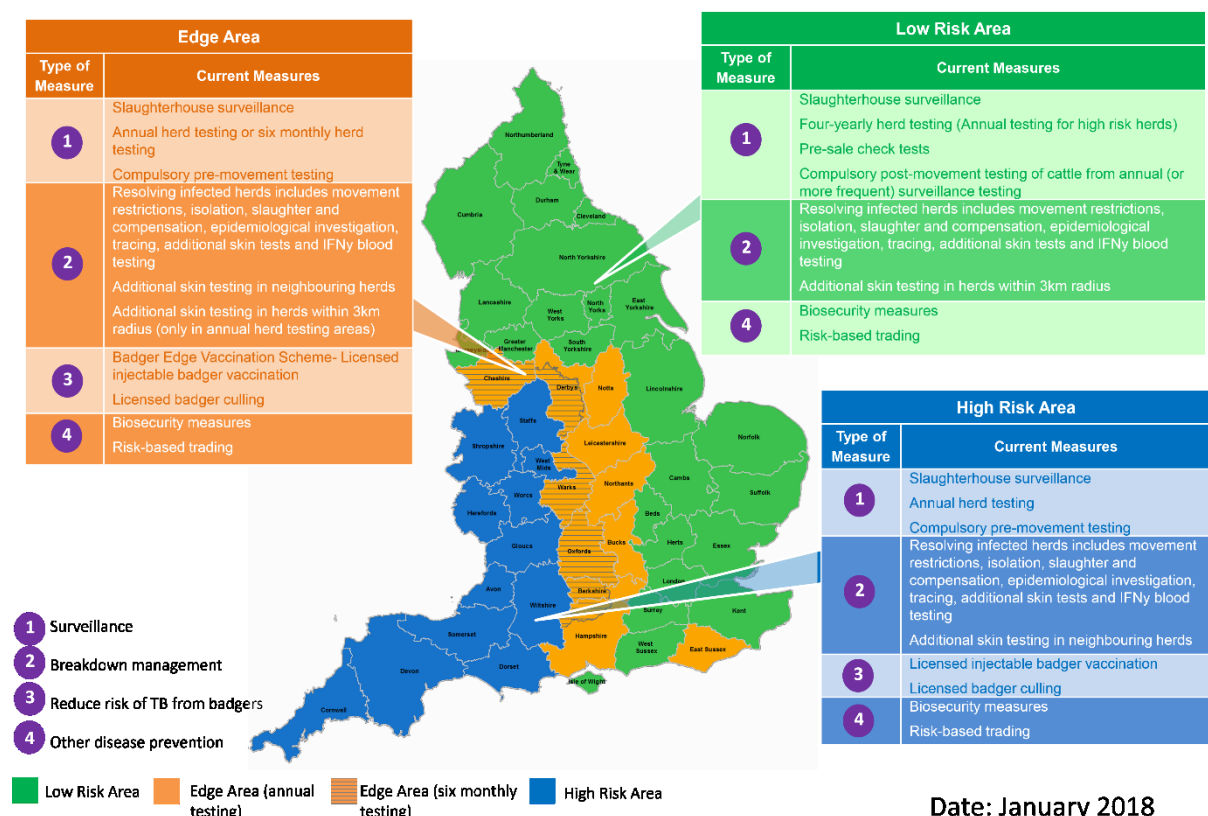


Figure 3.1 Summary graphic of the England TB Eradication Strategy

⁵ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300447/pb14088-bovine-tb-strategy-140328.pdf

⁶ <http://www.tbhub.co.uk/wp-content/uploads/2017/09/infographic-TB-measures.pdf>

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 controls. 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.

A range of new controls have been introduced in 2017 including new licensed badger control areas, wider use deployment of interferon-gamma (IFN- γ) blood testing in the HRA and the retention lifelong restriction of animals which pass a re-test following identification as an inconclusive reactor (IR) on the farm of detection. Further details of these and a full description of the current approach are presented in the Explanatory Supplement⁷. A brief history of controls can be seen in the England TB Epidemiology Report for 2016⁸.

Purpose of this report

This report aims to provide a better understanding of disease behaviour and the impact of the current strategy using epidemiological analyses of the available data, in conjunction with detailed information provided by colleagues working in the control programme.

The raw data can be misleading as the potential for finding herds that are infected with TB is directly related to (i) how hard we look – i.e. the design and effectiveness of the surveillance carried out (particularly the type and frequency of testing), and (ii) the level of disease, which differs by risk area. There are also factors that affect the probability of becoming infected that are unevenly distributed in the population, for example the differences in cattle demography, both the frequency of large herds and of dairy herds, in the different risk areas helps to explain some of the distribution of TB infection. Two other important factors affect the level of disease in the different risk areas in England; firstly the level of infection (prevalence) in the local cattle population which influences the chance of local transmission between cattle herds, and secondly the presence of TB (*M. bovis*) infection in other species to which cattle are exposed. The most important of these is the local badger population, which is endemically infected in the west and south of England.

⁷ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

⁸ <https://www.gov.uk/government/publications/bovine-tb-epidemiology-and-surveillance-in-great-britain-2015>

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.

A key measure of the epidemic is herd incidence, which describes the rate at which new incidents (also called 'breakdowns') occur in cattle herds over time. It is a measure of whether controls to prevent transmission of the disease and the propagation of the epidemic are working effectively. This is complemented by the herd prevalence, i.e. the proportion of herds restricted due to TB infection at a point in time. Herd prevalence gives two useful indicators, firstly a guide to how long it takes to remove disease from infected farms (measured by the duration of restrictions in comparison to the annual incidence). Secondly, as it reflects both incidence and duration of restrictions, a measure of the impact of the disease, including impacts on farmers. More information on how these measures of disease frequency are calculated is presented in the Explanatory Supplement⁹.

⁹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

4. The TB epidemic in England

4.1 Incidence, geographic distribution and trends over time

- In 2017 there were 3,816 new TB incidents in England as a whole, which is similar to recent years where total numbers per annum have remained relatively stable between 3,700 and 3,900 since 2011. As in previous years, most new incidents (85.4%) occurred in the High Risk Area (HRA), with 11.4% in the Edge Area and 3.2% in the Low Risk Area (LRA).
- Within the HRA, TB incidence rate has fluctuated between 17 and 18 incidents per 100 herd years at risk between 2001 and 2016; increasing to 19.2 incidents per 100 herd years at risk in 2017. Since 2010, there has been a continued increase in TB incidents within the Edge Area to 7.7 incidents per 100 herd years at risk in 2017, whilst incidence has remained low and stable during the same period in the LRA (not exceeding 1 herd year at risk).
- The number of herds that were newly infected with TB in 2017 was lower in the LRA when compared to 2016, but increased in the HRA, Edge Area and England overall.
- 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.
- Lesions typical of TB and/or positive culture results for *Mycobacterium bovis* were detected in cattle removed from 71% of new incidents in the HRA, 58% in the Edge Area and 38% in the LRA (OTF-W incidents).
- There was a net spread of 400km² of the areas considered to harbour endemic TB in England overall (2016-17), i.e. expansion of the 'endemic TB area' exceeded retraction.
- Much of the geographic distribution of TB is explained by the distribution of cattle herds, particularly large herds, and increases in herd size in the most infected areas may have contributed to maintaining the epidemic. However, 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 species (particularly badgers) and their environment, to which cattle are exposed.

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 years¹⁰.

In 2017, the total number of newly infected herds was higher in England overall and also in both the HRA and Edge Area compared to 2016, whereas the total number of newly infected herds in the LRA decreased in 2017. The increase in incidence in the Edge Area was statistically significant ($p=0.0014$).

The LRA had 123 TB incidents in 2017 which is a continued decrease since 2015 (156 in 2015, 137 in 2016). Just over a third of new TB incidents in the LRA ($n=47$, 38%) were lesion and/or bacteriologically positive (i.e. fully confirmed or 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. In contrast, the higher level of TB in both the Edge Area and HRA mean that a positive skin test is a very good indicator of infection in that herd, irrespective of post-mortem and laboratory results (See Explanatory Supplement¹¹ for further detail).

In summary, the highest levels of TB in England were found in the HRA where the number of new TB incidents in 2017 was 7.5 times higher than in the Edge Area, and 26 times greater than in the LRA. The proportion of TB incidents with OTF status withdrawn (OTF-W) was highest in the HRA and lowest in the LRA (Table 4.1.1). The proportion of TB incidents that were OTF-W in the Edge Area increased from 51% in 2016 to 58% in 2017.

Further analysis and discussion on new TB incidents in the LRA is presented in Section 5.3 to see if infection was acquired locally.

¹⁰ 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 cases found only partly reflects the disease level

¹¹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

Table 4.1.1 Number of TB infected herds¹ and incidence rate² in England, by risk region, 2016 & 2017

		High Risk Area (HRA)		Edge Area		Low Risk Area (LRA)		England
New TB incidents (% of total for England)	2017	3,259 (85.4)	↑	434 (11.4)	↑	123 (3.2)	↓	3,816
	2016	3,229 (86.0)		387 (10.3)		137 (3.7)		3,753
TB infected herds that were lesion and/or culture positive (OTF-W incidents) (% of total for risk area)	2017	2,305 (70.7)		250 (57.6)	↑	47 (38.2)	↑	2,602 (68.2)
	2016	2,300 (71.2)		196 (50.6)		43 (31.4)		2,539 (67.7)
TB incidence rate per 100 herd-years at risk (% change from 2016)	2017	19.2 (+7.3)	↑	7.7 (+14.9)	↑	1.0 (0)	↔	11.0 (+7.8)
	2016	17.9		6.7		1.0		10.2

¹Herds detected as infected with *Mycobacterium bovis* regardless of confirmation status (whether at least one animal was lesion and/or culture positive (OTF herd status withdrawn).

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

³Calculated from all incidents including introduced and OTF-S cases; incidence rate of OTF-W cases was 0.4 per 100 herd years at risk, a slight increase on 2016 (0.3). Note – red upward arrow denotes increase in number from 2016, green arrow denotes decrease from 2016 and amber arrow denotes no change

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 would have taken for the epidemic to double in size was estimated at 5.3 years (Figure 4.1.1a).

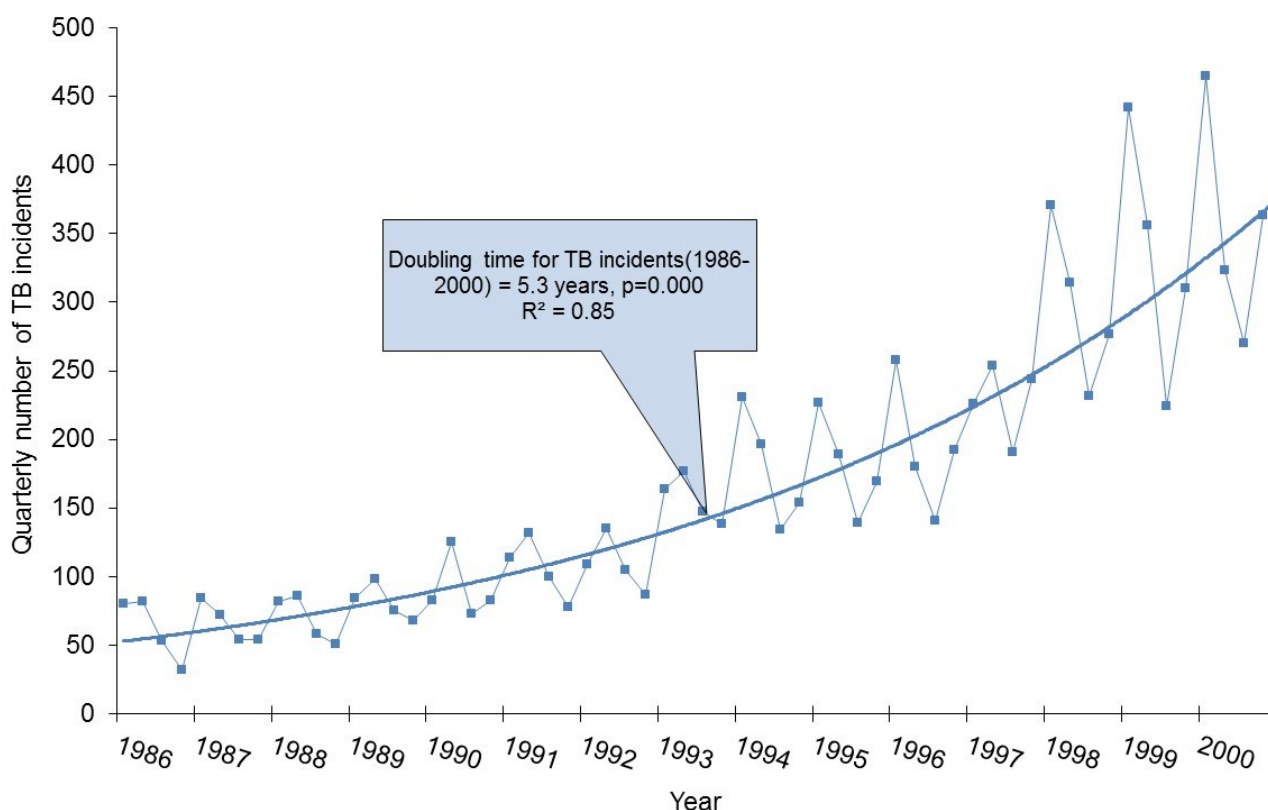


Figure 4.1.1a Quarterly totals for new TB incidents detected in England between January 1986 and December 2000

- 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 numbers 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 an annual rate of increase of 25.3%.

The rate of increase in TB incidents reduced once controls were re-established after the FMD epidemic (Figure 4.1.1b). 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).

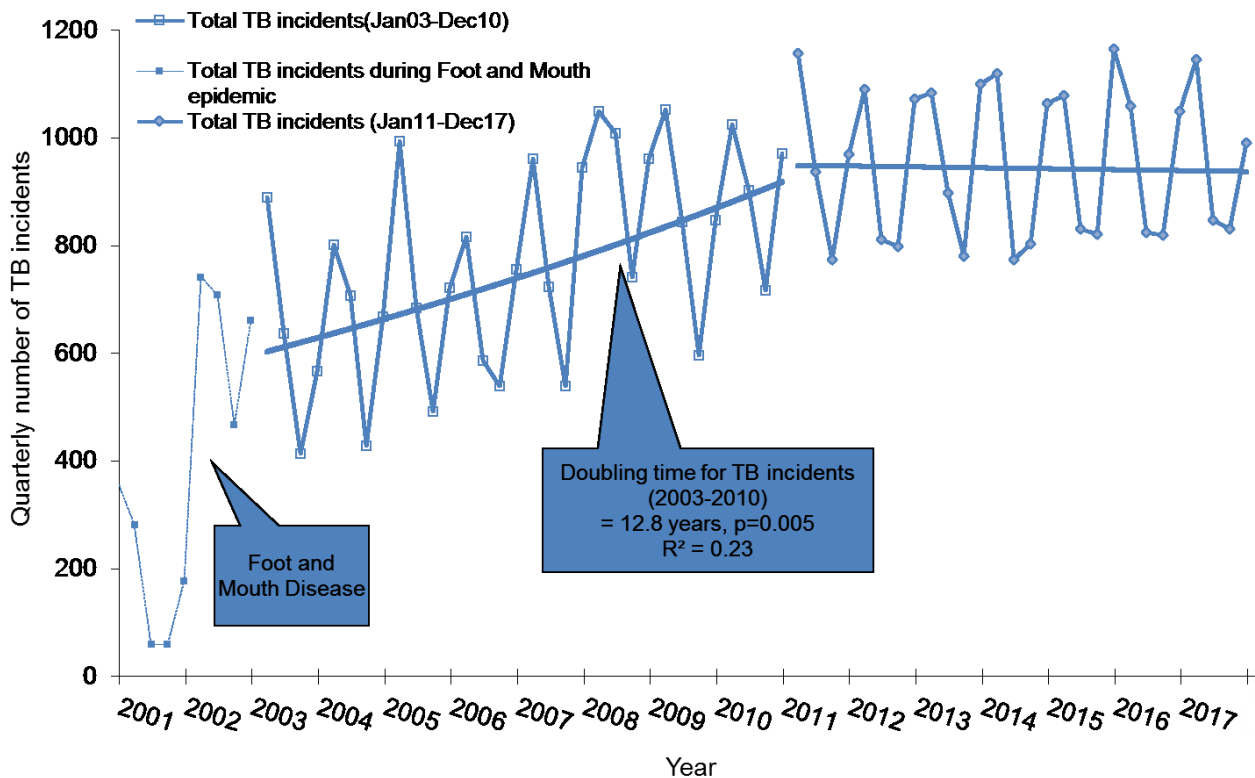


Figure 4.1.1b Quarterly totals for new TB incidents detected in England between January 2001 and December 2017

- Trend lines are shown for the two periods 2003-2010 and 2011-2017. The doubling time indicates the time it would take for incidents to double in number, given the trend of the data. This is shown for the period 2003-2010. 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. An R^2 of 1 would indicate a perfect fit.
- The upward trend observed between 2003 and 2010 was significant but for the period 2011-17 the epidemic appears to be now plateauing.

The total number of new TB herd incidents in England has remained fairly stable at between 3,700 and 3,900 since 2011 (Figure 4.1.2a). This is despite the expansion of the annual surveillance testing area, the introduction of radial testing in the LRA from 2013 and the adoption of six monthly surveillance testing of herds in the Edge Area of Cheshire in 2015. However the proportion of new incidents found in the Edge Area has increased since 2013 when annual surveillance testing was introduced.

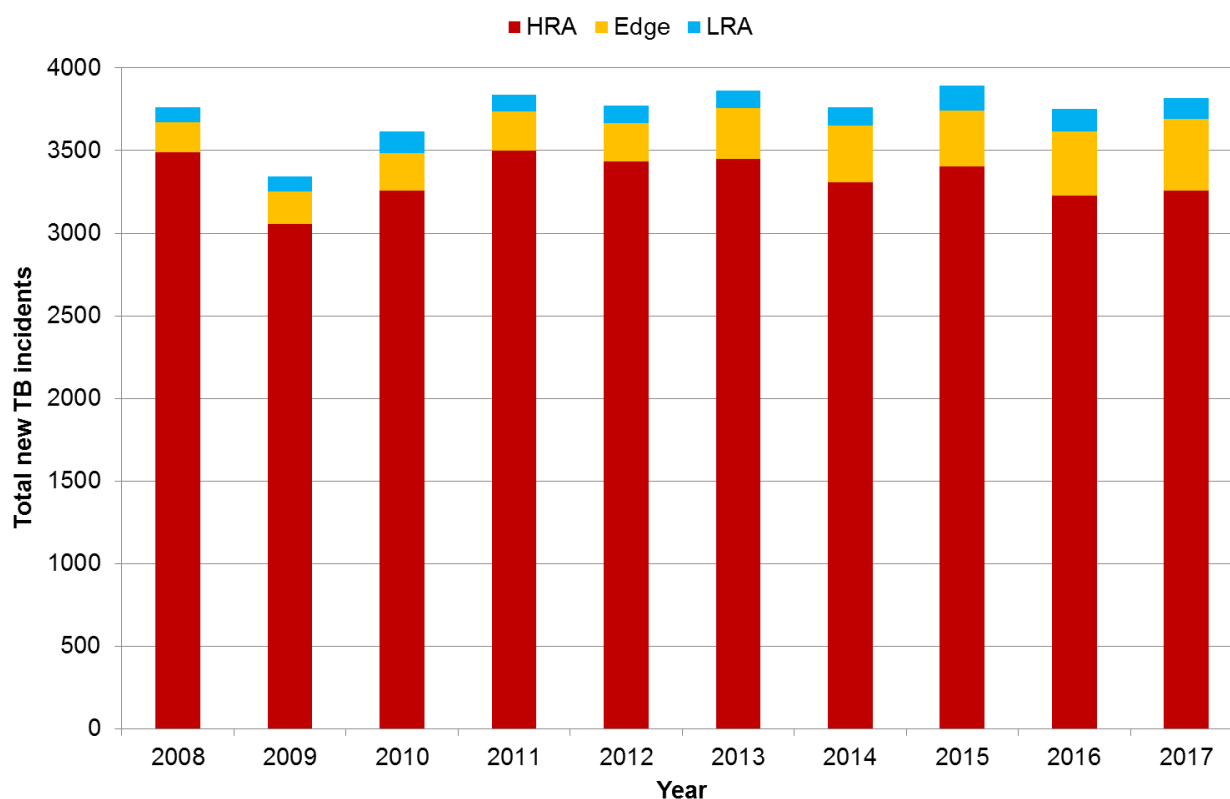


Figure 4.1.2a Trends in the number of new TB infected herds over time, by risk area

- The total number of new TB incidents has ranged between 3,700 and 3,900 since 2011
- The introduction of annual testing for herds in the Edge Area in 2013 increased the proportion of new TB incidents detected there. While the number of new TB incidents in the HRA has remained consistent over the past two years, the number in the Edge Area has increased.

Figure 4.1.2b displays the total number of TB incidents in the LRA, by confirmation status (TB infected (OTF-W) and TB suspected (OTF-S)). The number of confirmed TB infected herds has not varied much over the past ten years, although it was highest in 2015 (n=52).

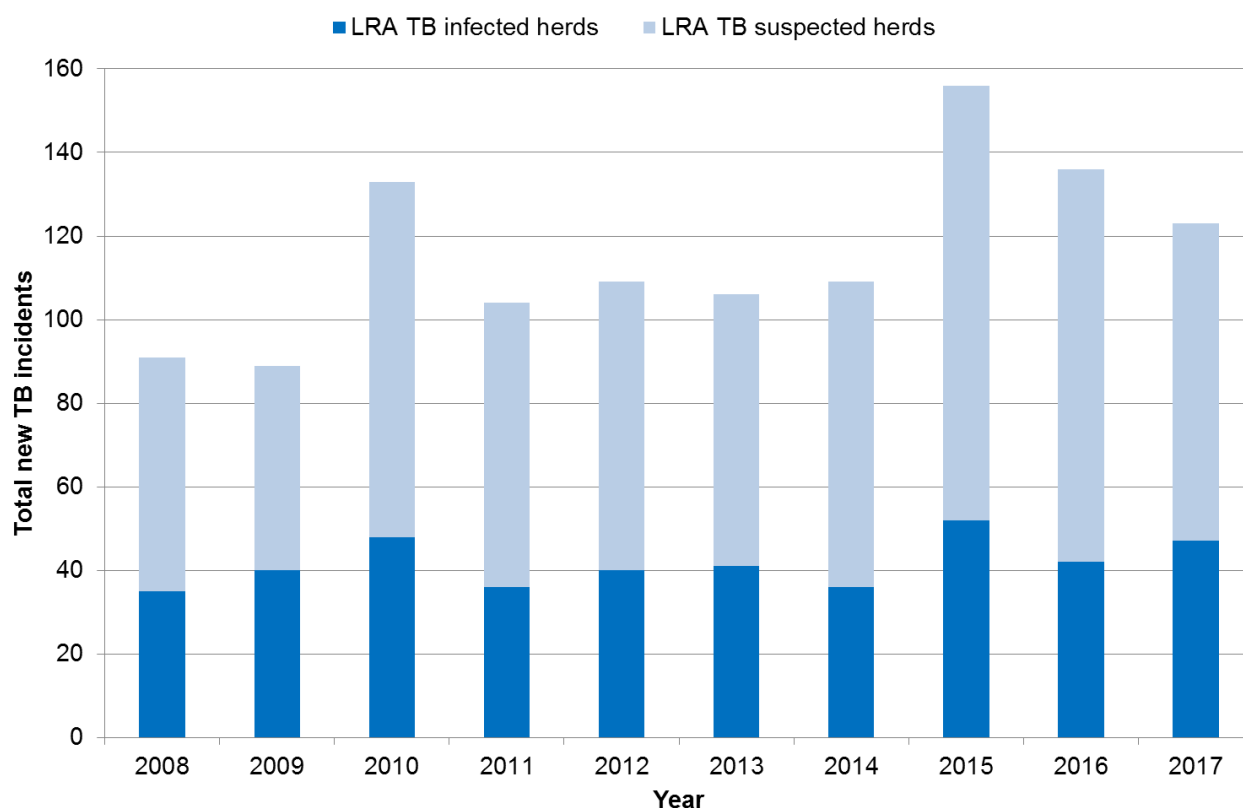


Figure 4.1.2b Trends in the number of new TB herd incidents of OTF status withdrawn [infected herds] and suspended [suspected herds] in the LRA over time

- In 2017, 38% of suspect TB incidents in the LRA were confirmed by post-mortem evidence of infection.

Annual incidence rate and geographical distribution of new TB incidents

Current Situation

The TB epidemic in England is best measured by the incidence rate¹², which reflects the rate at which herds become newly infected. The annual incidence rate of TB in England was 11 TB incidents per 100 herd-years at risk and has generally only fluctuated by one or two per cent since 2011. The limited fluctuation masks the changes at risk area level, namely that TB incidence in the Edge Area increased by 14.9% from 6.7 in 2016 to 7.7 in 2017 (TB incidents per 100 herd-years at risk, Table 4.1.1 and Figure 4.1.3). The denominator (herd-years at risk) has declined in 2017, while the number of TB incidents has increased in the HRA, Edge Area and England

¹² 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.

overall, therefore the incidence rate in these areas has increased compared to last year.

In the LRA, the incidence rate has remained stable and many of the new TB incidents were not confirmed by post-mortem tests of TB suspect animals.

The increase in TB incidence in the Edge Area was statistically significant in 2017 ($p=0.0014$) and remains a concern; this is discussed further in Section 4.2. Incidence in the HRA increased by 7.3% in 2017, but was not statistically significant ($p=0.178$). The increase in both the HRA and Edge Area has driven up the incidence rate in England overall, from 10.2 to 11.0 in 2017, a 7.8% increase. TB surveillance and case management policy changes implemented in 2017 and 2018 aim to address the increase observed in the Edge Area, and are further discussed in Section 4.5 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 2017, which was slightly higher compared to 2016.

There are substantial differences in TB incidence rates between risk areas as well as between counties within the same risk area (see Table 4.1.1, Figure 4.1.4). Historical trends in TB incidence rate (Figure 4.1.3) 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 both in the Edge Area over the same time period (Figure 4.1.2a). Further discussion of the incidence is presented in each risk area section (Sections 5.1, 5.2 and 5.3).

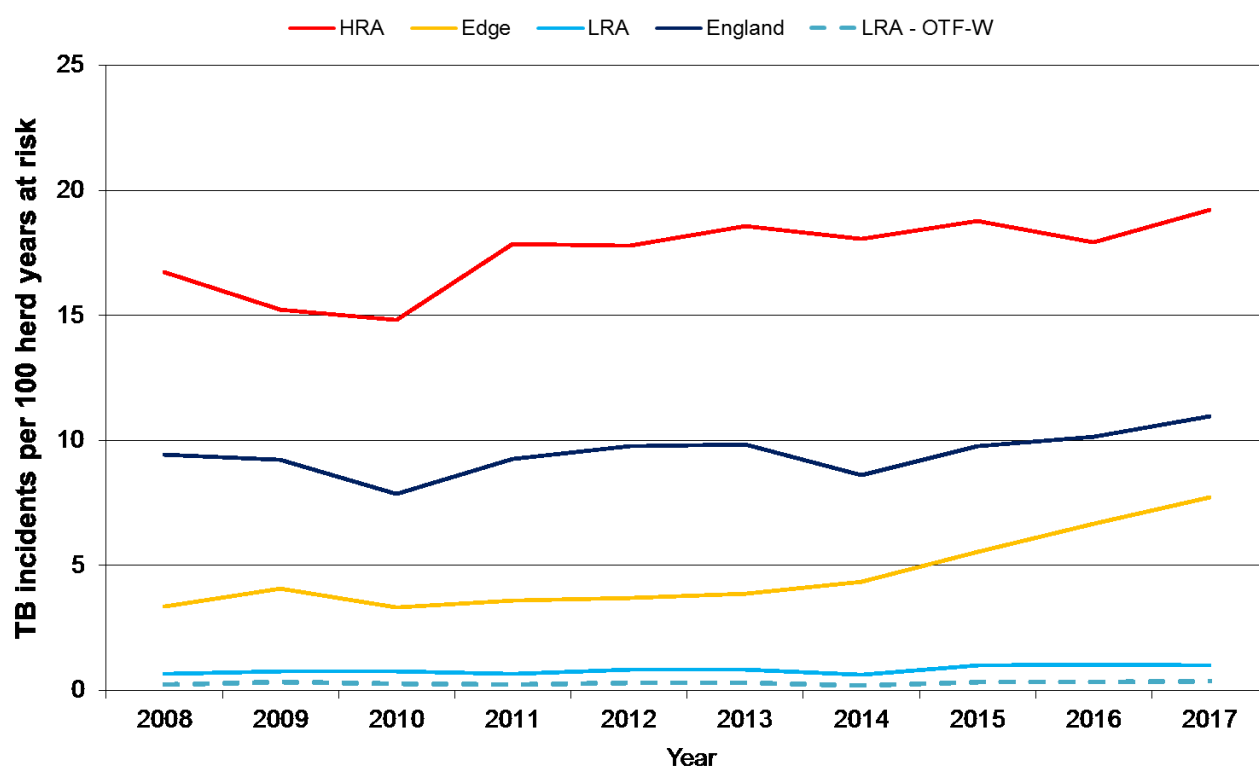


Figure 4.1.3 Annual incidence rate (per 100 herd-years at risk (HYR)) for England and by risk area, from 2008 to 2017.

- Incidence rates have been relatively stable in the LRA and HRA since 2011 (the increase observed in the HRA in 2017 was not significant, $p=0.178$).
- Incidence has continued to increase over the same period in the Edge Area.

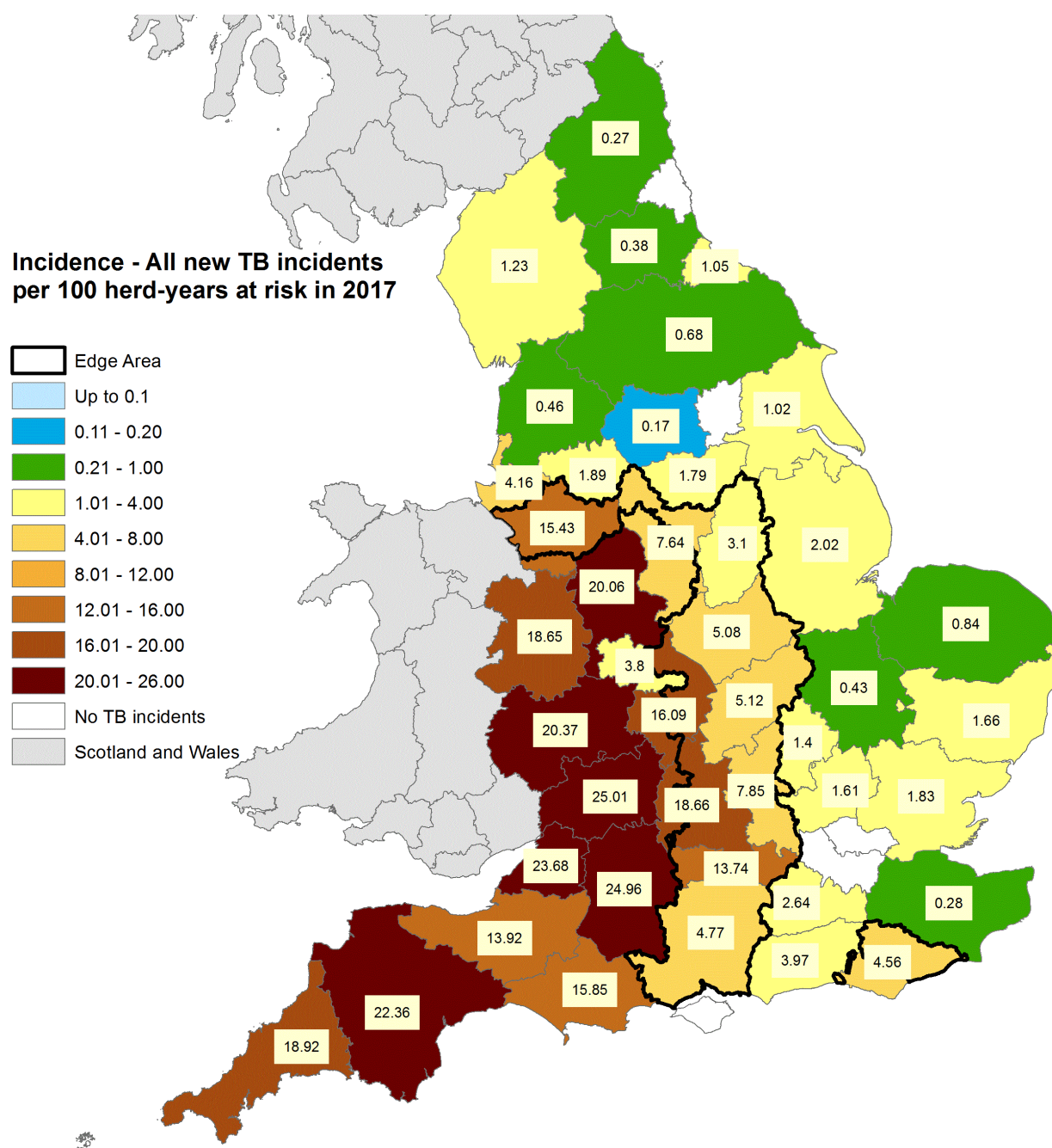


Figure 4.1.4 County incidence of all TB incidents per 100 herd years at risk in England in 2017

- As expected, there is wide variation in incidence rates by county and risk area. Incidence was highest overall in the HRA counties, particularly Gloucestershire, Wiltshire and Avon.

Spatial changes in the TB epidemic

Changes between 2016 and 2017 in the areas of England that can be defined as 'endemically infected' have been assessed and are shown in Figure 4.1.5, (see Explanatory supplement for definition and methodology for endemic infection). 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.

In England there was calculated to be approximately 2,380.7km² of spread and 1,980.5km² of retraction, resulting in a net change of 400.3km² from 2016-2017. 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. Areas of spread included East Cumbria and Oxfordshire. Areas of retraction included parts of Cheshire and Leicestershire.

Cattle demographics

Incidence rates by county boundary (such as the choropleth map in Fig 4.1.4) vary compared to kernel density maps such as Fig 4.1.5b as shown below, since the methodology for the map is based on a spatial kernel applied to the 100 closest herds (also accounting for herd density and TB incidents). Therefore, areas with high incidence but fewer herds with a TB incident in and around a specific area may not be as visible as when comparing to a county level choropleth map.

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 4.1.5a and b).

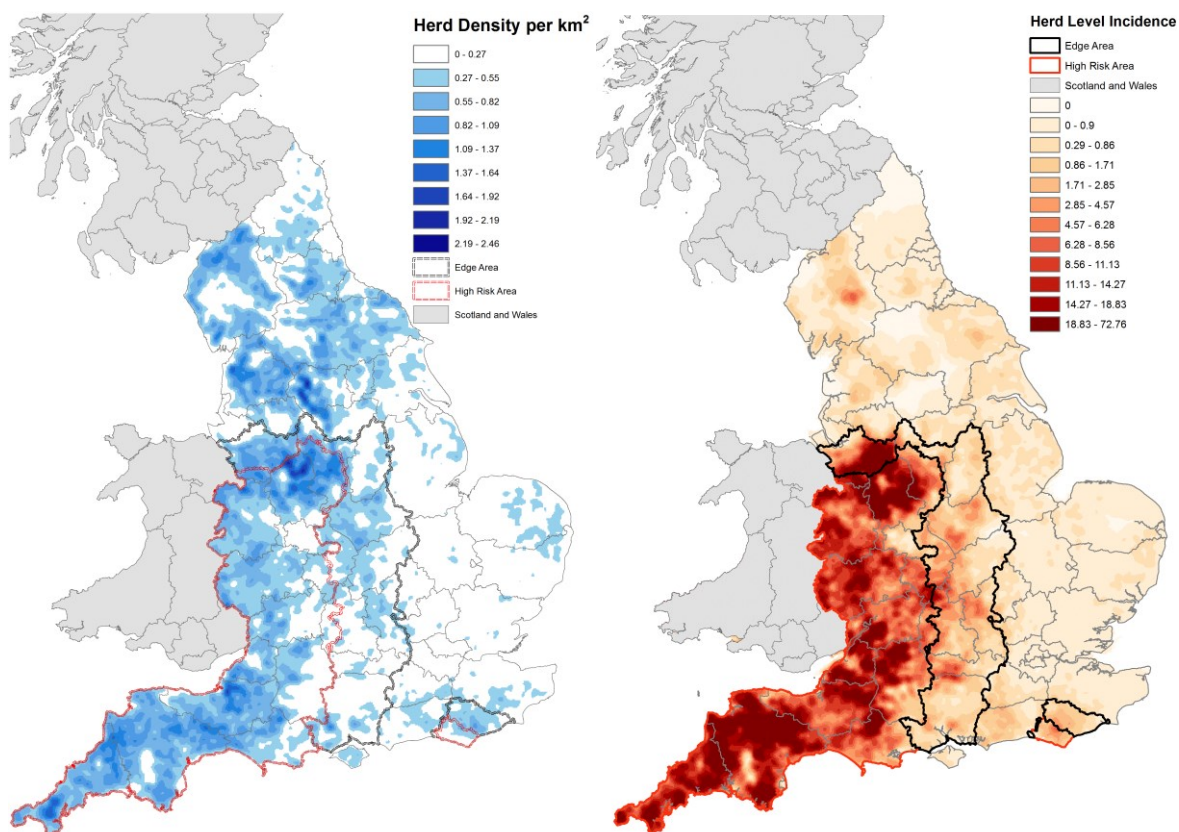


Figure 4.1.5 Herd density (a) and herd level incidence (b) of TB in England in 2017. Herd density is measured as the number of herds per square kilometre; herd incidence is the average incidence in the 100 closest herds to each herd location which ‘smooths’ the effect of political boundaries

- 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.
- Cattle demographics alone cannot explain the distribution of TB as can be seen by the differences between the maps, particularly in Northern England where density is high in places but incidence is low.

Other factors are also important in explaining the distribution of TB such as herd type, size of herds, contiguous herds (and their TB history), herd management (such as cattle purchasing) and environmental/ wildlife factors. This is discussed further in Section 4.2.

Figure 4.1.6 shows the proportional distribution of herds within each surveillance risk area by size and type, and this has remained similar to 2016. 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 (16% in the Edge Area). This may account for some of the difference in disease level between the two areas.

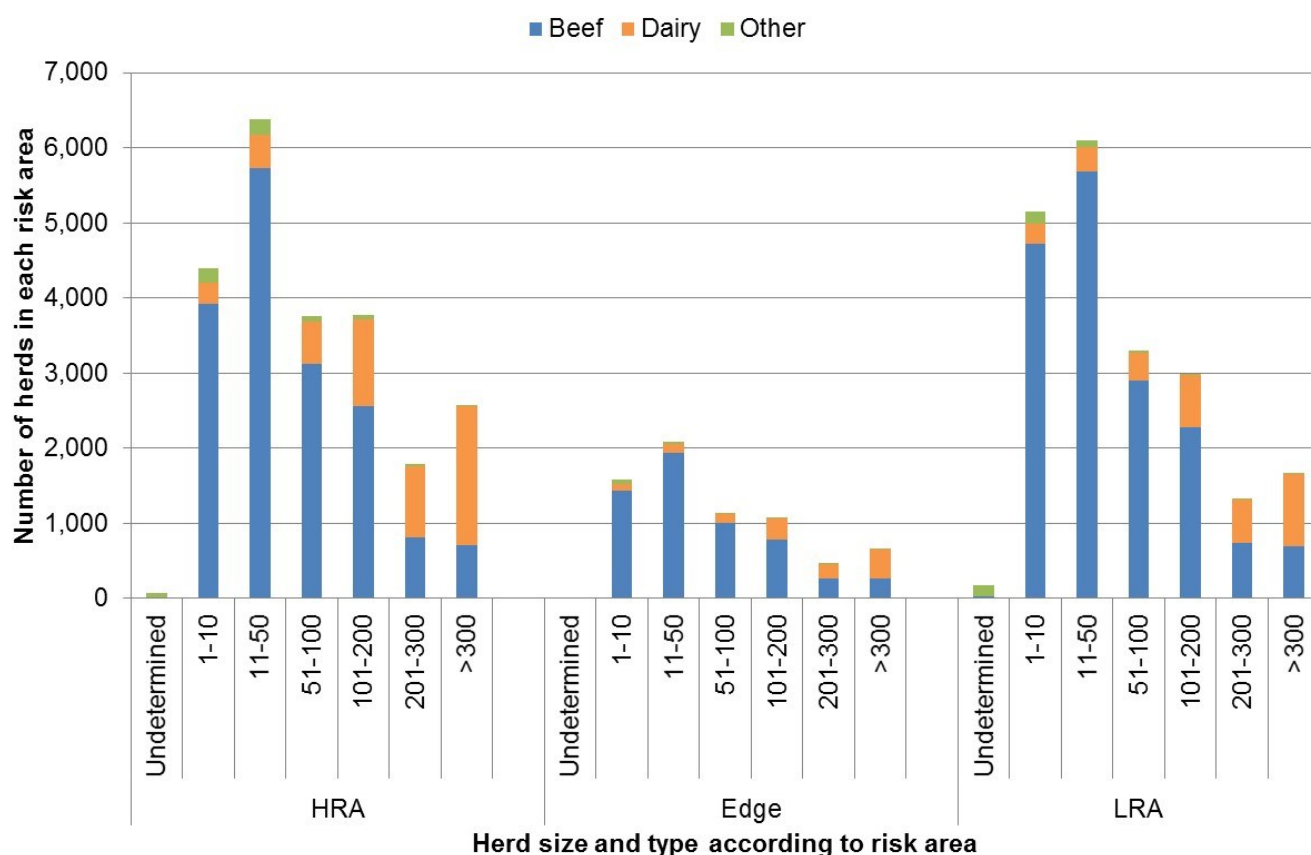


Figure 4.1.6 Proportion of herds by type and herd size in each risk area of England

- The differences observed in cattle demographics; both the frequency of large herds and of dairy herds in the different risk areas helps to explain some of the distribution of TB infection.

Two other important factors affect the level of disease in the different risk areas in England. These are:

1. The local level of TB infection (prevalence) already present in the cattle population, which influences the chance of local transmission between cattle herds, and
2. The presence of TB infection in other species to which cattle are exposed. The most important of these is the local badger population, which is endemically infected with *M. bovis* at a relatively high prevalence in the west and south of England.

The probability of finding cases (i.e. the sensitivity of the surveillance system) also has an effect on the level of disease disclosed and this differs due to differences in both policy and epidemic behaviour between risk areas. This is discussed further in Section 4.3.

4.2 Characteristics of herds found infected with TB in 2017

- Three key factors that increased the risk of a herd sustaining a TB incident in England in 2017 were: having over 300 cattle, being located in the HRA and being a dairy herd. These factors often co-exist, with herds in the HRA tending to be larger, and many dairy herds being large and located in the HRA.
- 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 nine per cent greater risk of infection than beef herds ($p=0.04$). 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.
- Analysis also shows that the probability of a dairy herd being found to be infected 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.
- A history of TB infection was also an important risk factor in all risk areas, and across England over half the herds that were found infected in 2017 had had a previous TB incident within the last three years. Recurrence was highest in the HRA (57%) followed by the Edge Area (26%) and LRA (14%).
- Most TB incidents from which *M. bovis* was recovered and typed were attributed to the local genotype (81%), i.e. they occurred within the 'home range', showing the type is not unexpected in that area.

Factors associated with the likelihood that a herd will become infected

The pathway by which TB infection gets into a herd differs between herds, but analysis shows that the herds most at risk of becoming infected with TB in England in 2017 were large herds located in the HRA (which tend to be dairy herds), and those that had previously been infected with TB (a 'recurrent' incident).

Herd size and type

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 2017, according to these demographics, are shown in Figure 4.2.1a, showing that large herds and dairy herds are much more likely to sustain a new incident, as are herds located in the HRA of England.

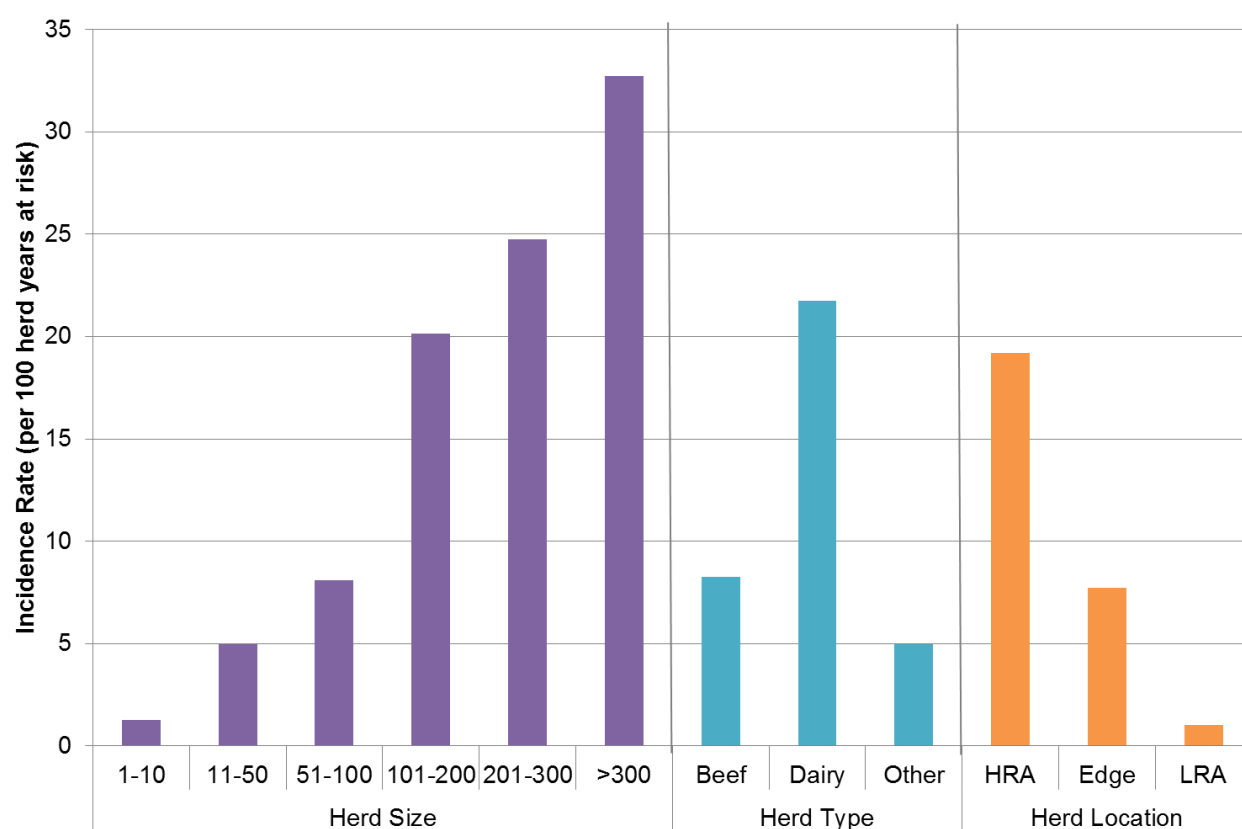


Figure 4.2.1a Incidence rates for new TB incidents in herds of different size or type, and in each risk area of England, in 2017

- 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 2017 was 33%, while it was <6.5% in herds with 50 or fewer cattle.
- Dairy herds were 2.5 times more likely to be found infected in 2017, as beef herds.

- Herds in the HRA were almost 2.5 times as likely to be found infected with TB, as herds in the Edge Area.

The disproportionately high risk of infection in larger herds is observed in Figure 4.2.1b, which shows that most herds are small, while most infection is found in larger herds.

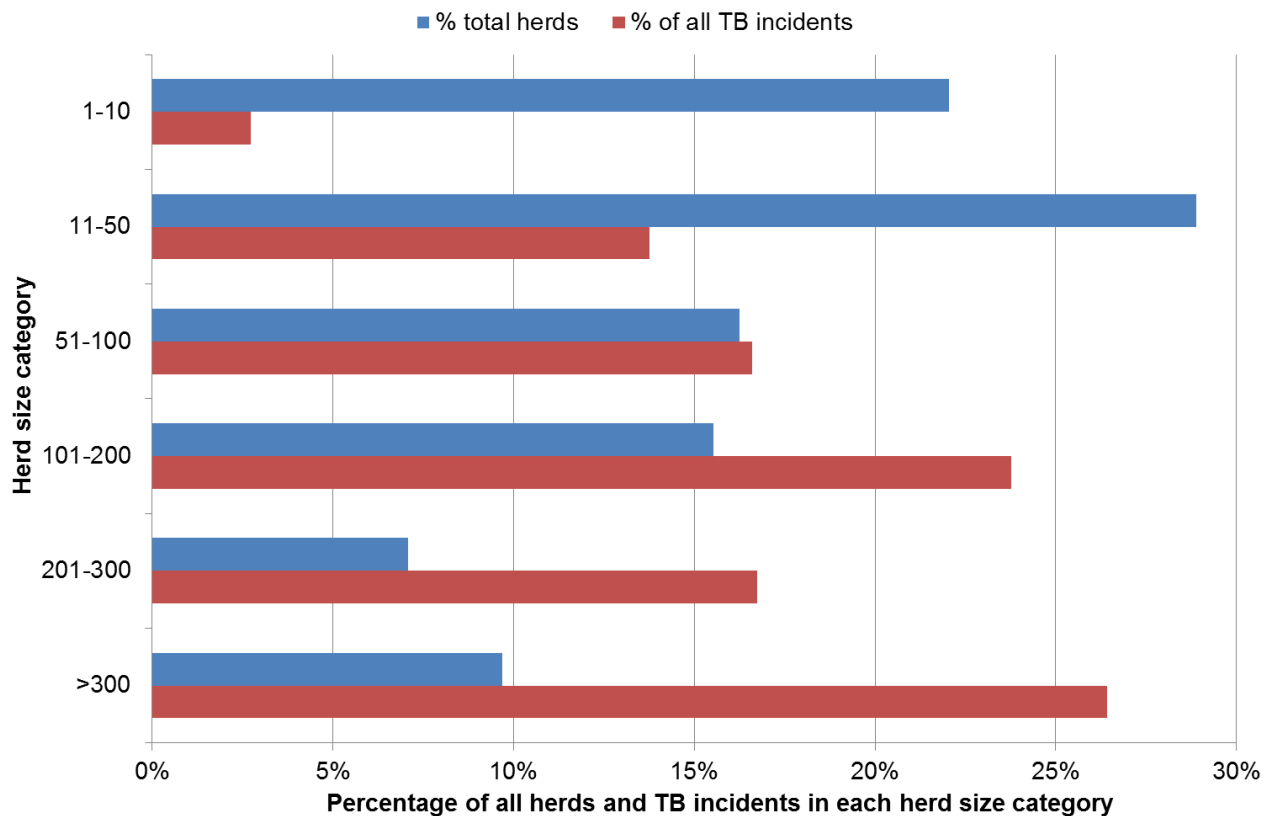


Figure 4.2.1b Percentage of herds of each size, and percentage that experienced a new TB incident in 2017 (herds with undetermined herd size (not shown) form 0.5% of the population and had no TB incidents.)

- Two thirds of TB incidents occurred in herds with more than 100 cattle, although they make up only one third of herds in the whole population.
- In smaller herd sizes of 50 or fewer cattle, there are relatively few TB incidents (16.5% of total) even though herds of this size account for over 50% of all herds.

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 4.2.1a shows that dairy herds had more than twice the risk of becoming infected (incidence) in 2017 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.

Exploring some of the potential risk factors are important in terms of determining the risk of infection. This is done by comparing the incidence rate ratio (IRR, i.e. the comparative proportion of herds in each category that become infected), and then taking the other factors into account which could affect the rate of infection. These comparative ratios are shown in Figure 4.2.1c, 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 rate ratio hardly changes, so herd size may be the most important explanatory factor.

The IRR increased with herd size and was highest in herds with more than 300 cattle. This effect remained after adjusting for the effects of herd type and risk area, with herds of over 300 animals having a higher IRR than herds with 1-300 animals, and this 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 2017 data greatly reduces the estimated risk associated with being a dairy herd. As in 2016, dairy herds are at slightly higher risk of new infection than beef herds of the same size and in the same location (IRR=1.08, 95% CI 1.0; 1.17, p=0.04). As expected, the incidence rate was significantly lower in the Edge and LRA compared to HRA, even after adjusting for the effects of herd size and type, indicating that location is an important risk factor. (Data can be seen in table form in the GB data Report¹³).

¹³https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739906/GBDataReport.ods

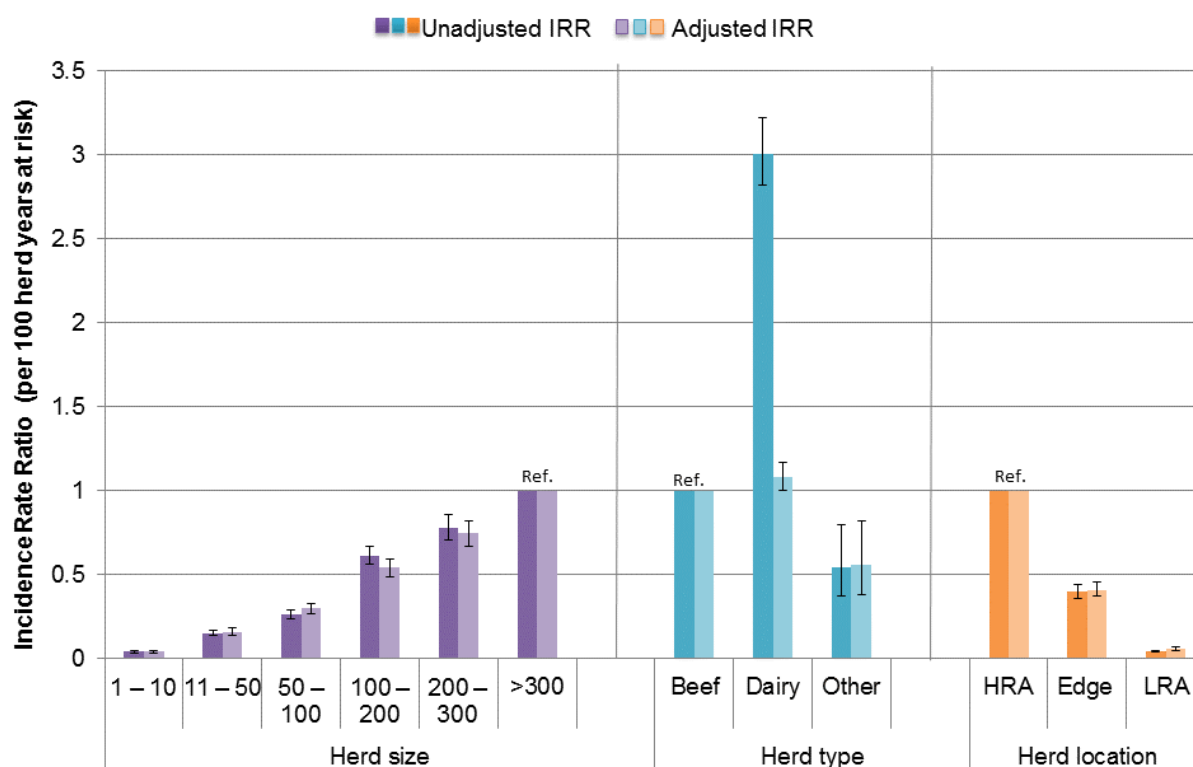


Figure 4.2.1c Incidence Rate Ratios (Unadjusted and Adjusted) for new TB incidents¹⁴ in herds of different size or type, and by risk area in 2017 (Poisson analysis, see Appendix 4, in 2015 report¹⁵)

- 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 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.
- The incidence rate for herds in the Edge Area was less than half the rate for herds in the HRA.
- After adjusting for herd size and location, dairy herds were 9% more likely to have a TB incident than beef herds.

¹⁴ All TB infected herds – includes OTF-W and OTF-S

¹⁵ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/593226/tb-epidemiology-england-2015.pdf

Herd Size

For every category of increasing herd size, the risk of becoming infected increases as well and this has remained so over the last 10 years. Figure 4.2.2 displays the incidence of TB incidents (per 100 herd-years at risk) from 2008-2017, by herd size category in England. This figure clearly shows the strong relation between herd size and the incidence of TB (note these are unadjusted figures, however the Poisson analysis shows that herd type and location have little effect on these estimates). Figure 4.2.2 also shows a dip in incidence rates in 2010 and 2014 in all categories that are more pronounced as herd size increases, for which we do not have an explanation, although cyclical trends are often observed in the number of TB incidents (Figure 4.4.1 also shows similar dips in TB prevalence in 2010 and 2014).

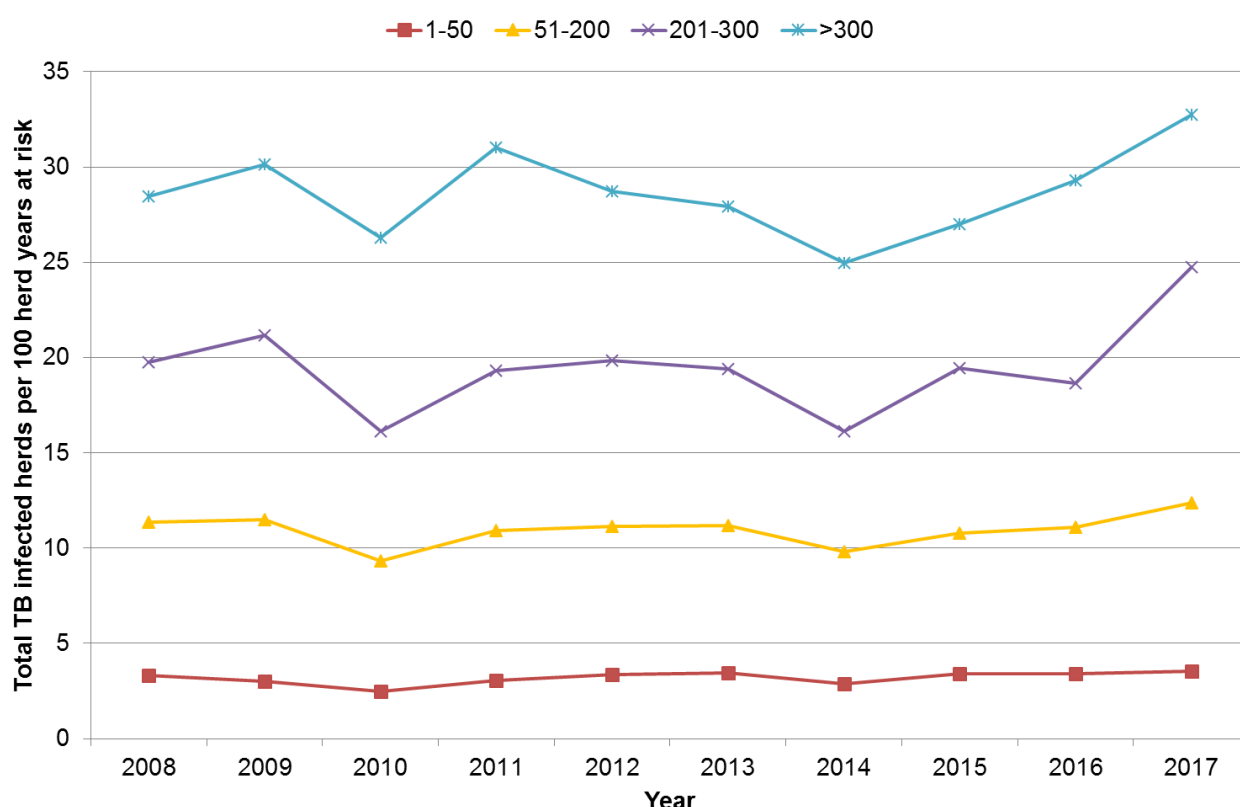


Figure 4.2.2: Incidence rate in different herd size categories over time

- For each category of increasing herd size, the risk of becoming infected increases (consistent over the past ten years).
- Smaller herds of less than 50 cattle show a much lower incidence compared to those with over 50 cattle, and has remained stable since 2008 at about 3%.

Changes in herd size may have contributed to the epidemic over recent years as there has been a continued steady increase in average herd size over the last ten years (See section 4.1). This has affected all areas, but is most pronounced in the HRA (15% increase over ten year period) and the Edge Area (13% increase) (Figure 4.2.3). In

the LRA, the average number of cattle per holding has increased by 5% over the past ten years, but has remained around 99/100 for the past 3 years. The increasing numbers of very large herds (i.e. much larger than 300 cattle) may also be affecting the incidence rate.

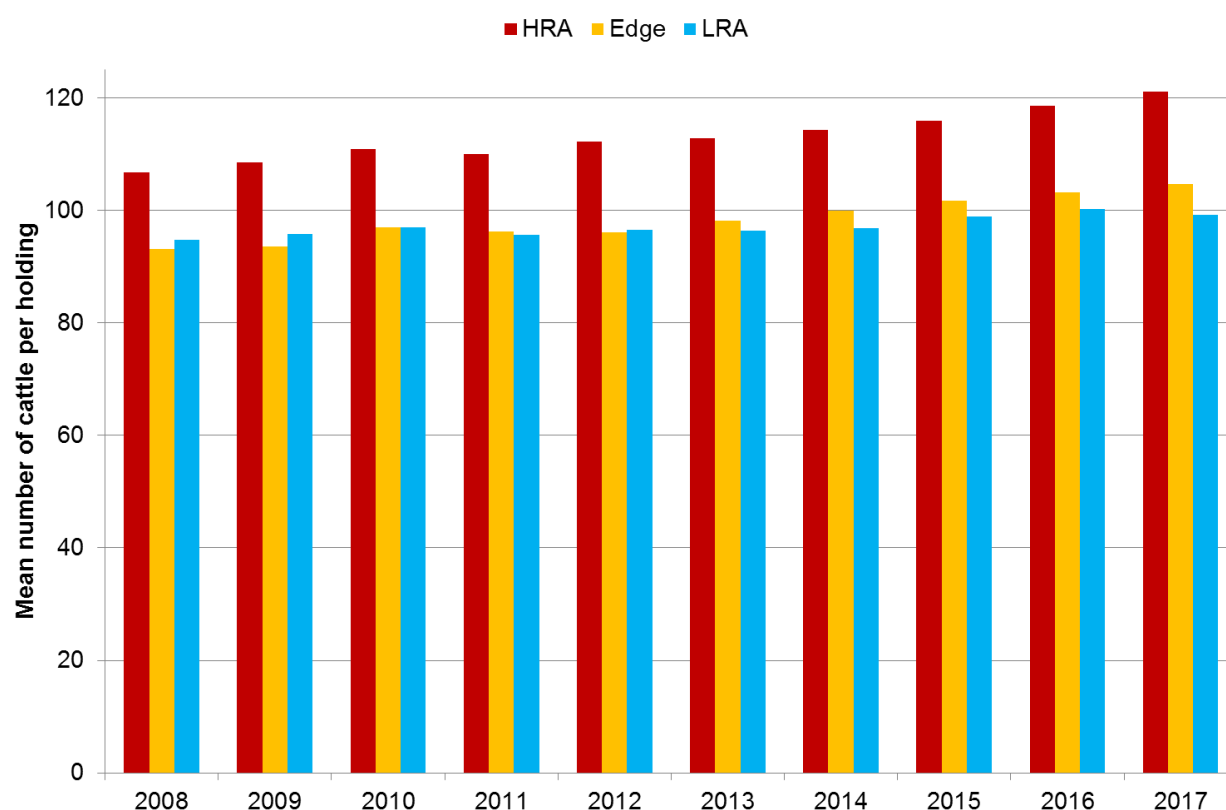


Figure 4.2.3 Changes in mean herd size from 2008 to 2017, by risk area

- In 2017, the average number of cattle per holding (recorded in July 2017) was 121 for the HRA, 105 in the Edge Area and 99 in the LRA.

The reason for the increased risk of infection with increasing herd size is not well understood but likely to be associated with one or more of the following:

- A higher probability of buying-in cattle; each purchase carries a risk of introducing infection.
- A likely larger area of land use for grazing, increasing the risk of exposure to *M. bovis* in the farm environment, including wildlife; greater land use may also be associated with a greater probability of using fragmented land parcels potentially taking cattle to areas with greater environmental exposure.
- A higher risk of residual infection remaining in the herd after officially testing clear of infection at the end of a TB incident, due to the larger number of animals and the imperfect sensitivity of the TB tests.

More research is needed to assess which of the possible factors associated with herd size may be affecting incursion and/or retention of infection in larger herds.

Herd Type

Herd type can be seen as a proxy measure for a particular type of husbandry which could include management and other factors that increase or decrease the risk of TB infection. Therefore if true, these differences could be further investigated to identify these factors, which could lead to better insight into which interventions are most likely to be effective in herds of a particular type.

Dairy herds in England are much more likely to become infected with TB than beef herds (Figure 4.2.4). As discussed above this increased risk is largely due to herd size and location. When adjusting for herd size and location, the IRR reduces greatly, however the overall trend remained in that dairy herds had an increased risk of infection with TB (Figure 4.2.1c).

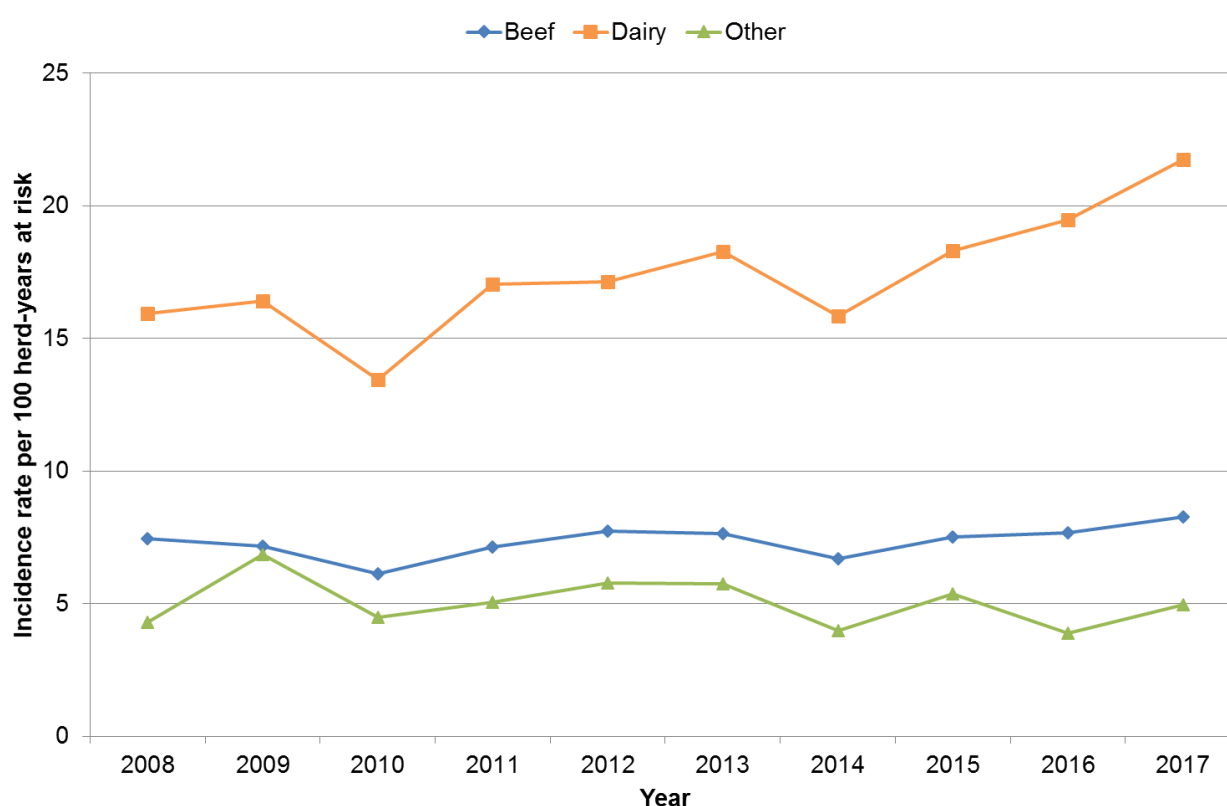


Figure 4.2.4: Incidence rate between 2008 and 2017, by herd type.

- Incidence rates in dairy herds in England were over 2.5 times higher than observed in beef herds, and have continued to increase since 2014.

Recurrent TB incidents

A recurrent TB incident is defined in this report as 'a TB incident disclosed in the reporting year (i.e. 2017) involving a herd that had also been under movement restrictions for a different TB incident in the previous 36 months'. In 2017, 57% of TB infected herds in the HRA had had a previous TB incident in the last 36 months (recurrent herds); 26.4% in the Edge Area and 14% in the LRA.

The proportion of TB infected herds with recurrent incidents in 2017 was highest in the HRA (Figure 4.2.5) and increased steadily from 2007 to a plateau of 58% since 2014 (declining slightly to 57% in 2017). In the Edge Area, the proportion of recurrent TB incidents has also risen since 2007, albeit with more fluctuation (reflecting lower numbers) and also showed a slight decline in 2017 to 26%. In the LRA the proportion of recurrent TB incidents is lower and also variable (14% in 2017). The overall proportion of new TB incidents in England that were recurrent in 2017 was 52%. In contrast, only 12% of herds with no history of TB had a TB incident in 2017.

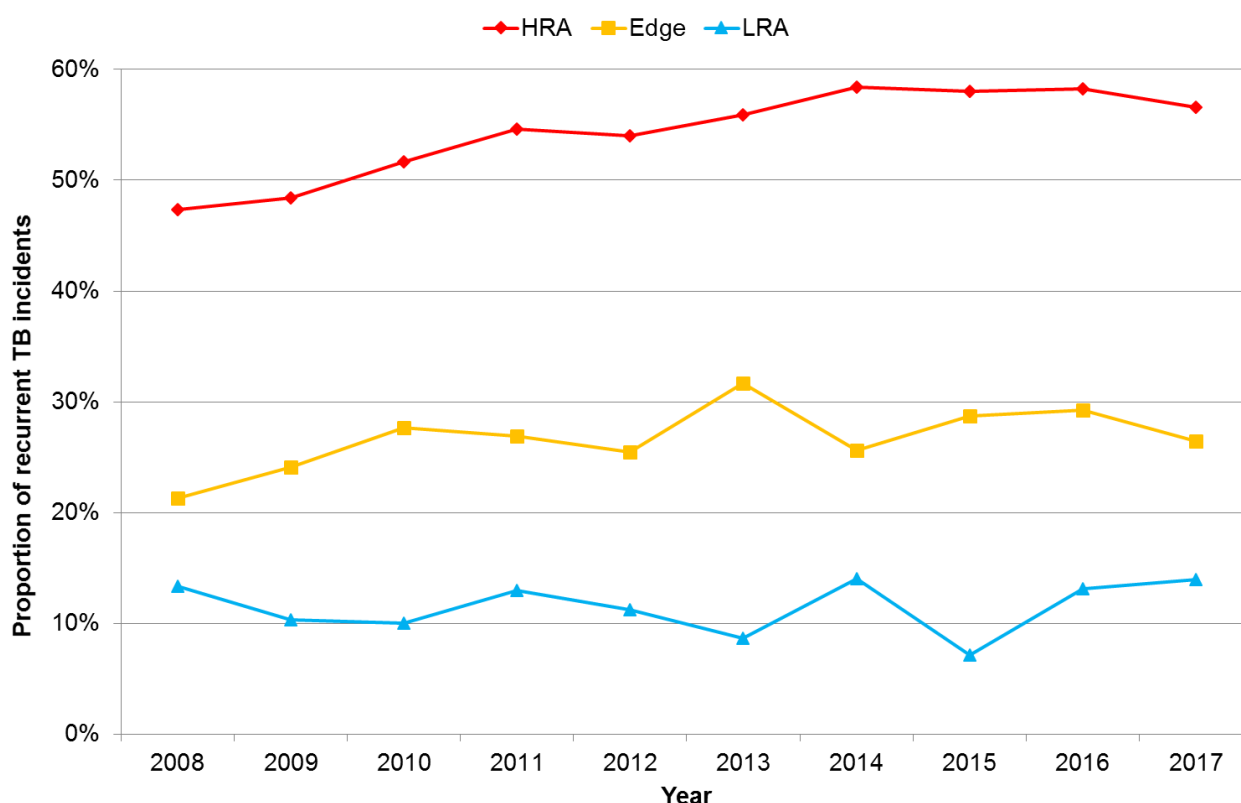


Figure 4.2.5: The annual proportion of herds with recurrent TB incidents between 2008 and 2017, by surveillance risk area.

- The proportion of herds with recurrent TB incidents has plateaued in the HRA and Edge Area since 2014 (slight decline in 2017) and showed continued fluctuation in the LRA (slight increase in 2017) based on far fewer incidents.

The LRA has the lowest incidence of TB and the lowest proportion of recurrent TB incidents of the risk areas. 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 albeit with wider confidence intervals (OR 5.8, 95% CI 3.4 to 9.8, Figure 4.2.6a). This is likely a reflection of the elevated risk of occurrence of TB incidents in fattening units which have repeatedly purchased cattle from the HRA.

In the HRA, the odds of having a TB incident was two times higher in herds with a history of TB compared to herds with no TB history (95% CI 1.9-2.2) and in the Edge area was 1.7 times higher (95% CI 1.3-2.1).

In contrast to 2016, the odds of having a TB incident in herds with previous TB history was *not* substantially higher in small herds (nor was it statistically significant). In 2017, the odds were close to double in all herd size categories but was highest in larger herds of 201-300 animals (OR 2.3, 95% CI 1.9 to 2.9).

When comparing herd type, the odds of having TB was roughly two times higher in herds with TB history compared to herds with no TB history (although was not statistically significant in 'Other' herd types, hence the wide confidence interval). Similar trends applied when the same analyses was run for OTF-W incidents only.

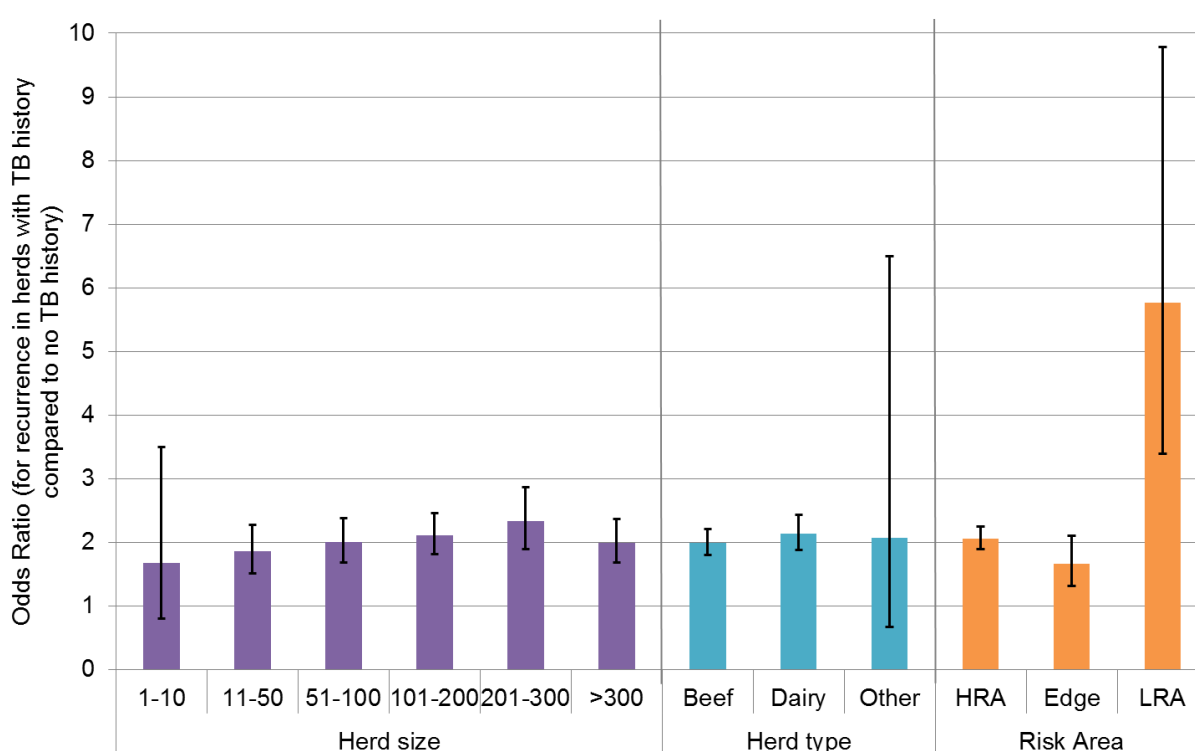


Figure 4.2.6a. The odds of recurrent infection in herds with a history of TB compared to herds with no TB history, by herd size, herd type and risk area (error bars show 95% confidence intervals)

- 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 similar in the HRA and Edge Area, but the LRA had six times greater odds of recurrent TB in herds with TB history compared to herds with no TB history.

Figure 4.2.6b displays the proportion of herds experiencing a new TB incident in 2017 by risk area, comparing herds *with* a history of TB in the previous 36 months, and those with *no* TB history. The proportion of recurrent TB incidents was highest in the

HRA for beef and dairy herds, however for 'Other' herds, the proportion was highest in the LRA (for herds with a history of TB, although this is based on one herd with a TB incident out of five herds with TB history). In the HRA and Edge Area, dairy herds experienced the highest proportion of TB infection, whether or not the herd had a history of TB in the previous 36 months.

Recurrence may have a number of causes, likely relating to location, biosecurity, residual undetected 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 Hub¹⁶ to help promote safer buying practices and improved biosecurity.

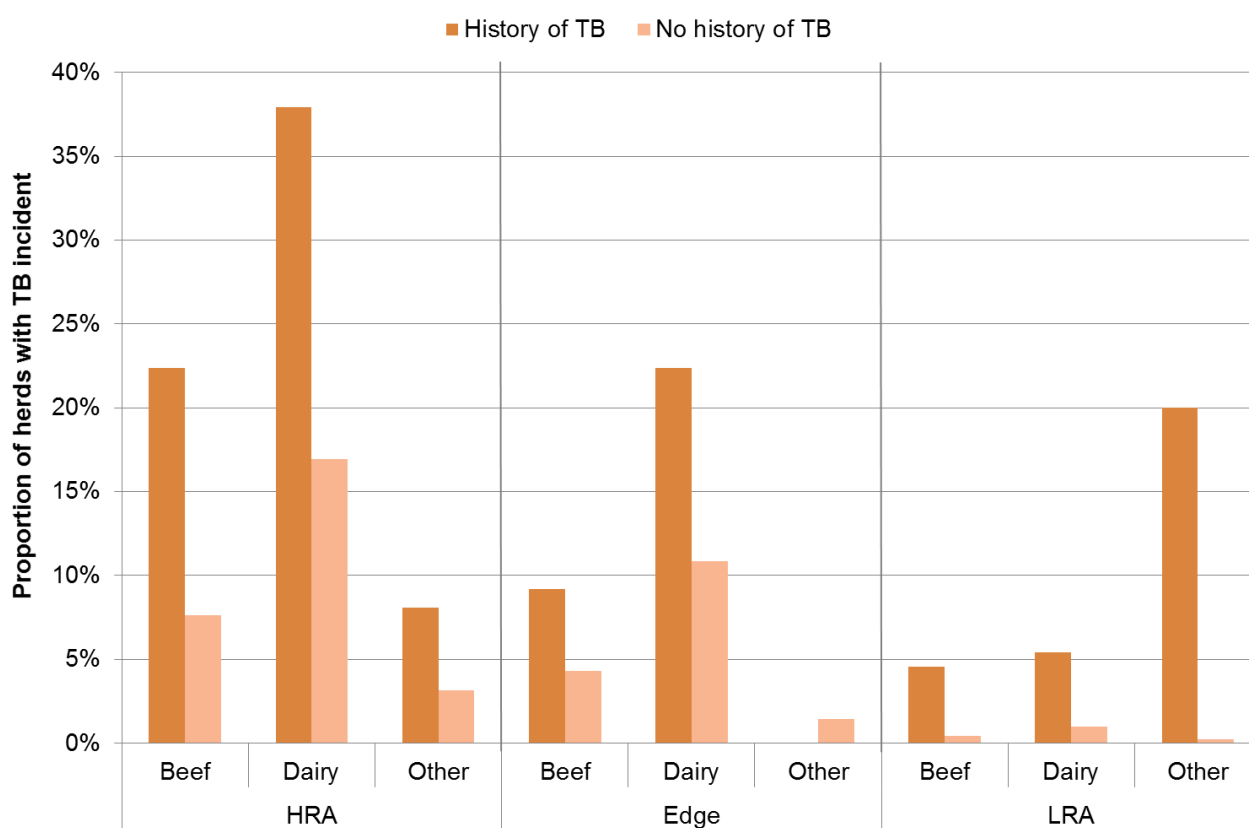


Figure 4.2.6b The proportion of herds by surveillance risk area and herd type, that experienced a TB incident in 2017, split by previous history.

¹⁶ <http://www.tbhub.co.uk/tb-facts/statistics/>

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 only apparent in when the disease is fairly advanced. TB is generally disclosed through skin testing (proactive surveillance) on farm or post-mortem surveillance at the slaughterhouse sometime after it arrives in a herd. 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 to intervene at different points along the risk pathway.

Currently, a proportion of new TB incidents (herd breakdowns) are fully investigated by the APHA. All new TB incidents in the Edge Area and Low Risk Area (LRA) (both OTFW and OTFS) undergo an epidemiological assessment. Additionally, one third of new incidents in the High Risk Area (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 OTFW 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 Supplement¹⁷ to this report. This section presents an analysis of the data for 2017 using a new methodology to examine all possible routes of introduction for the selected herd breakdowns.

The source(s) for each breakdown 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 breakdown, weighted by certainty, can be explored at county, region or national level. For example, a single breakdown may have the following source and risk pathway profile:

Source	Likelihood	Weighting	Proportion
Badgers	Most Likely	4	0.66
Cattle Movement (HRA)	Possible	1	0.166
Cattle Movement (Edge)	Possible	1	0.166
Total for incident A		6	1

¹⁷ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

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 breakdowns. This time consuming activity was not carried out for breakdowns in the HRA and LRA, meaning that we were less confident about the scores presented for these regions.

All incidents detected in England in 2017 that had likely sources and risk pathways recorded were identified for analysis, amounting to 1,823 of 3,816 new TB incidents in 2017. 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.

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 infected cattle onto the holding (Figure 4.2.8). At county level, the most common sources of infection attributed within the HRA or Edge were cattle movements in Buckinghamshire and badgers in Derbyshire (69.9% for each county) (Table 4.2.1).

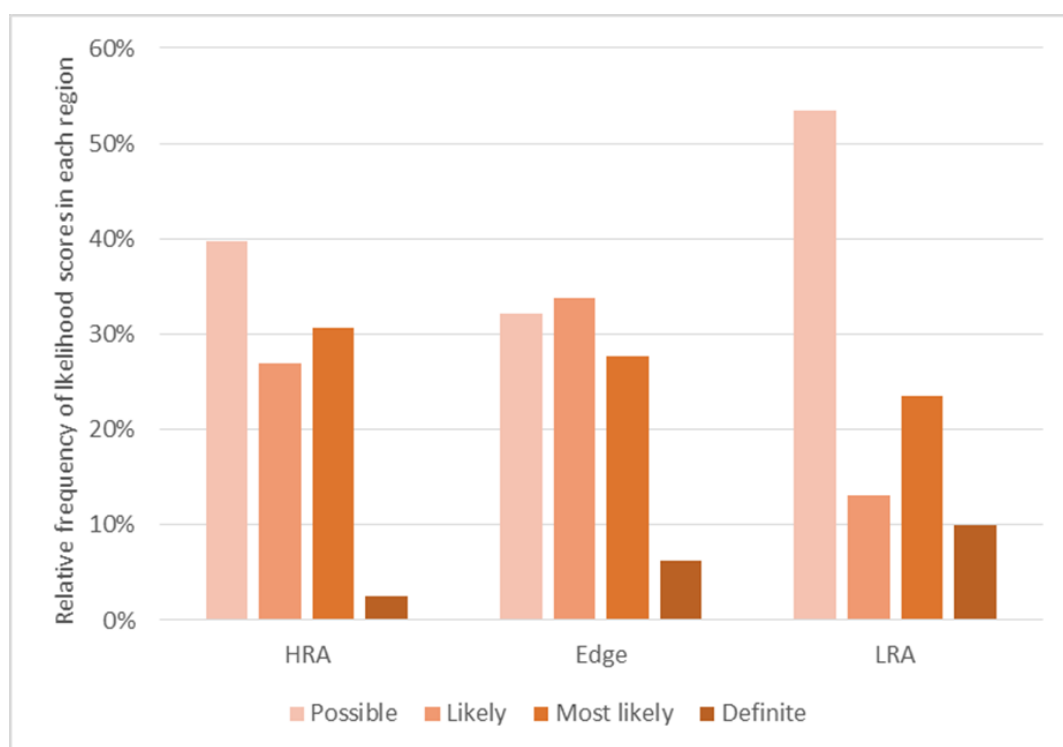


Figure 4.2.7. Relative frequency of likelihood scores given to each identified source in the LRA, Edge Area and HRA

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 infected cattle onto the holding (Figures 4.2.8 to 4.2.10). At county level, the most common sources of infection attributed within the HRA or Edge Area were badgers within the HRA portion of Cheshire (76%) and the HRA portion of Derbyshire (74%) and cattle movements in Buckinghamshire (70%) (Table 4.2.1).

Table 4.2.1 Number of incidents that started in 2017, and the weighted contribution each source of infection made to those incidents, by county

County ¹	Badgers	Cattle Movements	Contiguous	Residual	Domestic	Non-specific	Fomites	Wildlife	Other	Number of investigations
Cheshire (HRA part)	76.3%	6.6%	4.3%	8.4%	0.0%	0.4%	0.0%	0.0%	4.0%	25
Derbyshire (HRA part)	74.0%	13.7%	3.4%	5.7%	0.0%	0.6%	0.4%	0.4%	1.8%	55
Oxfordshire (HRA part)	55.3%	20.8%	0.0%	23.9%	0.0%	0.0%	0.0%	0.0%	0.0%	12
East Sussex (HRA part)	65.4%	12.6%	5.7%	1.8%	0.0%	12.5%	0.0%	2.1%	0.0%	8
Warwickshire (HRA part)	56.1%	16.7%	2.7%	1.9%	0.0%	0.0%	0.0%	16.7%	6.0%	25
Cornwall	65.3%	11.5%	1.0%	4.4%	0.0%	0.2%	0.5%	9.8%	7.3%	173
Devon	62.8%	10.7%	2.4%	6.3%	0.0%	1.4%	0.4%	10.1%	5.9%	284
Dorset	49.4%	19.4%	2.7%	14.6%	0.0%	0.0%	2.0%	7.8%	4.1%	62
Gloucestershire	45.4%	14.1%	7.1%	4.7%	0.0%	9.4%	2.7%	10.3%	6.3%	80
Hereford & Worcester	56.6%	17.6%	3.3%	9.5%	0.3%	2.1%	0.0%	7.8%	2.8%	123
Shropshire	67.8%	14.1%	1.8%	6.4%	0.0%	4.1%	0.4%	4.2%	1.2%	114
Avon	63.8%	9.6%	5.1%	7.9%	0.5%	0.5%	0.4%	8.1%	4.1%	49
Somerset	59.1%	20.6%	4.3%	8.5%	0.4%	0.0%	0.0%	5.6%	1.5%	88
Staffordshire	67.6%	14.9%	3.1%	4.6%	0.0%	4.3%	0.0%	4.3%	1.2%	141
Wiltshire	55.4%	15.8%	4.8%	7.3%	0.0%	1.4%	0.5%	9.5%	5.3%	72
West Midlands	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2
HRA	61.7%	14.0%	3.0%	6.8%	0.1%	2.1%	0.5%	7.6%	4.1%	1313
Cheshire (Edge part)	65.6%	21.7%	2.5%	7.8%	0.0%	0.0%	0.0%	2.0%	0.4%	144
Derbyshire (Edge part)	52.6%	27.9%	0.0%	6.2%	0.0%	0.0%	2.6%	5.6%	5.1%	13
Oxfordshire (Edge part)	46.5%	42.9%	2.7%	7.9%	0.0%	0.0%	0.0%	0.0%	0.0%	45
East Sussex (Edge part)	8.6%	45.5%	2.4%	0.0%	0.0%	19.2%	5.6%	0.9%	17.8%	12
Warwickshire (Edge part)	50.5%	33.0%	2.0%	5.0%	0.0%	0.0%	0.0%	9.5%	0.0%	20
Berkshire	40.7%	41.0%	0.8%	10.7%	0.0%	0.0%	0.0%	6.8%	0.0%	26
Buckinghamshire	5.4%	69.9%	0.0%	8.3%	0.0%	6.7%	8.3%	0.0%	1.4%	36
Leicestershire	53.5%	29.2%	3.3%	4.4%	0.0%	0.0%	0.0%	1.3%	8.2%	39
Northamptonshire	53.3%	27.0%	1.4%	0.9%	0.0%	0.0%	0.0%	13.0%	4.3%	23
Nottinghamshire	16.7%	33.3%	0.0%	0.0%	0.0%	16.7%	0.0%	0.0%	33.3%	6
Hampshire	17.6%	53.6%	0.0%	17.5%	0.0%	0.0%	0.0%	5.9%	5.4%	34
Edge Area	46.7%	35.1%	1.9%	7.6%	0.0%	1.4%	1.0%	3.2%	3.0%	398

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

Source Attribution from DRF: HRA Only

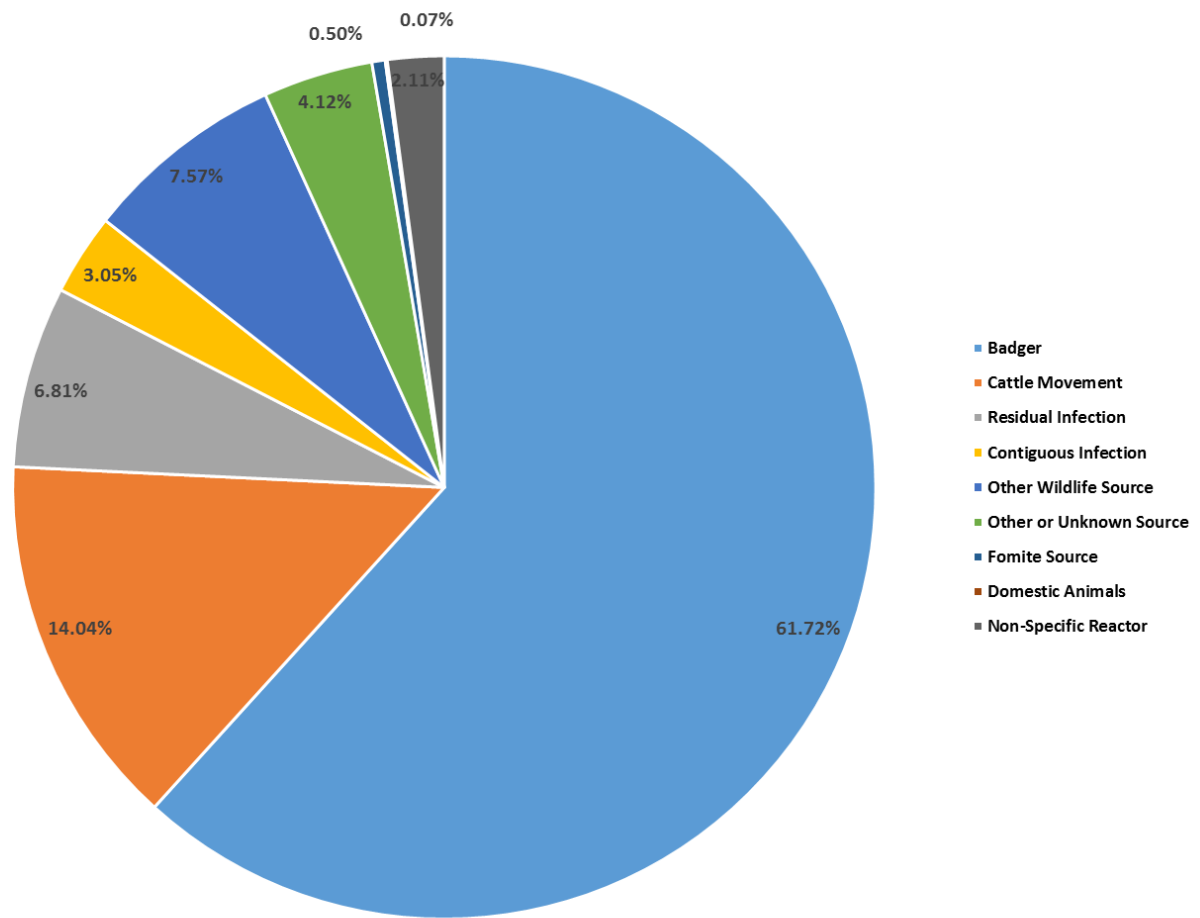


Figure 4.2.8 Summary of the weighted source of infection attributed for all incidents (both OTFW and OTFS) incidents that started in 2017, in the HRA (n=1,313)

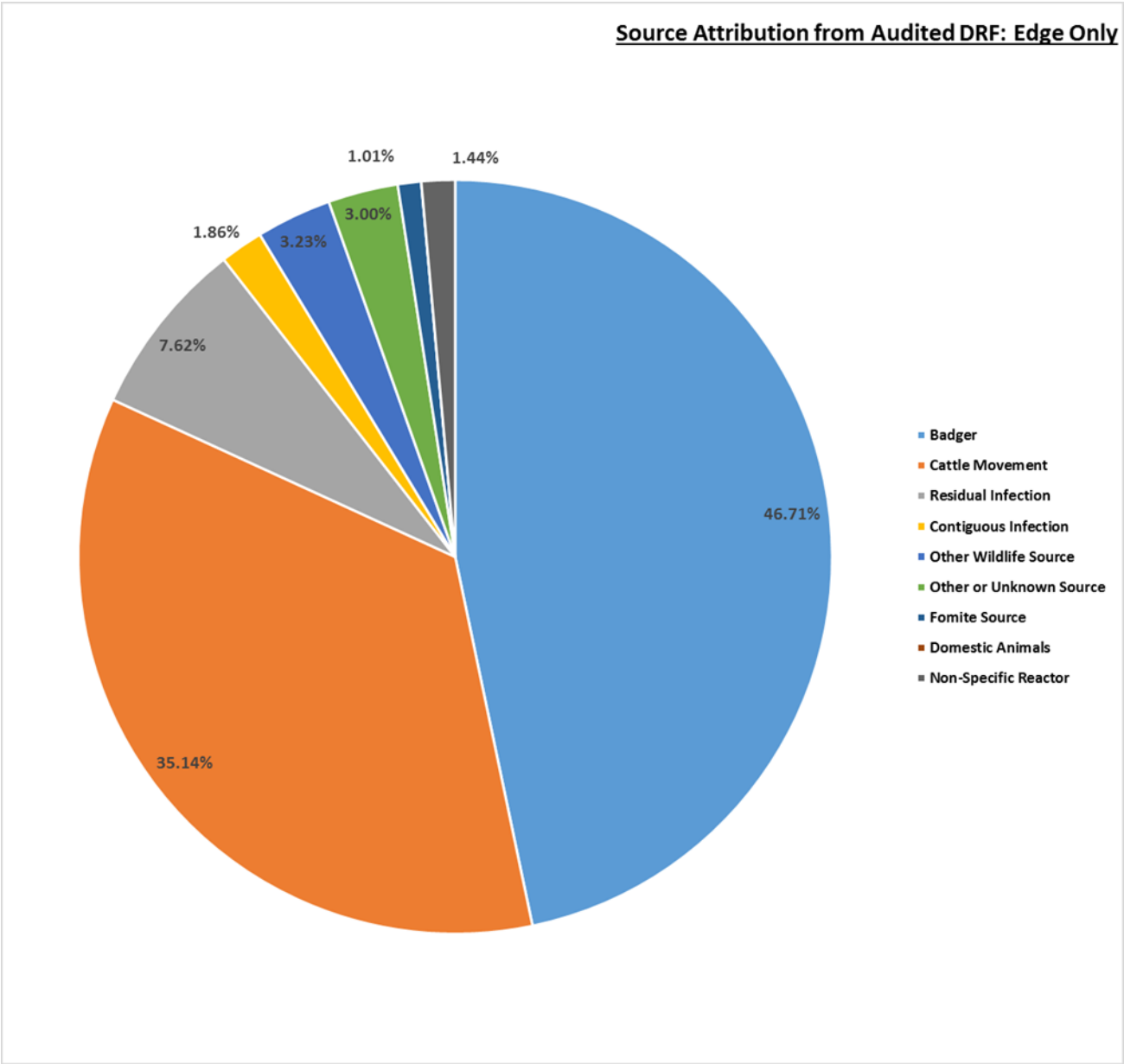


Figure 4.2.9 Summary of the weighted source of infection attributed for all incidents (both OTFW and OTFS) incidents that started in 2017, in the Edge Area (n=398)

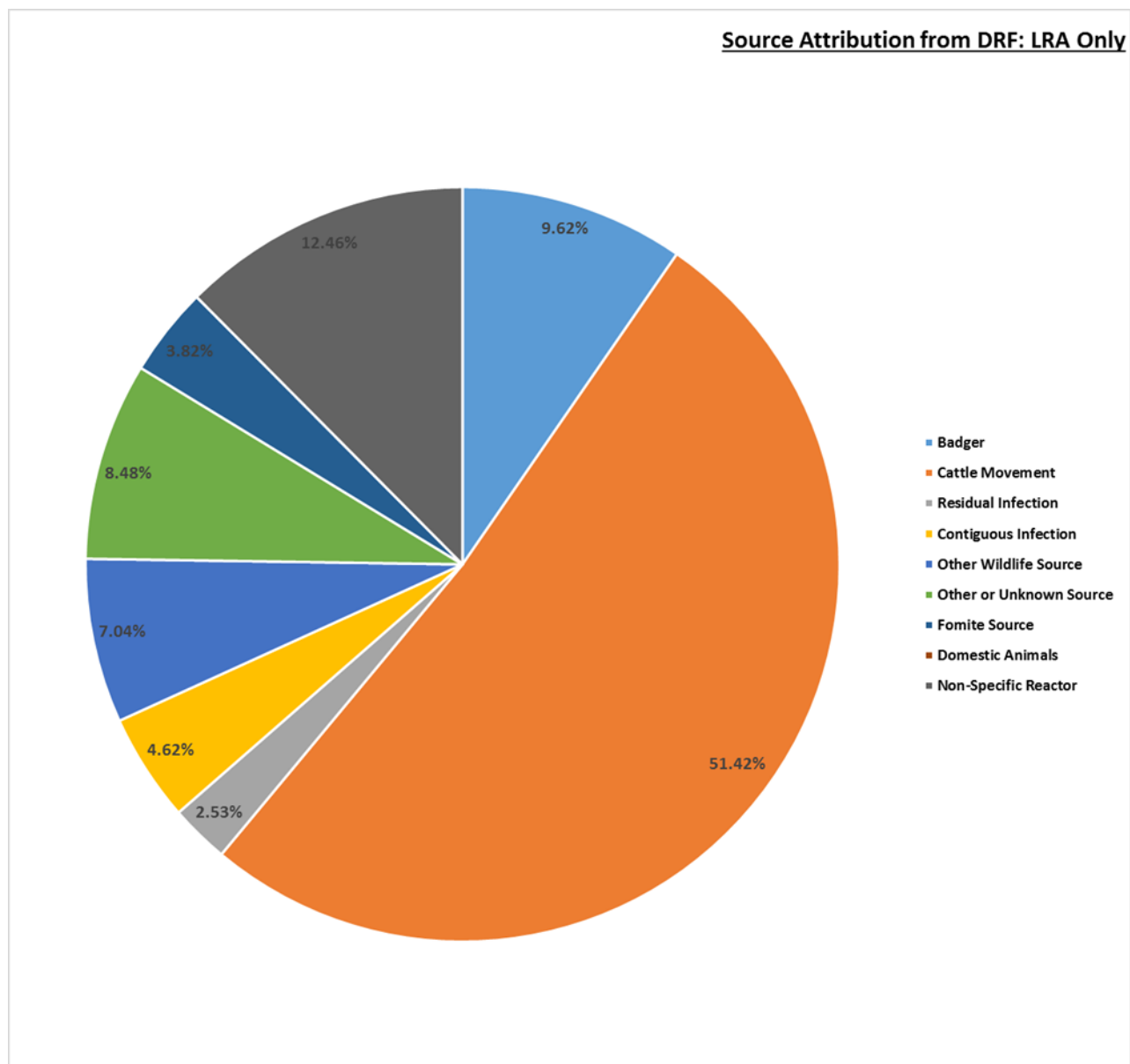


Figure 4.2.10 Summary of the weighted source of infection attributed for all incidents (both OTFW and OTFS) incidents that started in 2017, in the LRA (n=112)

The calculated contributions of each source of infection for the HRA, Edge Area and LRA TB incidents are depicted in Figures 4.2.8 to 4.2.10 respectively. Within the HRA badgers constituted 62% of the weighted opinion, while cattle movements accounted for 15% of the weighted opinion (Figure 4.2.8). In the Edge Area the source was still most strongly ascribed to badgers (48%), but cattle movements (33%) were also identified as posing a high risk of introduction (Figure 4.2.9). Conversely, in the LRA the contribution of badgers was much lower at only 10% (and limited to the bTB hotspot in the East of Cumbria where infection in badgers has been confirmed) and overall breakdowns were most strongly attributed to cattle movements (51%). However, in the LRA sources other than cattle movement or badgers also played a greater role in the possible introduction of *M. bovis*

infection (39% of attributed source) compared to the HRA (24%) and the Edge Area (19%) (Figure 4.2.10).

Geographical variation in the source of infection with the highest level of certainty is examined in Figure 4.2.11. Incidents within the HRA are most often attributed to badgers, while cattle movements are the most significant source of infection within the LRA. Within the Edge Area, incidents bordering the HRA are often ascribed to badgers, while those towards the LRA are more commonly linked to the movement of cattle. Further details on the relevant risk pathways for each county within the Edge Area can be found in the Edge Area individual county reports.

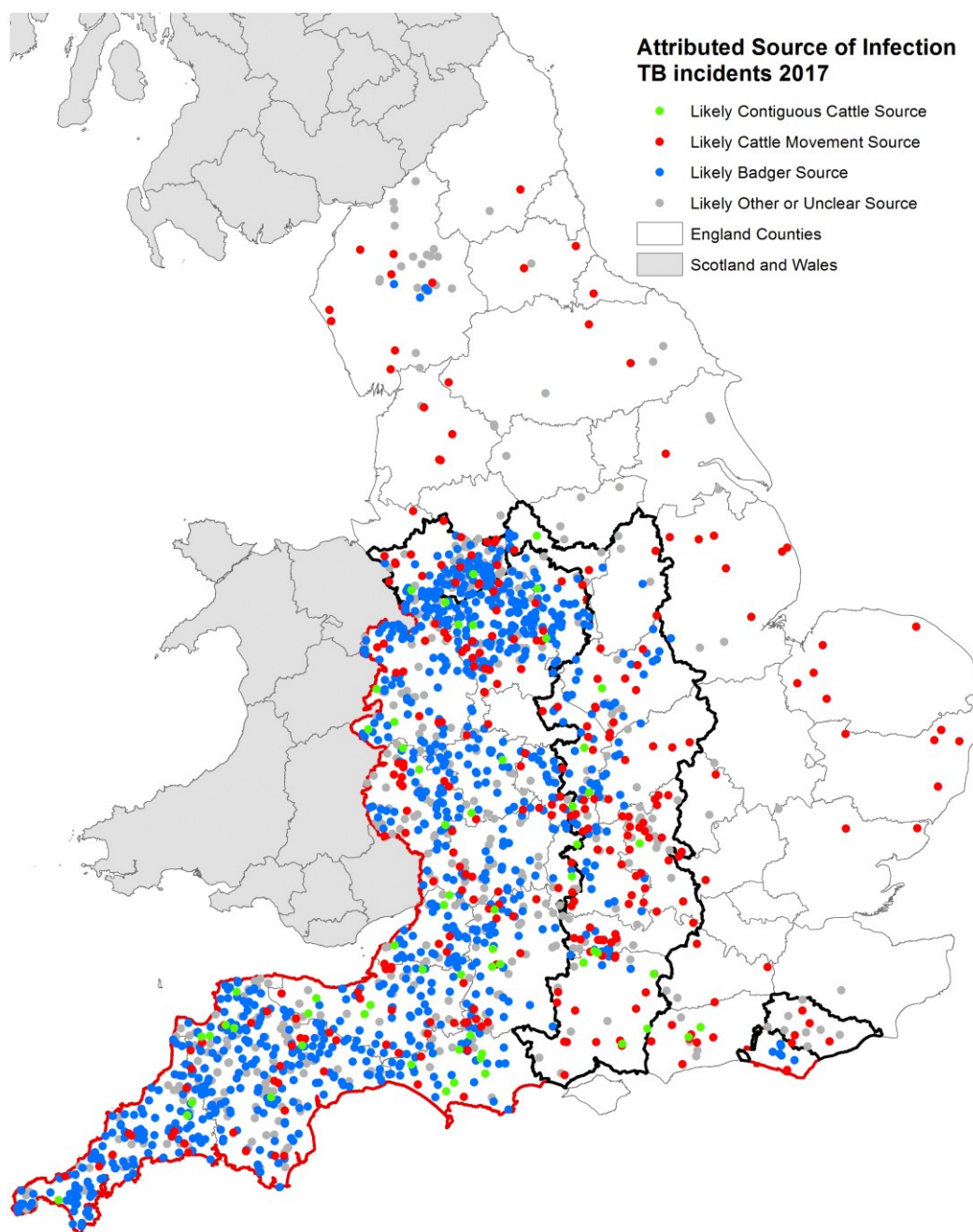


Figure 4.2.11 The source of infection recorded with the highest level of certainty, selected by informed veterinary opinion, for all incidents (both OTFW and OTFS) that started in 2017

Molecular typing

Attempts are made to recover *M. bovis* from all TB incidents and to subject at least one isolate per TB incident to genotyping, specifically Spoligotyping and Variable Number Tandem Repeat (VNTR) typing. This knowledge is used to describe areas where particular genotypes are common, so called 'home ranges' and then to compare isolates from new TB incidents with the previous known distribution, including the homerange, of the particular genotype identified. Most isolates are recovered from premises located within the home range of the genotype identified. Specifically, of the 2,992 isolates with location and a full genotype that has a calculated home range identified in 2017, 79% are in their home range (635 out-of-home range isolates). Further information about genotyping is given in the Explanatory Supplement¹⁸. The assessments described in the previous section on source of infection, and in the Edge Area and LRA epidemiology reports (see Sections 5.2 and 5.3) will have been informed by knowledge of the genotype where available. Further statistics on the outcomes of *M. bovis* genotyping carried out in 2017 is included in the GB Data Report¹⁹.

Research suggests that molecular typing through Whole Genome Sequencing (WGS) can provide greater discrimination between strains of *M. bovis* than genotyping. This could potentially allow explicit identification of transmission pathways between some farms, or confirm certain incidents have been caused by residual infection in the herd from a previous incident, rather than reintroduction. Isolates sent for genotyping have also been sequenced since mid-2017. Genotyping is likely to be replaced by whole genome sequencing (WGS) at some point in the future.

¹⁸ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

¹⁹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739906/GBDataReport.ods

4.3 Finding Infected herds: Effectiveness of different TB surveillance streams

Surveillance Overview

Bovine tuberculosis (TB) is a slowly progressing disease with infected individuals rarely displaying clinical symptoms, during which time they can potentially spread infection. Non-specific signs, such as light fever and weight loss, are mostly observed in the advanced stages of infection. Therefore surveillance for TB is based on detecting changes that occur before clinical signs including changes in the immunological response in live cattle and pathology characteristic of *M. bovis* infection. 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 an APHA vet.

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 Supplement²⁰). 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 of 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, tracing tests and check tests after a TB incident.
- **Slaughterhouse:** passive surveillance through *post-mortem* inspection of all slaughtered cattle.
- **Trade and other²¹:** active surveillance through field tests generally conducted for the purposes of trade such as private test requested by farmers, pre- and post-movement testing of individual cattle and tests at artificial insemination centres.

²⁰ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

²¹ Referred to as Proactive testing in earlier reports

Surveillance streams over-view

- In 2017, a total of 5.4 million TB tests were carried out; more than half of which were in the HRA (57%).
- In both the HRA and LRA, 49% of TB incidents in 2017 were detected through Area and Risk surveillance, compared to 19% in the Edge Area.
- Routine surveillance has resulted in the detection of 68% of new incidents in the Edge Area compared to 31% in the HRA and 24% in the LRA.
- The proportion of TB incidents disclosed through Slaughterhouse surveillance was lower in all risk areas in 2017 compared to 2016 (and 2015). Eleven per cent of all new TB incidents in 2017 were detected at slaughter in the HRA and LRA, and seven % in the Edge Area, suggesting that infected cattle are being detected earlier through live animal testing.
- The similar proportions of TB incidents disclosed by Slaughterhouse surveillance in the LRA and HRA probably reflects the fact that background force of infection is higher in the latter so that a similar proportion of TB incidents are disclosed by slaughterhouse surveillance despite the higher frequency of routine surveillance (annually compared to four yearly).
- The proportion of new incidents detected through the Trade & other surveillance stream in the LRA doubled between 2016 and 2017, accounting for 17% LRA incidents in 2017; and may be due to the introduction of post-movement testing in 2016.
- Within the Area and Herd Risk surveillance stream, 65% and 73% of TB incidents in the HRA and Edge Area were detected by post-incident tests compared to seven % in the LRA. This reflects the difficulty of clearing infection in the HRA and Edge Areas' and highlights the need for better understanding of the factors that lead to recrudescence and reinfection on farms.
- Radial tests detected proportionally more TB incidents in the LRA than any other Area and Herd Risk Tests; detecting 70% of incidents in the LRA in the Area and Risk surveillance stream. 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 substantial proportions similarly affected in the Edge and LRA. This indicates IRs are an important predictor of the presence of infection and supports the policy to restrict IRs to the herd in which they are disclosed for life.
- Trade & other surveillance disclosed less than 10% of the TB incidents in the HRA and Edge Area (mainly pre-movement tests) but a higher proportion of incidents in the LRA (17.1% although representing only 21 TB incidents). The majority of trade

tests in the LRA are post-movement tests (compulsory since April 2016 to mitigate the risk of disease incursion from cattle higher risk areas).

- Cattle in all risk areas are predominantly moved within that risk area than between risk areas. A total of 309 TB incidents were detected in 2017 by pre-movement tests (89% occurred in the HRA; 9% in the Edge Area and 1% in the LRA).

Over 5 million cattle were kept in nearly 50,000 active cattle holdings in England in 2017. A total of 5.4 million TB tests were carried out, more than half of which in the HRA (57%) and a total of 3,816 TB incidents were detected in England overall.

Figure 4.3.1 and Table 4.3.1 show the relative proportions of individual cattle tests, herd tests, reactors and incidents for the four surveillance streams. 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)).

Just over 82,000 tests were conducted in herds, resulting in the detection of 3,815 TB incidents (85% of them in the HRA, Table 4.3.1). There were 402 new TB incidents detected through Slaughterhouse surveillance (leading to 391 OTF-W incidents); 89% in the HRA, 7% in the Edge Area and 3% in the LRA.

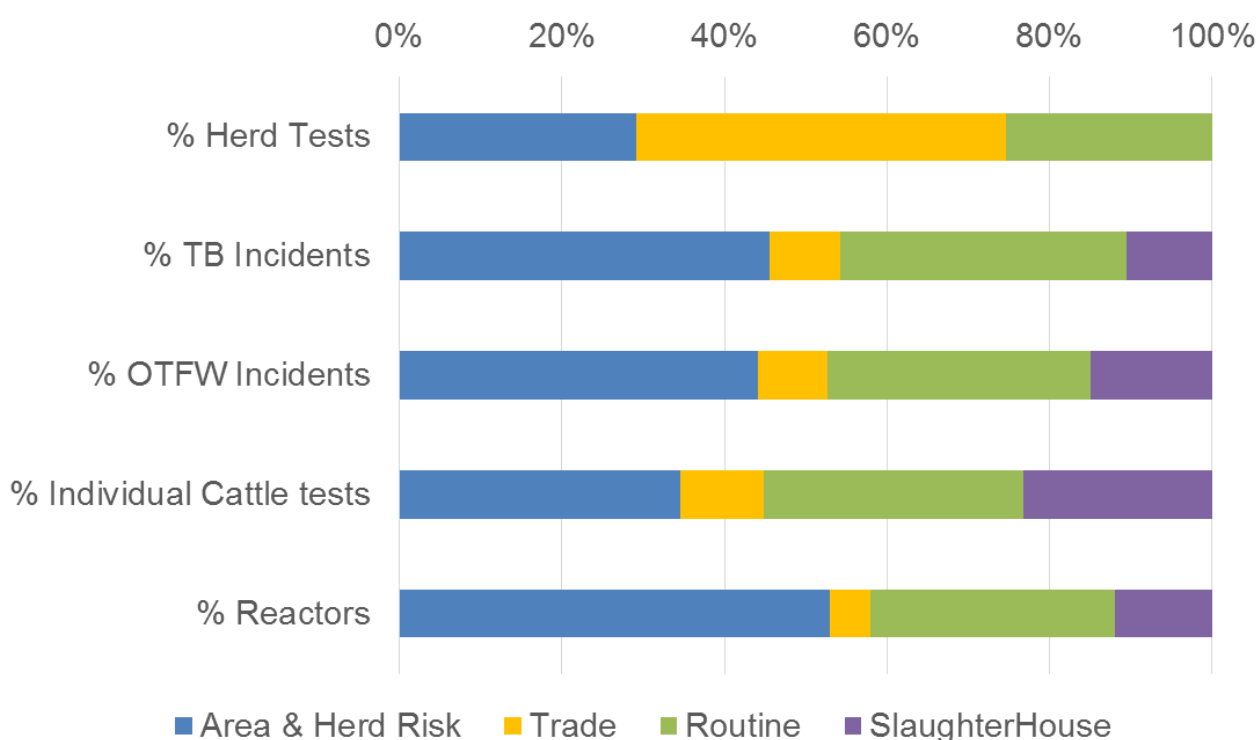


Figure 4.3.1. Proportion of tests, TB incidents in herds and cattle detected through different surveillance streams.

Table 4.3.1.Total number of tests, reactors, and TB incidents by risk area and surveillance stream in 2017.*

Area	Surveillance Stream	Herd Tests (%)	TB Incidents (%)	TB Incidents per 100 herd tests	OTF-W Incidents (%)	Reactors per 1,000 cattle tested
HRA	Routine	11,745 (22.2)	1,022 (31.4)	8.7	673 (29.2)	2.9
	Area & Herd Risk	17,230 (32.6)	1,596 (49.0)	9.3	1,091 (47.4)	4.2
	Slaughterhouse	NA	359 (11.0)	NA	349 (15.1)	0.78 **
	Trade & other	23,826 (45.1)	281 (8.6)	1.2	191 (8.3)	1.5
HRA Total*		52,801 (64.3)	3,258 (85.4)	(Average) 6.4	2,304 (88.6)	2.9
Edge	Routine	6,187 (40.4)	293 (67.5)	4.7	158 (63.2)	1.0
	Area & Herd Risk	2,425 (15.8)	82 (18.9)	3.4	45 (18.0)	1.9
	Slaughterhouse	NA	30 (6.9)	NA	30 (12.0)	0.14**
	Trade & other	6,701 (43.8)	29 (6.7)	0.4	17 (6.8)	0.4
Edge Total		15,313 (18.7)	434 (11.4)	(Average) 2.8	250 (9.6)	1.1
LRA	Routine	2,887 (20.7)	29 (23.6)	1.0	10 (21.3)	0.2
	Area & Herd Risk	4,284 (30.7)	60 (48.8)	1.4	12 (25.5)	0.1
	Slaughterhouse	NA	13 (10.6)	NA	12 (25.5)	0.02**
	Trade & other	6,794 (48.7)	21 (17.1)	0.3	13 (27.7)	0.2
LRA Total		13,965 (17)	123 (3.2)	(Average) 0.9	47 (1.8)	0.2
Routine Total		20,819 (25.4)	1,344 (35.2)	14.4	841 (32.3)	4.2
Area & Herd Risk Total		23,939 (29.2)	1,738 (45.6)	14	1,148 (44.1)	6.2
Slaughterhouse Total		NA	402 (10.5)	NA	391 (15.0)	0.94**
Trade & other Total		37,321 (45.5)	331 (8.7)	1.9	221 (8.5)	2.1
England Total		82,079	3,815	(Average) 12.1	2,601	1.8

The Table 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 or routine herd tests conducted as part of the 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 Trade & other surveillance. *Restrictions were not imposed as a result of a specific surveillance test on one OTF-W herd, and has not been included in this table. **Reactors per 1,000 cattle slaughtered

In the HRA, almost half of all incidents were detected by Area and Herd Risk surveillance and almost one third of incidents by routine surveillance (Table 4.3.1). Analysis by individual test types showed that most new TB incidents were detected by post-incident tests, which suggests that enhancing within-incident procedures to clear disease more effectively may be beneficial.

In the Edge area, two thirds of incidents were detected by Routine surveillance. Almost 20% of incidents were detected by Area and Herd Risk tests. Almost seven % of TB incidents were detected through Slaughterhouse and through Trade & other surveillance.

In the LRA, where disease is rare, almost half of TB incidents were detected by Area and Herd risk surveillance (radial tests in particular). Around a quarter of incidents were detected by 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 TB incidents disclosed by slaughterhouse surveillance was just over 10%, similar to in the HRA. The relative importance of slaughterhouse surveillance compared to field surveillance is however greater in the LRA than in the other risk areas, because of the lower frequency of Routine surveillance. The proportion of incidents detected through Trade & other surveillance was around double the proportion detected by this surveillance stream in the other TB risk areas (Table 4.3.1).

Overall, tests conducted as part of the Area and Herd Risk surveillance stream detected more reactors, TB incidents (and OTF-W incidents) in 2017 in all risk areas than Routine surveillance. This highlights the value of targeting higher risk herds through specific tests e.g. post-incident tests.

The proportion of TB incidents detected through Slaughterhouse surveillance was lower in all risk areas in 2017 compared to the previous four years (Figure 4.3.2).

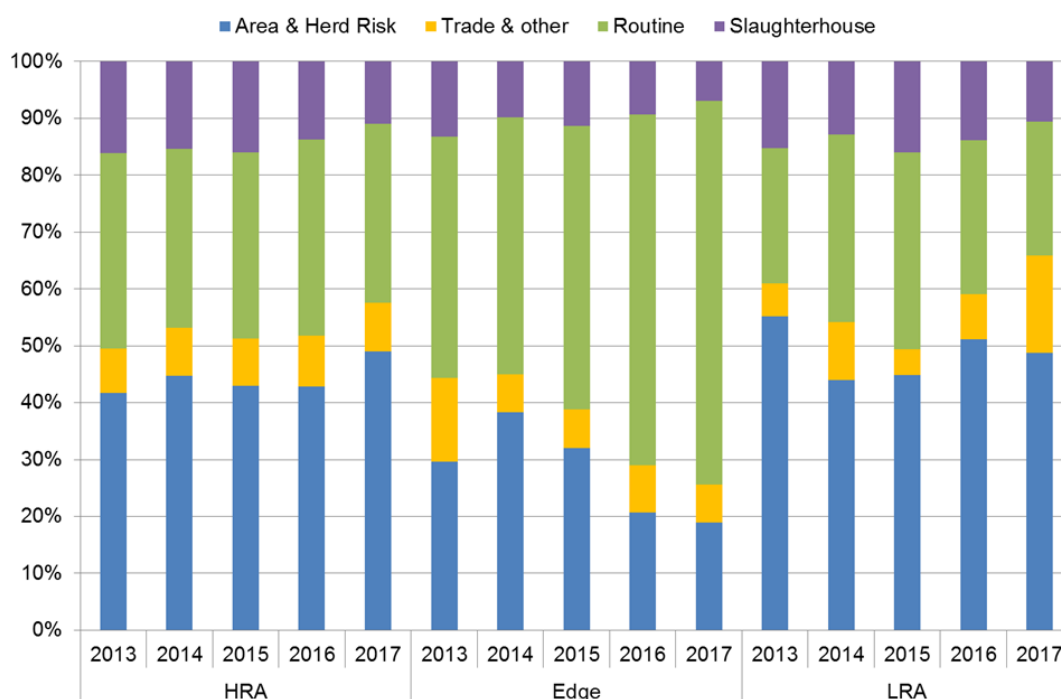


Figure 4.3.2. Annual proportions of new TB incidents detected by different surveillance streams within each risk area from 2013 to 2017 (data in GB Data Report²²)

Over the past five years, the HRA has remained fairly stable in terms of the relative proportion of TB incidents disclosed by different surveillance streams, which may be because TB control policies have changed the least in this risk area. There has been more variation in the relative proportion of new TB incidents detected by surveillance streams in the LRA and Edge Area. This is due in part to the low number of TB incidents but may also be due to the larger number of policy changes.

The proportion of TB incidents detected by Area and Herd Risk surveillance increased in the HRA compared to 2016, but did not show a similar increase in the Edge Area or LRA. The percentage of new incidents detected by Routine surveillance in the Edge has increased since 2013. Overall, since 2012, Trade & other surveillance has detected around 8-9% of incidents in the HRA and around 7% of incidents in the Edge Area since 2014. However the proportion of incidents detected through Trade surveillance in the LRA doubled between 2016 and 2017. This may be an effect of post movement testing for cattle from other risk areas, introduced in 2016.

In all risk areas, the proportion of new TB incidents detected through Slaughterhouse surveillance has decreased and in England overall has dropped by more than a third over the past five years (15.9% in 2013 vs 10.5% in 2017). This could be explained by infected cattle being detected by field tests at earlier stages of infection.

Routine Surveillance Stream

The Routine surveillance stream includes whole herd tests (WHT) and routine herd tests (RHT) conducted in OTF herds at scheduled intervals herds ranging from 6 months (WHTs), one year (WHTs) to four years (RHT), as well as new herd tests (NH). WHTs are conducted in all cattle over six weeks in the HRA and Edge Area; and to high risk herds in the LRA. The RHT in the LRA is conducted mainly in breeding stock.

Table 4.3.2. Routine Surveillance: Number of cattle and herd tests, reactors, and TB incidents (total and OTF-W) by risk area in 2017.

Area	Cattle tests (thousands)	Reactors	Reactors per 1,000 cattle tests	Herd Tests	TB incidents	TB incidents per 100 herd tests	OTF-W incidents
HRA	922.99 (53%)	2,721 (80%)	2.9	11,745 (22%)	1,022 (31%)	8.70	673 (29%)
Edge	618.55 (36%)	635 (19%)	1.02	6,187 (40%)	293 (68%)	4.74	158 (63%)

²² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739906/GBDataReport.ods

LRA	185.55 (11%)	36 (1%)	0.19	2,887 (21%)	29 (24%)	1.00	10 (21%)
England total	1,727.09	3,392	1.9	20,819 (25%)	1,344 (38%)	6.46	841 (32%)

Proportionally more reactors were disclosed per test in the HRA compared to the Edge Area (Table 4.3.2), 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 4.3.1). WHTs disclosed almost all of the TB incidents within the Routine surveillance stream in the HRA and Edge Area and one sixth of incidents in the LRA (Table 4.3.4).

Table 4.3.3. Performance of main test types within the Routine surveillance stream by surveillance risk area in 2017

Area	Test Type	% TB Incidents	% OTF-W Incidents	% Reactors
HRA	New Herd tests	2%	1%	1%
	Whole Herd Tests	98%	99%	99%
Edge	New Herd tests	1%	1%	1%
	Whole Herd Tests	99%	99%	99%
LRA	New Herd tests	3%	0%	0%
	Whole Herd Tests	14%	0%	8%
	Routine Herd Tests	83%	100%	92%

Area and Herd Risk Surveillance Stream

The Area and Herd Risk surveillance stream comprises tests carried out in higher risk situations. The surveillance stream includes hotspot and inconclusive reactor tests in unrestricted herds as well as tests for controlling disease once detected e.g. tracing, contiguous herds, radial and post-incident tests. A higher proportion of incidents are disclosed by the Area and Herd Risk stream in the HRA and LRA, compared to the proportion detected by the routine surveillance stream (Table 4.3.1).

In the HRA, the highest performing tests in terms of TB incident detection in the Area and Risk surveillance stream are post-incident tests; where they represent 27% of herd tests in this stream in the HRA (4,641), disclosing around two thirds of reactors and TB incidents (3,791 and 1,041 respectively) (Figure 4.3.3 and Table 4.3.2). They are followed by contiguous tests and tracing tests; though there are fewer contiguous herd tests conducted in the HRA (2,989), the test is detects a similar number of reactors per 1,000 cattle tests as post-incident tests (3.83 and 4.34 respectively) (Table 4.3.2b).

In the Edge area, post-incident tests are also the highest performing (in terms of TB incident detection) within this surveillance stream (Figure 4.3.3 and Table 4.3.2). Representing 22%

of Area and Herd Risk herd tests in the Edge, they disclosed 73% of incidents and 70% of reactors (60 TB incidents and 177 reactors). The next in performance in terms of reactors found are tracing tests, though these tests produced over three times reactors per 1,000 cattle tests as post-incident tests (6.2 and 1.66 respectively).

In the LRA, the best Area and Herd Risk performing tests are radial tests (RAD, RAD6 and RAD12), which accounted for 53% herd tests within this area and surveillance stream (2,287 herd tests) and disclosed 70% of incidents (42) and 55% of reactors (30). Only 12% of the incidents disclosed were OTF-W (although not necessarily confirmed as the same *M. bovis* genotype as the index case). 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. Due to the low incidence, post-incident tests only represented 136 tests in herds, with 4 incidents and 2 reactors disclosed in 2017.

Post-breakdown tests, radial tests, contiguous tests and tracing tests will not be recorded if conducted at the same time as another herd test (e.g. a Whole Herd Test), as only one test type is recorded in the system and routine surveillance stream tests take precedence..

Further information on this surveillance stream can be found in section 4.5.

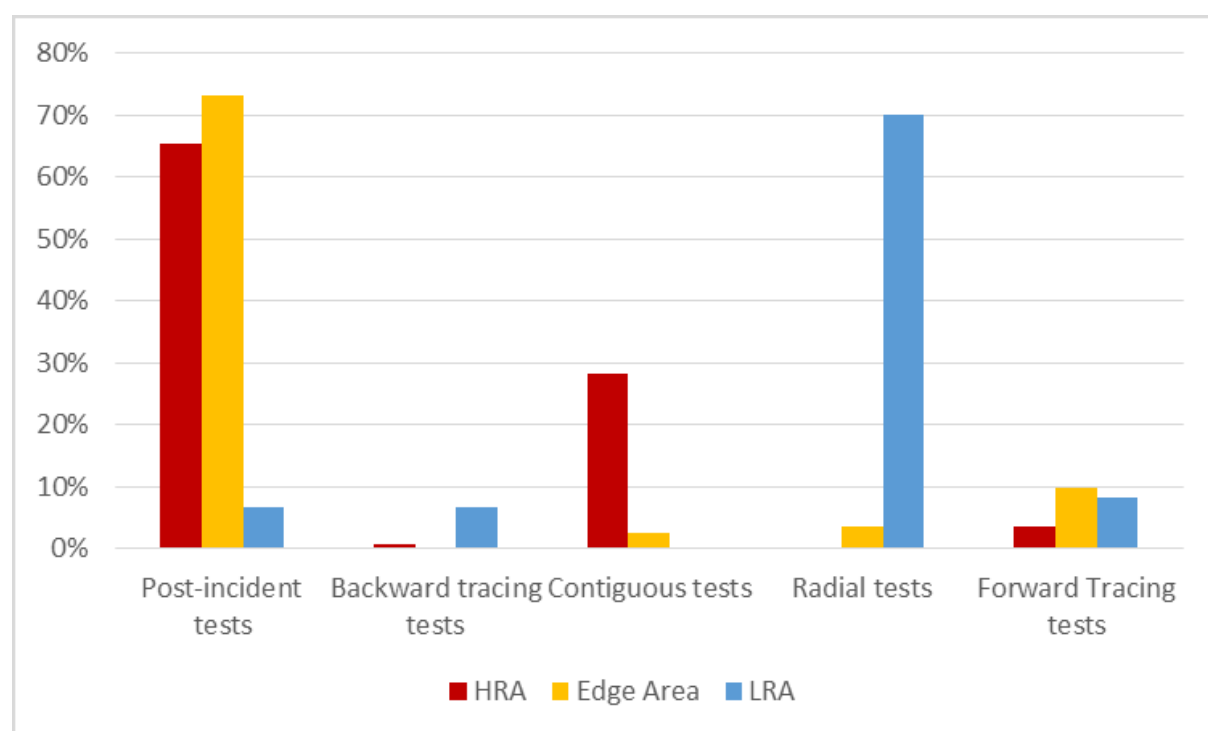


Figure 4.3.3. Percentage of main test types resulting in a TB incident within the Area and Herd Risk surveillance stream by surveillance risk area in 2017

Table 4.3.4. Percentage of main test types within the Area and Herd Risk surveillance stream by surveillance risk area in 2017

Area	Test Type	Herd Tests (%)	Reactor s (%)	Reactor s per 1,000 cattle tests	TB Incidents (%)	TB incident s per 100 herd tests	OTF-W Incidents (%)
HRA	Post-incident tests	4,641 (27%)	3791 (67%)	4.34	1041 (65%)	22.43	701 (64%)
	Backward tracing tests	82 (0.5%)	395 (7%)	0	11 (1%)	13.41	9 (1%)
	Contiguous tests	2989 (17%)	1326 (23%)	3.83	450 (28%)	15.06	323 (30%)
	Radial tests	17 (0.1%)	0	0	0	0	0
	Forward Tracing tests	7,184 (42%)	74 (1%)	2.4	58 (4%)	0.81	42 (4%)
Edge Area	Post-incident tests	527 (22%)	177 (70%)	1.66	60 (73%)	11.39	35 (78%)
	Back-tracing tests	70 (3%)	0	0.95	0	0	0
	Contiguous tests	34 (1.4%)	36 (1%)	0.46	39 (2%)	114.71	37 (2%)
	Radial tests	61 (2.5%)	8 (3%)	1.50	3 (4%)	4.92	1 (2%)
	Forward-tracing tests	1333 (55%)	33 (13%)	6.2	8 (10%)	0.60	6 (13%)
LRA	Post-incident tests	136 (3.2%)	2 (4%)	0.08	4 (7%)	2.94	1 (8%)
	Back-tracing tests	70 (1.6%)	8 (31%)	0.95	4 (7%)	5.71	1 (33%)
	Contiguous tests	5 (0.1%)	0	0	0	0	0
	Radial tests	2287 (53%)	30 (55%)	0.09	42 (70%)	1.84	5 (42%)
	Forward-tracing tests	1380 (32%)	9 (16%)	1.65	5 (8%)	0.36	3 (25%)

Inconclusive Reactors (IRs)

Inconclusive reactors (IRs) are cattle that have a reaction to the TB skin test²³ which is not large enough to classify them as reactor/s. These animals remain isolated in the herd awaiting the results of a retest in 60 days' time with movement restrictions applied to the whole herd (i.e. whole herd restrictions²⁴). These herd restrictions are replaced by individual restrictions only on the IR/s if the herd has not had an OTF-W incident in the previous three years (three-year rule). If the IRs are reactors or IRs at the first retest (i.e. two-time IRs), the IRs are deemed to be reactors thereby disclosing a TB incident in the herd (resulting in whole herd restrictions, reactor removal and additional incident testing imposed).

As expected, the highest percentages (76% and 79%), of IR-only tests are conducted and IRs identified by these tests in the HRA and the least in the LRA. Between 2016 and 2017, there was an increase in the number of IR-only herds and IRs disclosed in the HRA, but reductions in both the Edge area and LRA (Table 4.3.5).

Table 4.3.5. Summary of number of IR-only tests and IRs disclosed, their percentages and percentage change between 2016 and 2017 by surveillance risk area.

Region	IR-only tests (% of all IR-only tests) (% change 2016-17)	IRs disclosed (% of all IRs disclosed) (% change 2016-17)
HRA	2083 (76%) (+2%)	4319 (79%) (+3%)
Edge Area	424 (16%) (0)	771 (14%) (-1%)
LRA	224 (8%) (-2%)	399 (7%) (-2%)

In the Edge and LRA, nearly all IR-only tests in 2017 took place in herds with no recent OTF-W incidents (92% and 97% respectively). In the HRA, 69% of IR-only tests took place in herds which had had an OTF-W incident in the previous three years. This follows from the higher incidence observed within this region.

²³ Single Intradermal Comparative Cervical Tuberculin test or SICCT test.

²⁴ 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.

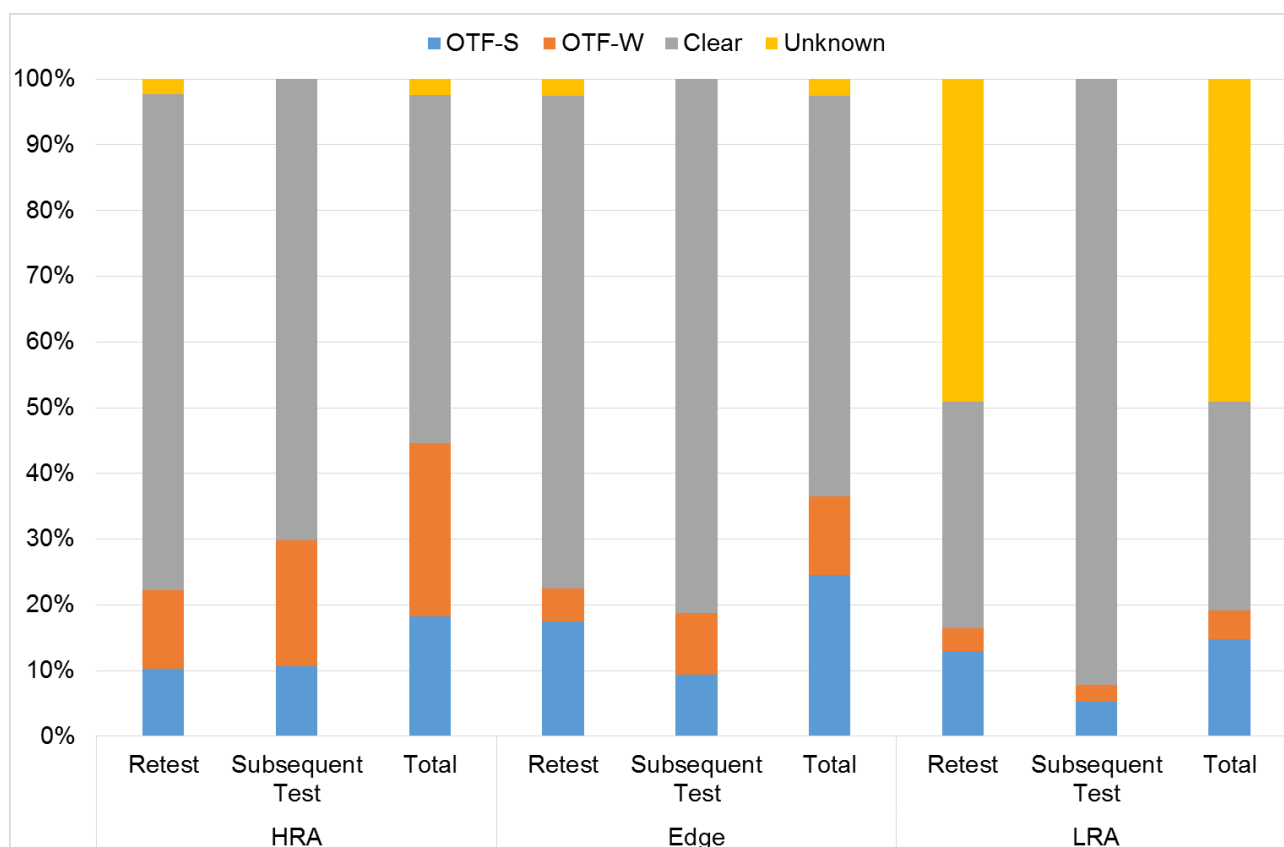


Figure 4.3.4. Fate of IR-only tests, following disclosure in 2017 by surveillance risk area. The fate of some herds is recorded as unknown due to reasons such as ceasing trading and not having a retest.

Over 40% of herds that had an IR disclosed and no reactors (IR-only herds) went on to have an incident within the following 15 months in the HRA (37% in the Edge and almost 20% in the LRA). About half of those incidents were detected at the IR only herd retests. HRA incidents were detected at retest. A higher proportion of incidents were OTF-W vs OTF-S in the HRA. Figure 4.3.5 suggests that IR only herds in the HRA 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 al (in press) 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.

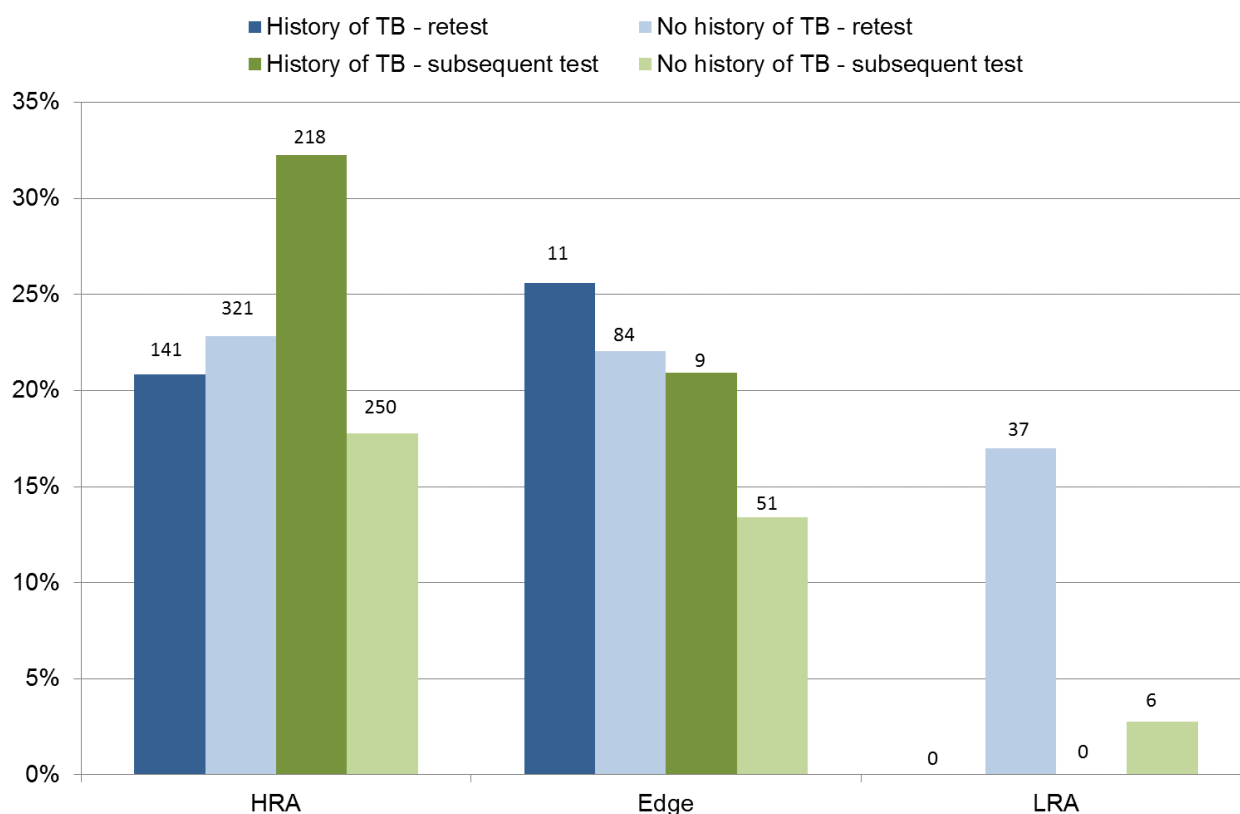


Figure 4.3.5 Proportion of IR-only herds going on to have a TB incident in 2017 at either the IR retest or a subsequent test (within 15 months after IR test), by surveillance risk area and TB history. Totals above each column represent the number of herds with a TB incident

Slaughterhouse Surveillance Stream

Slaughterhouse surveillance utilises compulsory post-mortem inspection (meat inspection with palpation and incision of lymph nodes) of all cattle slaughtered for human consumption, followed by confirmation by culture and isolation of the *M. bovis* bacteria or confirmation through histopathology. It is ongoing surveillance that may detect infected cattle missed by active live animal surveillance.

The proportion of new TB incidents disclosed by Slaughterhouse surveillance depends on background force of infection and also on the frequency and efficacy of live animal surveillance tests that take place in cattle herds²⁵. Herds are tested 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 2017. As in previous years, the proportion of all TB incidents disclosed by Slaughterhouse surveillance is virtually the same in the LRA and HRA (11% vs nearly 14% in 2016); likely reflecting that the background force of infection is higher in the latter. Seven % of TB incidents were detected

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

in the Edge Area, which has annual routine surveillance as in the HRA (except in Cheshire where routine surveillance is six-monthly). This lower disclosure rate through this surveillance in the Edge Area probably reflects a lower background force of infection coupled with relatively frequent testing through routine surveillance.

Table 4.3.6. TB incidents disclosed by the Slaughterhouse Surveillance Stream by risk area, 2017

Area	Cattle Slaughtered (from unrestricted holdings*)	TB incidents disclosed	OTF-W incidents disclosed	% of all OTF-W Incidents
HRA	465,161	359	349	15.15
Edge	208,398	30	30	12.00
LRA	581,965	13	12	25.53
England total	1,255,524	402	391	15.46

*holdings with no TB incident

As observed in previous years, the proportion of OTF-W incidents detected by the SLH surveillance stream is similar in HRA and Edge areas (15% and 12%) but higher in the LRA (26%), though with a much lower number of cases. The total number of OTF-W incidents in the LRA was similar in 2016 (43) and 2017 (47).

Since 2008, the proportion of OTF-W TB incidents disclosed through Slaughterhouse surveillance in the HRA has remained fairly consistent but there has been greater fluctuation in the Edge and LRA. (Figure 4.3.6). The pronounced fall in Edge cases detected at slaughter in recent years may reflect success of Edge Area control policies in achieving earlier detection through increased live animal testing.

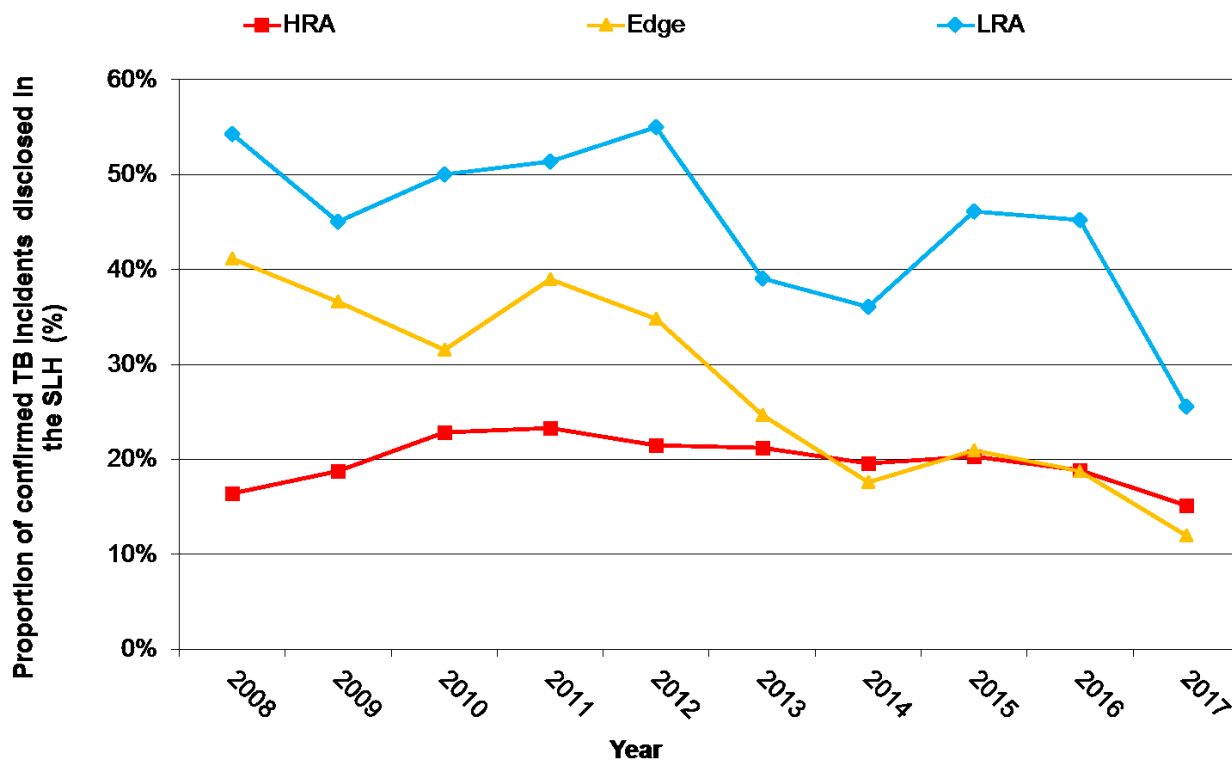


Figure 4.3.6. The proportion of new OTF-W TB incidents that were disclosed by slaughterhouse surveillance from 2008 to 2017, by risk area

Trade & other surveillance Stream

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

Though there are large numbers of cattle movements across the country, cattle do not need to undergo pre-movement testing if the animal has been subject to a herd test within the required timeframe for the animal test. This means, animal tests, such as pre-movement tests will be underreported within surveillance data. Trade & other tests detect the smallest proportion of TB incidents of all the surveillance streams (9%); however, this amounts to a relatively high rate of reactors detected per 1,000 tests (1.47 in the HRA, where most tests in this stream are conducted), and they play an important role in preventing high impact disease spread (e.g. into the LRA).

Table 4.3.7. Trade & other surveillance stream: Number and percentage of tests, reactors and TB incidents (total and OTF-W) by risk area in England in 2017.

Area	Cattle tests (thousands)	Herd Tests (%)	Reactors	Reactors per 1,000 Cattle Tests	TB incidents (%)	OTF-W incidents (%)
HRA	334.9 (19%)	23,826 (45%)	493 (6%)	1.47	281 (9%)	191 (8 %)
Edge	95.9 (9%)	6,701 (44%)	41 (4%)	0.43	29 (7%)	17 (7%)
LRA	122.3 (10%)	6,794 (49%)	19 (17%)	0.16	21 (17%)	13 (28%)
England total	553.1 (10%)	37,321 (45%)	553 (6%)	1.00	331 (9%)	221 (8%)

*Trade & other surveillance tests are mainly individual animal tests but form a high proportion of tests in herds because they are conducted more frequently than tests conducted on the whole herd (e.g. pre-movement tests are more common than whole herd tests).

The majority of Trade & other surveillance cattle tests were conducted in the HRA (60%) compared to 17% in the Edge and 22% in the LRA (an increase from 16% in 2016). In the HRA and Edge areas virtually all Trade & other surveillance stream tests in 2017 were pre-movement tests (PRMTs) (Table 4.3.7), 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 5% of cattle tests in 2017 (down from 15% in 2016) and disclosed just one TB incident (OTF-S). International trade tests (pre-export and Irish post-import tests) and the voluntary pre-sale check test resulted in the disclosure of just one OTF-W incident each (Table 4.3.8).

Table 4.3.8. Performance of main test types within the Trade & other surveillance stream by surveillance risk area in 2017

Surveillance Area	Test Type	% TB Incidents	% OTF-W Incidents	% Reactors
HRA	Pre-movement	99%	98%	99%
	Pre-export	0.00%	0.00%	0.00%
	Post-import (Ireland)	0.71%	0.52%	0.20%
	Private	0.71%	1.05%	0.41%
Edge	Pre-movement	97%	94%	98%
	Pre-export	0%	0%	0%
	Post-import (Ireland)	0%	0%	0%
	Private	3%	6%	2%
LRA	Pre-movement	19%	8%	16%
	Post-movement	62%	77%	79%

	Pre-export	5%	0%	0%
	Post-import (Ireland)	5%	8%	5%
	Private	5%	0%	0%
	Pre-sale Check LRA	5%	8%	0%

Pre-Movement Testing (PRMT)

There were just over 2.8 million cattle movements within GB in 2017 (300,000 more than in 2016), excluding movements to a slaughterhouse directly and indirectly (e.g. via slaughter markets and authorised finishing units). Farms in all risk areas move more cattle within their area than other areas and there is more cattle movement between areas closest in terms of TB risk (Table 4.3.9). In the HRA and LRAs around 80% of cattle move within their area compared to 50% of Edge area cattle.

Table 4.3.9. Summary of number of cattle movements between risk areas and countries, 2017

Cattle movements in 2017	To HRA	To Edge Area	To LRA	To Scotland	To Wales	Total
From HRA	701,672	98,004	53,161	634	32,601	886,072
From Edge Area	61,856	156,462	39,015	474	18,187	275,994
From LRA	22,587	42,622	663,578	26,190	5,992	760,969
From Scotland	2,071	4,943	56,079	433,736	869	497,698
From Wales	93,327	32,932	25,747	489	273,608	426,103
Total	881,513	334,963	837,580	461,523	331,257	2,846,836

The largest number of cattle movements occur within risk areas and countries. More cattle are moved from HRA farms to Edge area farms than to LRA farms. Farms in the Edge Area move more cattle to the HRA than to the LRA. LRA farms move more cattle to the Edge area than to the HRA. Scotland receives more cattle from the LRA farms than farms in any other risk area of England. Wales receives more cattle from HRA farms than farms in any other risk area.

A total of 1.16 million of cattle in 2017 were moved out of the yearly-tested HRA and Edge areas (up 60,000 from 2016, which had also increased by 24,000 cattle in 2015). However, only 425,717 cattle tests were recorded as PRMT (around 37%), probably because herd tests were used to provide the same evidence of infection status prior to movement.

The proportion of TB incidents disclosed by pre-movement tests in the HRA has remained fairly stable since 2008; there has been more variability in the Edge Area and LRA (Figure 4.3.7). An increased proportion of TB incidents were detected by pre-movement tests 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 pre-movement tests.

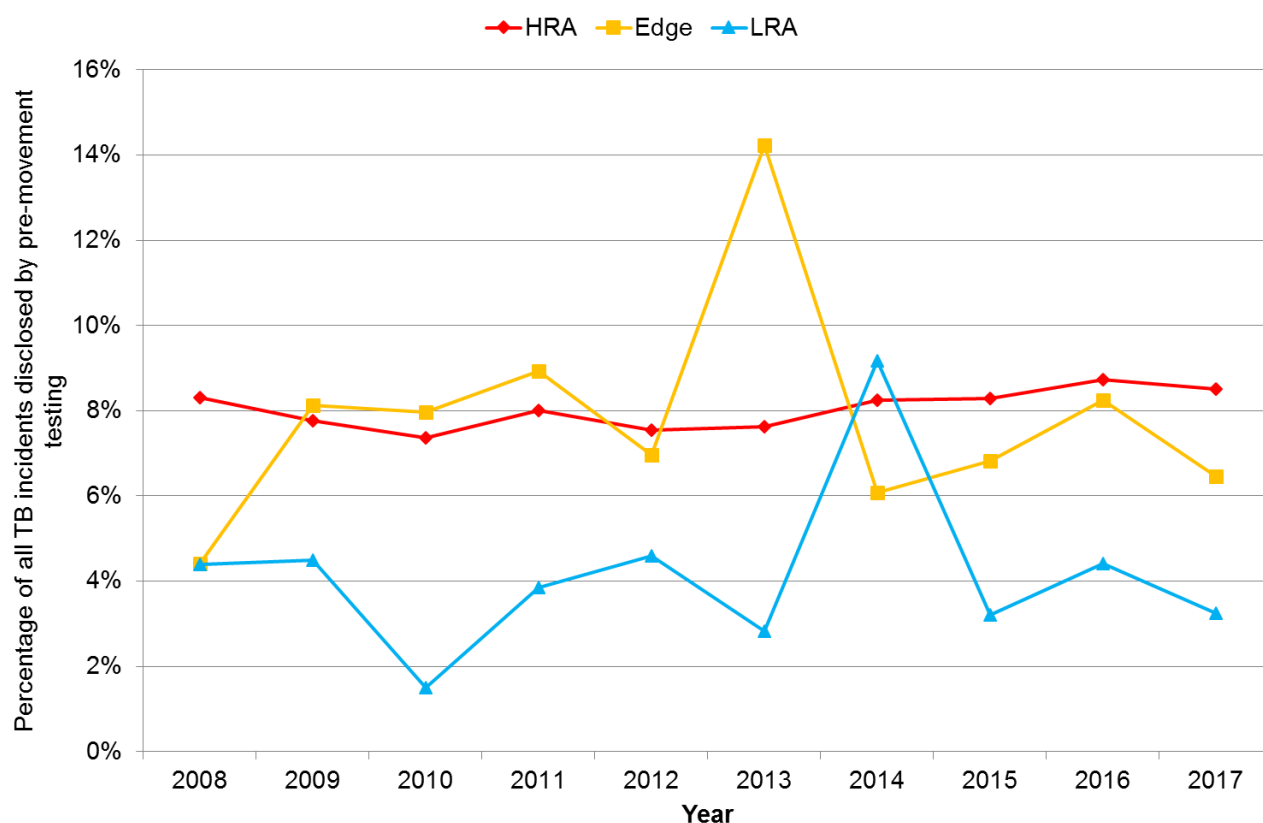


Figure 4.3.7. The proportion of total TB incidents disclosed by pre-movement testing* between 2008 and 2017, by risk area. *These data refer to tests *categorised* as PRMT, but does not include other tests that can be used as a pre-movement test.

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

- During 2017, 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 are in the HRA, where in 2017 on average around 2,000 herds were under restriction at any one time (11.4% average in 2017); this level has been relatively stable since 2011. Prevalence in the HRA was highest in the counties of Gloucestershire (16.3%), Wiltshire (15.0%) and Avon (15.5%).
- 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 Edge Area policy. Prevalence averaged nearly 4% (~180 herds) during 2017 and was highest in the counties of Berkshire (9.4%) and Buckinghamshire (3.3%).
- TB infected herds remained under restriction for a median of around six months in the HRA and Edge Area, and four months in the LRA, however the range was wide. Herds were under movement restrictions for longer periods in larger herds (>200 animals) and in TB incidents with more than one reactor.
- The proportion of TB incidents classed as 'persistent' (movement restrictions lasting for 18 months or longer) in the HRA has been stable at around 6.5% to 6.7% since 2015, remaining lower than observed in 2013 (9.3%). This equated to 209 persistent TB incidents that closed in 2017. The proportion of persistent TB incidents halved in the Edge Area (2.1%, down from 4.3% in 2016) and there were none in the LRA in 2017 (1 in 2015 and 2016).
- At the end of December 2017, 386 herds had a persistent TB incident that was ongoing ('open'), the majority of which were located in the HRA (n=360).
- In 2017, 33,438 cattle were slaughtered for TB control reasons, with a median of two reactors removed per incident. The mean number of reactors removed fluctuated between risk areas, with an average of seven in the HRA, eight in the Edge area and six in the LRA in 2017. The fluctuation and 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 control strategy. The latter is determined by the risk of leaving infection present if controls are removed too soon, and specifies the extent of testing needed to provide sufficient evidence to declare a herd officially free of TB, which 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 2017, 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 4.4.1. Figure 4.4.1 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 increased slightly compared to 2016. In the Edge Area, herd prevalence has increased steadily since 2007 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 LRA, prevalence has remained consistently low for the past ten years.

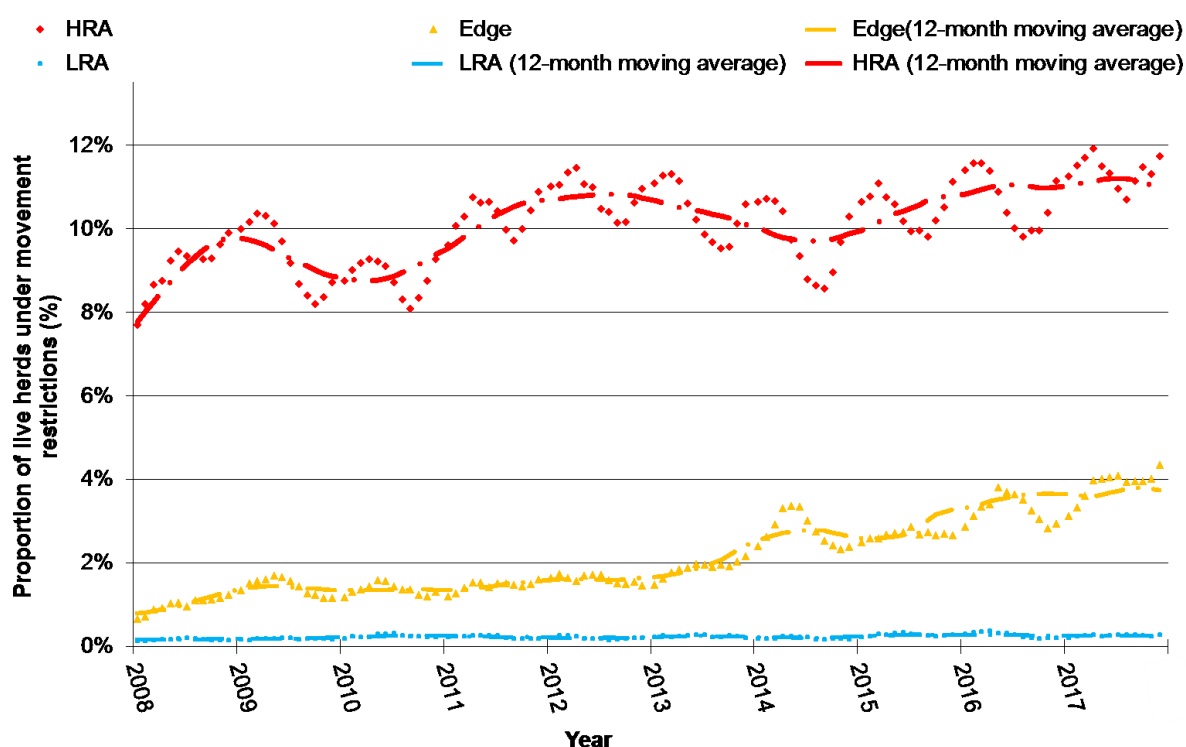


Figure 4.4.1 Proportion of live English herds under TB movement restrictions (prevalence) as a result of any TB incident, by month, between January 2008 and December 2017

- 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 2017, as in previous years, there was a wide variation in county-level prevalence of TB incidents (Figure 4.4.2), with the highest prevalence seen in Oxfordshire (22.9%), and the lowest in counties in the LRA. Further details about prevalence at county level within each risk area are presented later in the report (Sections 5.1 to 5.3).

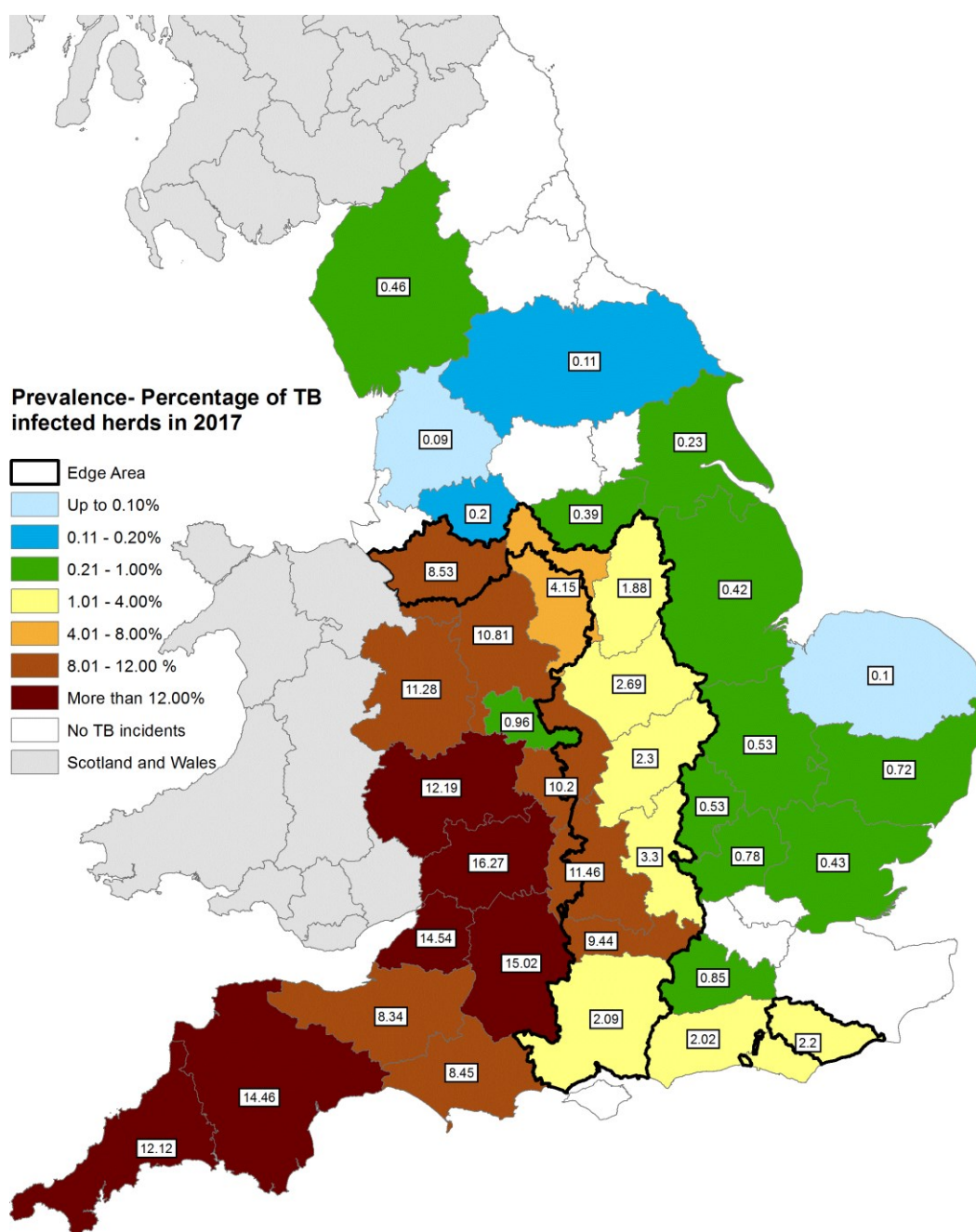


Figure 4.4.2 County prevalence: percentage of herds in each county that were under restrictions due to a TB incident at the end of 2017 (15th December)

- Prevalence is generally greatest in the HRA but some Edge Area counties also have high levels of prevalence (mainly counties straddling the HRA and Edge Areas) including Cheshire, Oxfordshire and Warwickshire. Berkshire also had a higher prevalence than some HRA counties in 2017.

Duration of TB incidents (period of movement restrictions)

Herds infected with TB are prevented from moving cattle (except under licence directly to slaughter, to slaughter markets or finishing units approved by APHA) while infection is being removed, to limit the risk of spreading TB. The duration of such movement restriction affects both farmers and tax payers because restrictions constrain the management of the herd. Longer durations are generally associated with more tests and thus greater costs. 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.

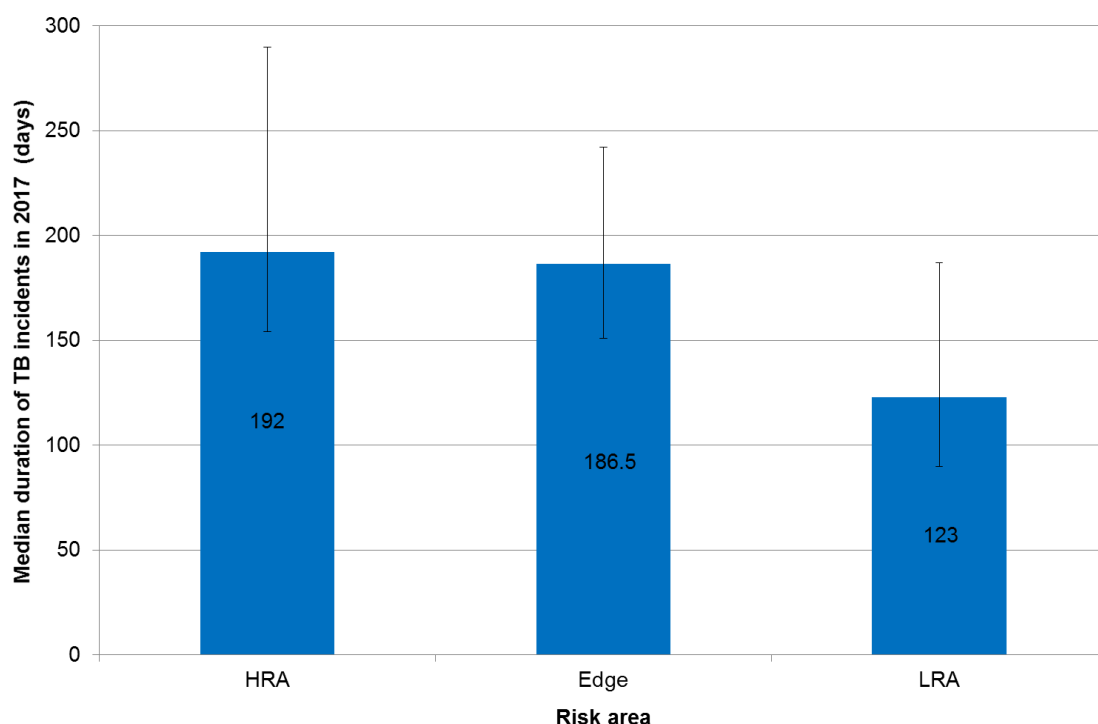


Figure 4.4.3a Median duration (and ‘interquartile range’, IQR) of all TB incidents that closed in 2017 by risk area

- 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 just over six months. Additionally, the interquartile range (IQR) indicates that half of herds in the HRA were under restriction for between five and nine-and-a-half months. However, in the LRA, the median duration of TB

incidents was notably shorter at four months (IQR ~ 3 - 6 months), reflecting the high number of suspect cases (OTF-S), which require only a single short interval test (SIT) to demonstrate infection is not present.

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

The duration that a herd was under movement restrictions was associated with herd size in all risk areas (Figure 4.4.3b). 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.

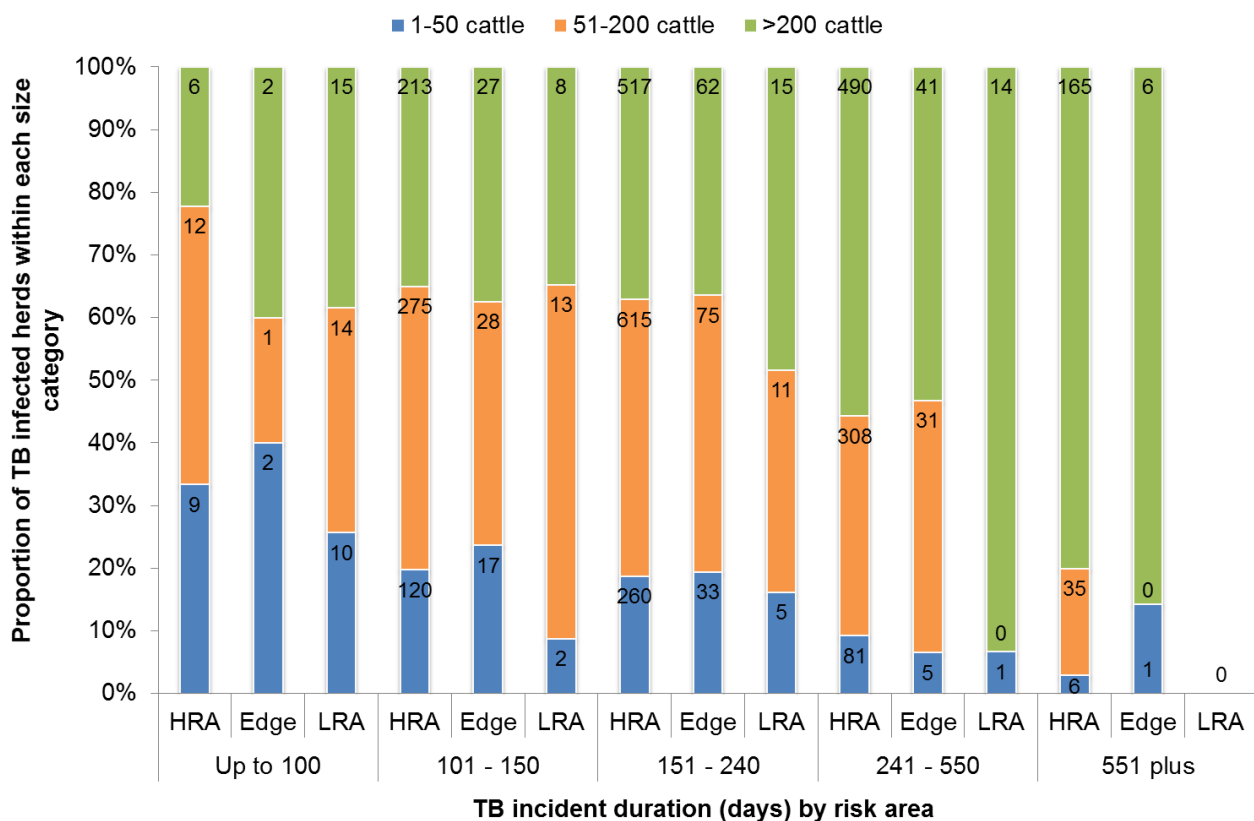


Figure 4.4.3b Comparative duration of TB incidents that closed in 2017, by risk area and herd size (values show number of herds in each size category)

- 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 restriction periods are the result of challenges in removing infection, or in demonstrating that this is the case. 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 animal 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.

There were a total of 3,568 herds in England where movement restrictions were lifted in 2017 (TB incidents closing at the end of 2017). Figure 4.4.3c shows the number of Short Interval Tests (SITs) it took to clear a TB incident, comparing risk area and herd size. Overall in England, fifty per cent of herds (with TB incidents that closed in 2017) took two SITs to clear, and 90% of all herds had five or fewer SITs to clear a TB incident. Only 2% of herds had more than ten SITs.

In the HRA and Edge Area, most TB incidents took two or three SITs to clear; for the LRA this was one or two. The HRA had TB infected herds under restrictions for longer, with 340 herds receiving more than five SITs in 2017; in the Edge Area only 14 herds received more than five SITs and in the LRA, none.

In the HRA, smaller herds of 1-50 cattle mostly required 2 SITs to clear a TB incident (64%); 80% of medium size herds (51-200 cattle) required two or three SITs to clear an incident and 62% of larger herds (>200 cattle). Interestingly, the number of larger herds (>200 cattle) in the HRA requiring three SITs to clear a TB incident was lower than the number requiring five or more (294 vs 350).

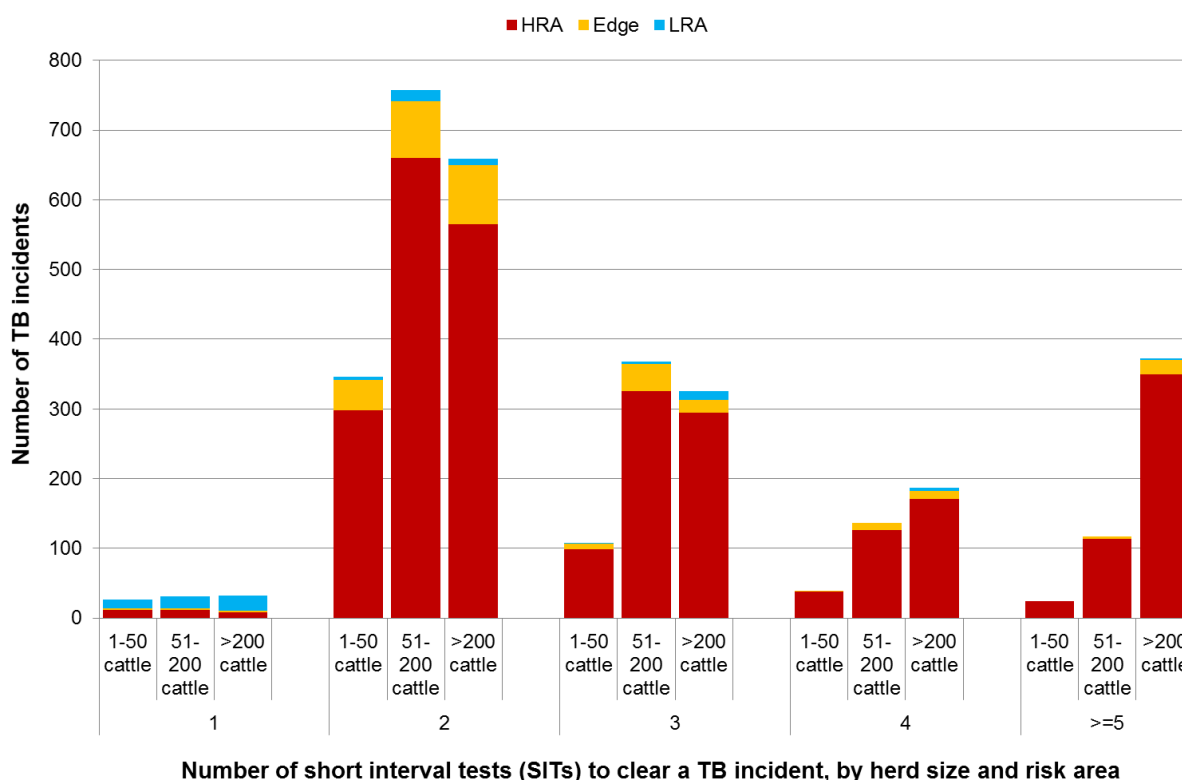


Figure 4.4.3c Number of short interval tests (SITs) to clear a TB incident, by risk area and herd size (for TB incidents ending in 2017). Note: 36 herds were missing information on SITs)

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

Changes in 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 4.4.4). 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 many cases are suspect rather than confirmed, hence the lower duration for such herds in this area.

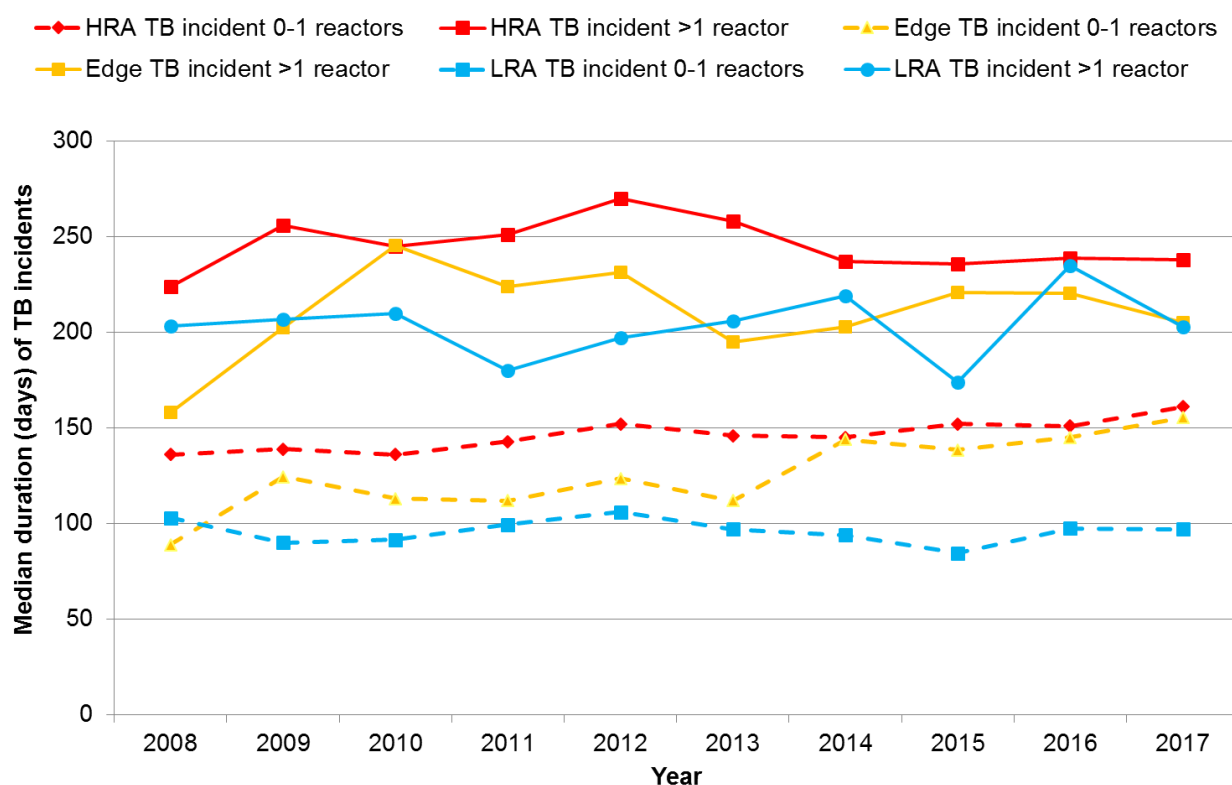


Figure 4.4.4 Median duration of TB incidents that closed in each year, between 2008 and 2017

- Since 2008, TB incidents in the HRA and those with more than one reactor have consistently been under restriction for longer, compared to incidents in the Edge Area or LRA.
- Since 2013, most single reactor herds in both the HRA and Edge Area have required two SITs to clear a TB incident, leading to a similar duration of around 150 days.

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 (discussed further in Section 4.5).

Figure 4.4.5a shows the number of persistent TB incidents that were resolved in each year since 2008 by risk area; the vast majority are in the HRA (note y-axis is scaled to a tenth true value for the HRA so that values for the Edge Area and LRA can be seen). The number of persistent TB incidents in the HRA resolved in each year have been reducing since 2013. In the Edge Area there was an increase since 2013 up to 2016 (n=16) but this has since dropped again in 2017 (n=7). Further details of the Edge Area epidemic are given in Section 5.2.

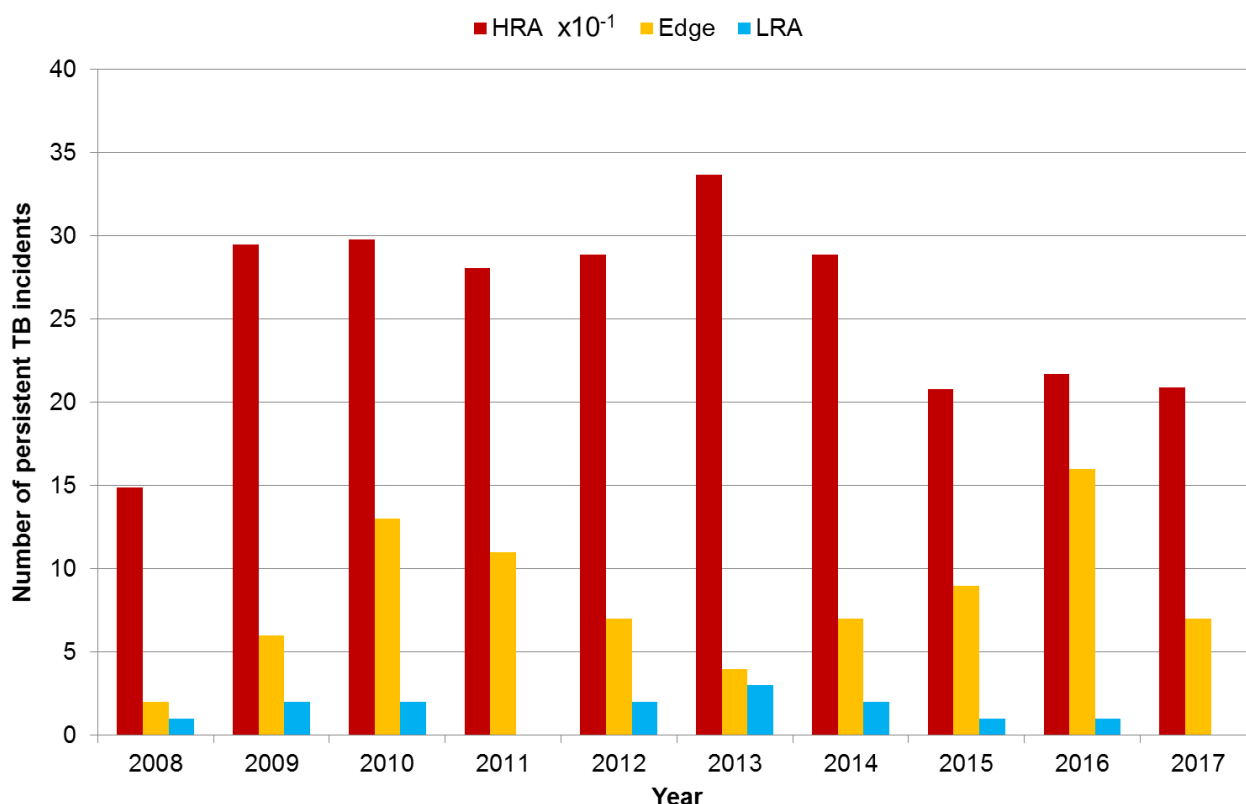


Figure 4.4.5a Number of TB incidents that ended in each year shown and lasted more than 550 days ('persistent' TB incidents). (Note HRA values presented as a tenth their true value for clarity)

- The number of persistent TB incidents resolved is consistently higher in the HRA; in 2013 peaked at 337 but has since declined to around 200 (209 in 2017).
- In the Edge Area, the number of persistent TB incidents resolved was highest in 2016 (16), but shows a fluctuating trend.
- In the LRA, the total number of persistent TB incidents resolved has been between 0 and 3 since 2007 with none classed as persistent in 2017.

At the end of 2017, there were 386 herds that had a persistent TB incident that had not been resolved ('open'), most of which were located in the HRA (360), 25 in the Edge area and one in the LRA.

Persistent TB incidents have a variety of causes including:

- The limitations of the test in finding all infected animals, particularly in large herds, due to presence of animals that fail to react to the test, 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.

In 2017, there were 216 persistent TB incidents resolved in England, 97 per cent of which were located in the HRA (n=209, compared to 216 in 2016), and just seven in the Edge area (compared to 16 in 2016). There were no persistent TB incidents closing in 2017 located in the LRA (one in 2016) (Figure 4.4.5b).

Most herds that have prolonged infection with TB are located in the HRA, with the proportion highest in Oxfordshire (HRA portion) and Avon (10.5%) as well as Somerset (9.0%), Dorset (8.9%), Gloucestershire (8.2%) and Devon (8.0%).

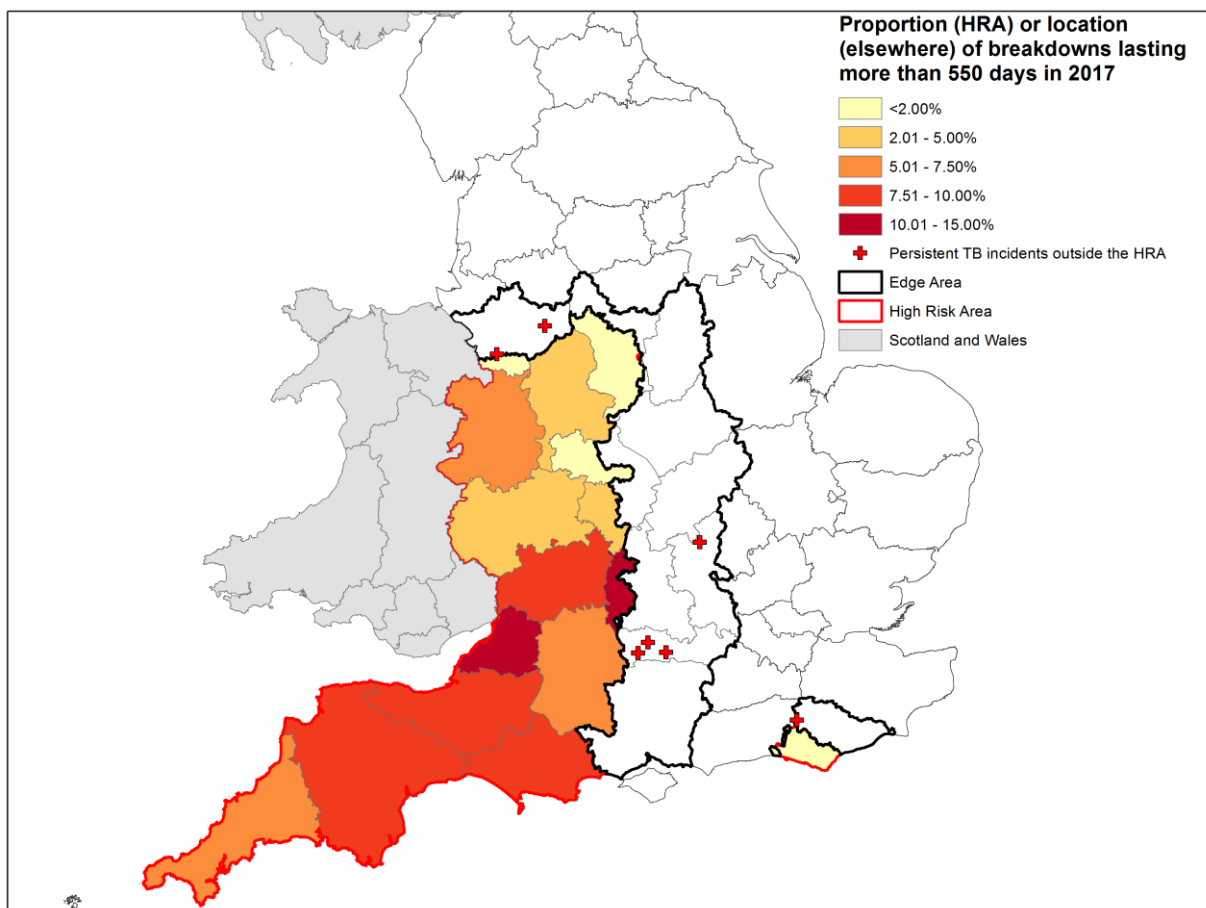


Figure 4.4.5b Proportion (HRA) and location (elsewhere) of all TB incidents that ended in 2017 that had lasted more than 550 days (persistent incidents)

- Most herds that have prolonged infection with TB (that closed in 2017) are located in the HRA, with the highest proportions observed in Oxfordshire (HRA portion) and Avon (10.5%).
- Very few TB incidents that closed in 2017 in the Edge Area or LRA had TB incidents persisting for longer than 18 months, therefore are shown by their location rather than as a proportion of all incidents.

Number of animals removed

In 2017, a total of 33,438 cattle were slaughtered for TB disease control. 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 interferon-gamma test positive animals) in the HRA per TB incident was around six from 2009 to 2014 and has since fluctuated between 6-8, showing a drop towards the end of 2017. Figure 4.4.6a reflects the moving average 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.

The median number of skin test reactors (and interferon-gamma ([IFN- γ] test positive animals) removed in 2017, for TB incidents that had closed at the end of the year, was two in England overall and the HRA and Edge Area, and lower in the LRA with a median of 1). Sixty-three per cent of TB incidents closing in 2017 in England had two or more reactors, largely driven by the HRA but also the Edge Area (64% and 61% respectively). In the LRA, the proportion of TB incidents with two or more reactors was 39% in 2017. Although the proportion of TB incidents with two or more reactors increased in all individual risk areas and England overall in 2017 compared to 2016, the changes were not statistically significant (England, $p=0.17$; HRA, $p=0.19$; Edge, $p=0.22$; LRA, $p=0.55$).

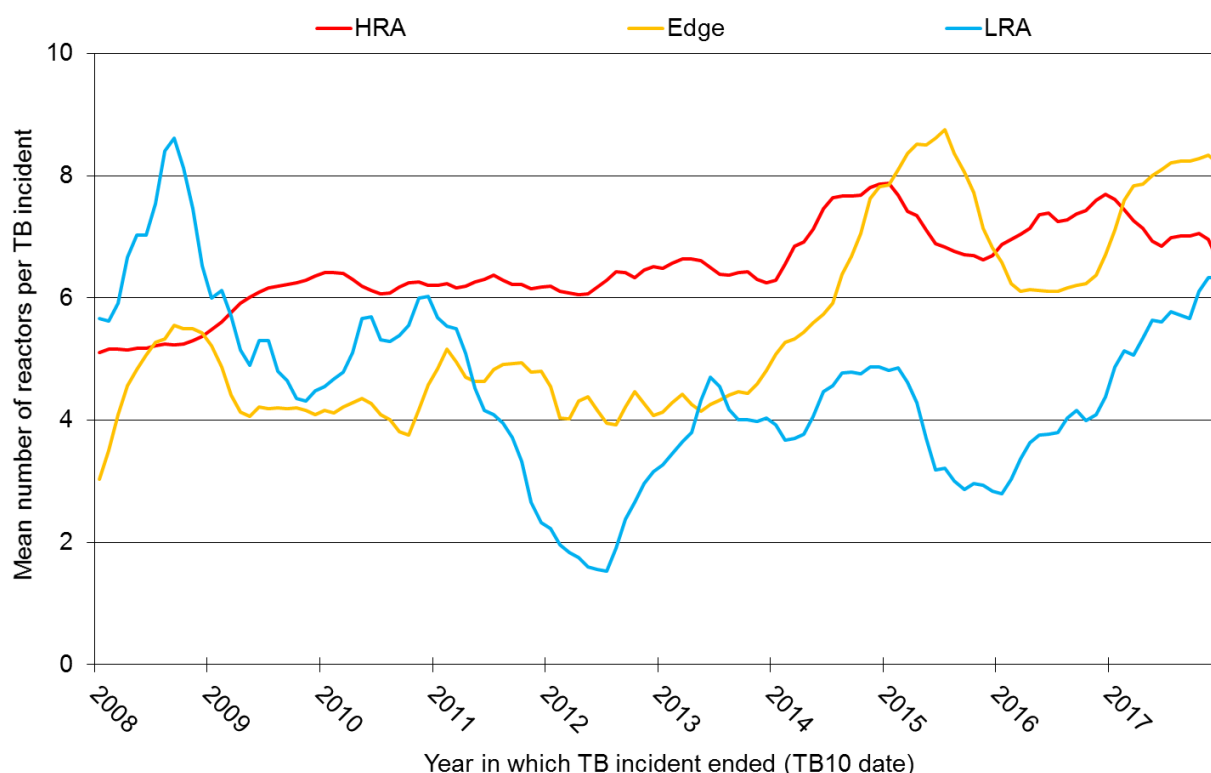


Figure 4.4.6a Rolling mean total number of test reactors taken per TB incident that closed between Jan 2008 and Dec 2017, by risk area (12-month moving average)

- 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 6-8 reactors.
- 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 (between 4 and 6 in 2017).

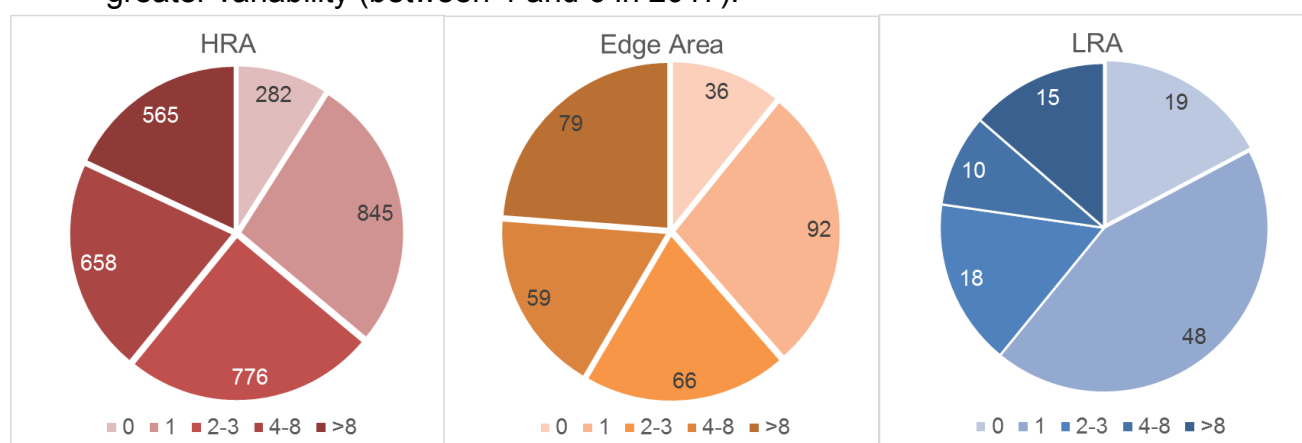


Figure 4.4.6b Number of reactors per TB incident that closed in Dec 2017, by risk area

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 2017: 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 2017, there was a 14% increase in the number of cattle removed from herds across England compared to 2016. The majority of the 33,438 cattle removed from herds were reactors taken from the HRA (n=26,649, 80%), which has been the pattern over the last ten years (Figure 4.4.7). However substantial numbers are also taken as inconclusive reactors (IRs, 925 in the HRA) and direct contacts (DCs, 667 in the HRA). There has also been a steep increase in the number of reactors removed from herds in the Edge Area, jumping from 1,327 in 2013 to 4,027 in 2017, reflecting the impact of more stringent controls introduced in 2013.

The measure requiring two clear tests at severe interpretation before restrictions are lifted from any incident has applied since April 2016 in the HRA (since 2013 in the Edge Area). This means that IRs disclosed at standard interpretation may be removed as reactors when reinterpretation at severe is applied, increasing the number of reactors and reducing the risk of leaving residual infection in the herd. There was an increase in the number of reactors taken in the HRA in 2017, and an increasing number in the Edge Area since 2013.

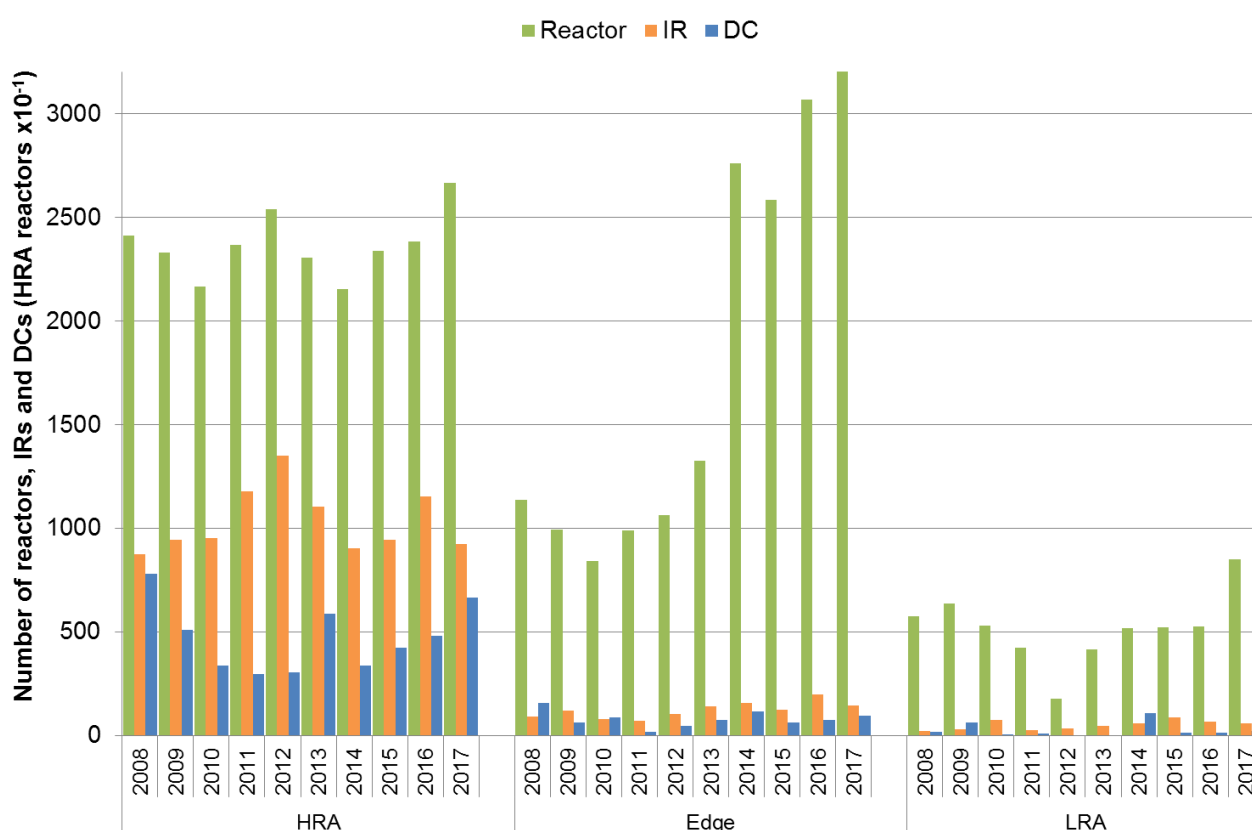


Figure 4.4.7 Number of reactors, inconclusive reactors and direct contacts removed from herds between 2008 and 2017, by risk area (note HRA reactors presented as a tenth their true value)

- Most cattle removed are reactors taken from the HRA (same pattern observed over the past ten years), 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 the requirements to a) have two clear tests at severe interpretation for all incidents before lifting restrictions and b) compulsory application of IFN- γ test in all OTF-W TB incidents, were rolled out from 2013 and 2014 respectively.

4.5 Reducing transmission of disease: effectiveness of different controls

- New controls introduced in 2017 in England included:
 - Wider use of interferon-gamma (IFN- γ) blood testing in the HRA (from April 1st 2017).
 - Using 'severe' interpretation for skin tests on traced cattle (from April 1st 2017).
 - Mitigating the risks from IRs: If an animal's skin test result is not clearly negative or positive, the affected animal is temporarily classified as an inconclusive reactor (IR), pending a re-test 60 days later. If the skin re-test gives a positive or a second inconclusive result, the IR is slaughtered as a reactor. However, from November 1st 2017, any IR in the HRA or Edge Area (or in a TB breakdown herd in the LRA) that passes the re-test is no longer free to be moved. Instead, those animals must stay on the farm of detection for the rest of their lives until they die or are removed for slaughter.
 - More effective control of the movement of cattle from one TB incident herd to another. For business sustainability reasons APHA will sometimes license the movement of cattle between TB incident herds. To reduce the risk of TB transmission between herds under restrictions, such movements will only be permitted where the destination herd is due to have at least two Short Interval Tests (SITs) at severe interpretation (from October 1st 2017).
 - The timing of short-interval tests (SITs) in herds affected by TB incidents was harmonised so that those tests now take place at least 60 days after removal of the last test positive (reactor) animal rather than 60 days after the previous test.
 - Eleven new badger control areas were licensed (10 in different counties of the HRA and one in the Edge Area of Cheshire).
- As in previous years, the vast majority (94%) of cattle removed for TB control reasons were test positives (reactors). Of the cattle removed as test positives, 65% were identified by standard interpretation of the skin test, 20% through severe interpretation of the skin test and 15% by IFN- γ testing. As previously, bacterial culture from tissue samples effectively confirmed *M. bovis* infection in 96% of visibly-lesioned (VL) carcasses.
- Confirmation proportions for TB-affected animals removed within each risk area were highest among standard-interpretation skin test reactors (38-44%). The confirmation proportion was also relatively high in IFN- γ test positives in the HRA (14%) (figure 4.5.2.a), demonstrating the value of its application to remove further infected animals within breakdown herds.
- A total of 98,529 cattle were tested with IFN- γ in 2017 in England and 5.2% were positive (5,094 IFN- γ test positives). A total of 732 herds were sampled and 557 had IFN- γ reactors disclosed (76%).

- Mandatory parallel IFN- γ tests in OTF-W incidents in the Edge Area accounted for 61% of all blood samples processed in England in 2017 for IFN- γ testing. From 454 submissions with 60,003 samples, a total of 2,517 were positive.
- The best performing tests for finding subsequent infection when an incident is being controlled were the 6- and 12-month post-incident check tests, followed by contiguous tests.
- Twenty-four herd depopulations were authorised in England in 2017 (one total and 23 partial).
- Results in 2017 ²⁶indicate that (where results are known), all 19 badger control areas undergoing culls in 2017 delivered the level of badger removal required and that the operations were carried out to a high standard of public safety.

Cattle Slaughtered for Disease Control Purposes

The vast majority of cattle removed for disease control purposes were test reactors (94.2%, Figure 4.5.1); 65% of which were standard-interpretation reactors²⁷; 20% severe-interpretation reactors²⁸ and 15% IFN- γ test positives. The remaining 5.8% were removed as inconclusive reactors before they could be re-tested or as direct contacts.

Confirmation of TB infection means the detection of typical lesions at post mortem (PM) examination (visibly-lesioned or VL sample) in a slaughtered test reactor, or identification of *M. bovis* in culture. All cattle slaughtered for disease control purposes have a post mortem examination²⁹ (PME), but not every TB-affected animal is sampled for laboratory culture and isolation of *M. bovis*.

In line with previous years, 96% of VL samples from cattle yielded a positive culture result, whereas only 4% of non-visibly-lesioned (NVL) samples did so (Figure 4.5.1).

²⁶ <https://www.gov.uk/government/publications/bovine-tb-summary-of-badger-control-monitoring-during-2017>

²⁷ 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)

²⁸ 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.

²⁹ Missing PM examination in 0.8% of reactors and 0.7% of IRs and DCs slaughtered.

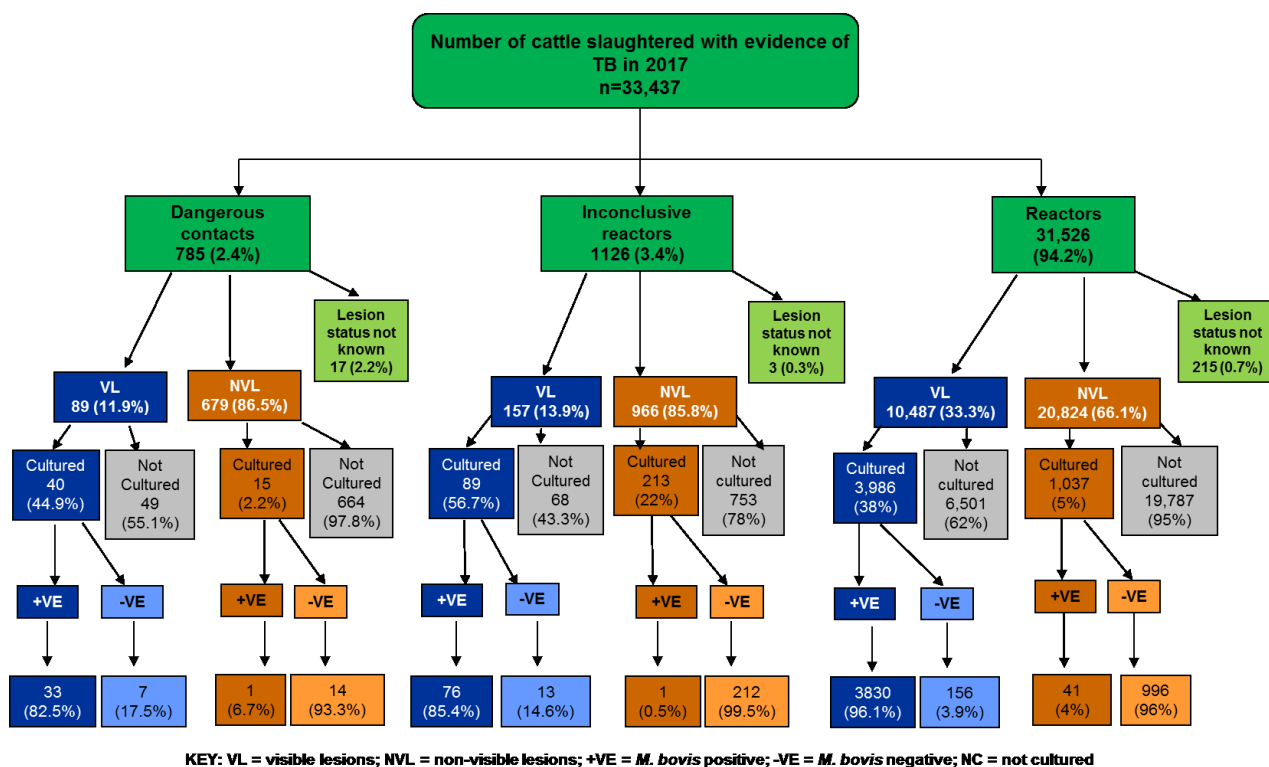


Figure 4.5.1. Diagram showing the number of cattle that were slaughtered for TB control reasons in 2017 and the number in which infection with *M. bovis* was confirmed.

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 wider use of IFN- γ blood testing was carried out in the HRA. IFN- γ test positive animals represent just seven per cent of all cattle slaughtered for TB control reasons in the HRA, but 52% in the Edge Area and 70% in the LRA (Figure 4.5.2a).

Over 90% of OTF-W incidents (in Figure 4.5.2a defined as any VL animal or NVL *M. bovis* positive animal) in cattle slaughtered were standard-interpretation reactors.

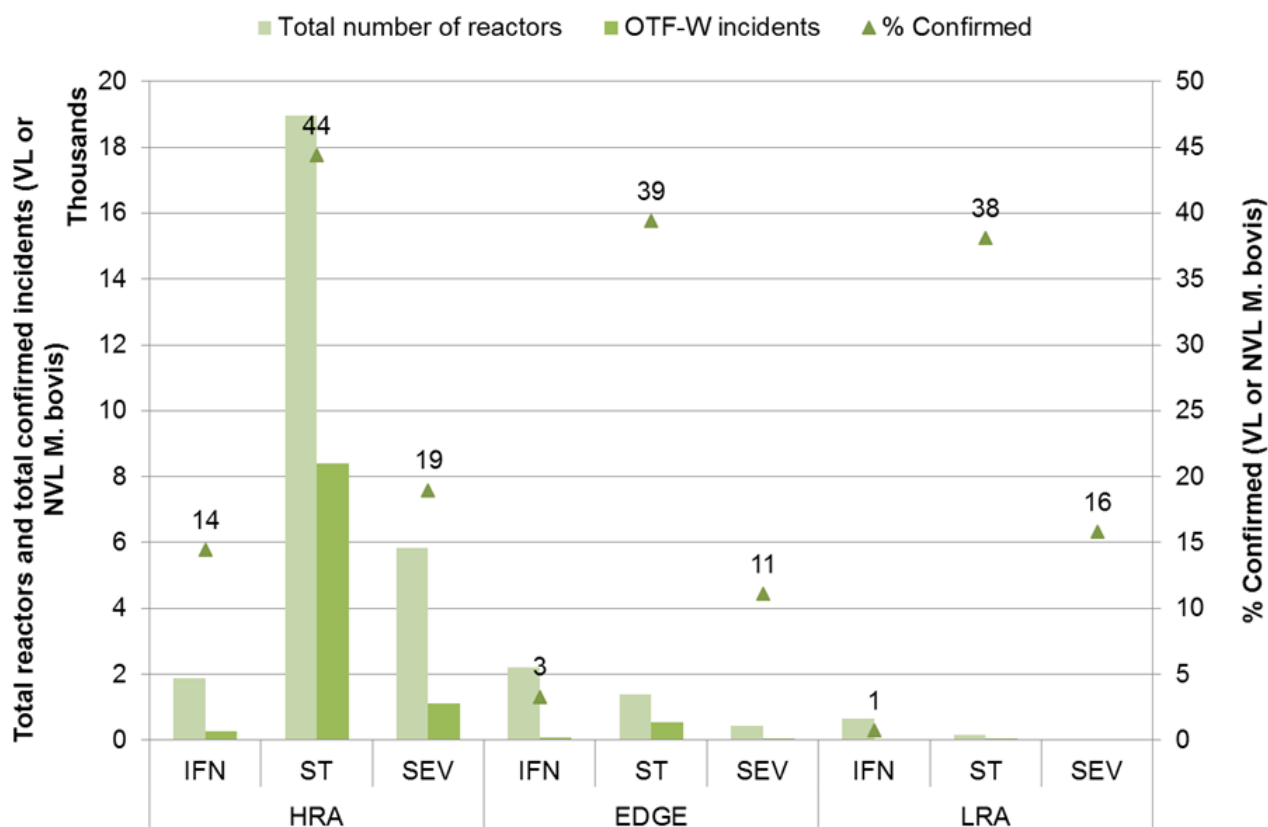


Figure 4.5.2 Number of reactors (IFN- γ , standard and severe interpretation) and total (and %) VL or NVL (*M. bovis*) confirmed incidents, by risk area

Characteristics of herds with TB incidents

All incidents where the causative organism of bovine tuberculosis (*M. bovis*) is isolated, undergo DNA testing to determine its genotype. Examining the spatial distribution of these genotypes gives an indication of the typical location or 'home range', using historical sampling. The most frequent genotype found in England in 2017 was 11:a, found in 20% of the *M. bovis* isolates subjected to genotyping. This was followed by 17:a (18%) and 25:a (15%), based on 2,279 incidents starting in 2017 with a genotype identified. These three genotypes accounted for 53% of all genotypes disclosed and cover extensive areas in the South West of England and Wales (Figure 4.5.3).

Genotyping of *M. bovis* isolates can help to provide information on the causal pathways involved in herd incidents, for example where a purchased confirmed animal is the index case of a new TB incident and the home range of the genotype of this reactor's sample matches the location of the originating farm. There is ongoing work at APHA developing mechanisms to provide valuable additional information through whole genome sequencing.

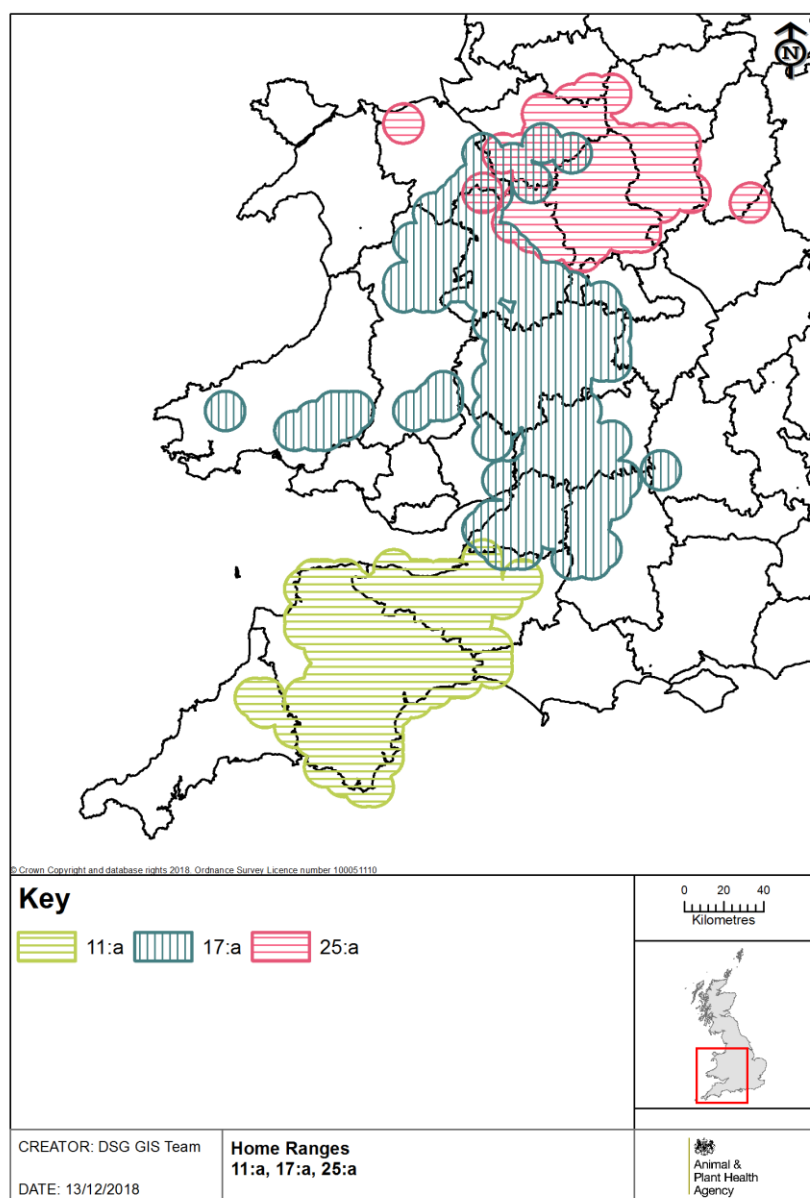


Figure 4.5.3. Homeranges³⁰ of genotypes 11:a, 17:a and 25:a

Dealing with infected herds

The comparative tuberculin skin test (SICCT) is the main test used in the surveillance for the detection of TB in cattle in GB, as well as in the control of TB incidents at 60-day intervals (Short Interval Testing - SIT).

³⁰ "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 incorrect handling of missing data. Further details on the adjustments to this method are available in the report titled [Bovine tuberculosis in Great Britain in 2017: Explanatory supplement to the annual reports](#)

One way to enhance the detection of infected cattle (that applies to all areas) is to remove negative-testing cattle that are nevertheless suspected of being infected or exposed to *M. bovis* through an epidemiological link (close contact) with known infected cattle in the same herd. Such animals are removed as direct contacts (DCs) at the discretion of APHA veterinarians.

Use of additional or “ancillary” tests for detection of infected cattle within a TB incident

The IFN- γ ³¹ 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 fully confirmed (OTF-W) TB incidents in the LRA and Edge Area and in badger control 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. It is also applied in explosive or chronic breakdown herds considered for whole or partial slaughter. Outside these scenarios, the deployment of the blood test in 2017 was discretionary.

A total of 98,529 cattle were tested with IFN- γ in 2017 in England and 5.2% were positive (5,094 IFN- γ test positives). A total of 732 herds were sampled and 557 had IFN- γ reactors disclosed (76%).

In 2017, the proportion of IFN- γ test positives (gamma reactors) detected from all samples taken was 6%, and since 2010 has been around 4-5% (Figure 4.5.6). The proportion of blood samples with a positive IFN- γ test result was lower in 2017 (7%) than in the last ten years (between 10-15%). This test identifies infected cattle up to two weeks post-infection which is very early, therefore the chance of having positive samples confirmed by post-mortem examination is lower than for skin tests as there has been little time for lesions to form.

³¹ Supplementary or ancillary test: Bovigam interferon- γ blood test (Prionics AG, Switzerland)

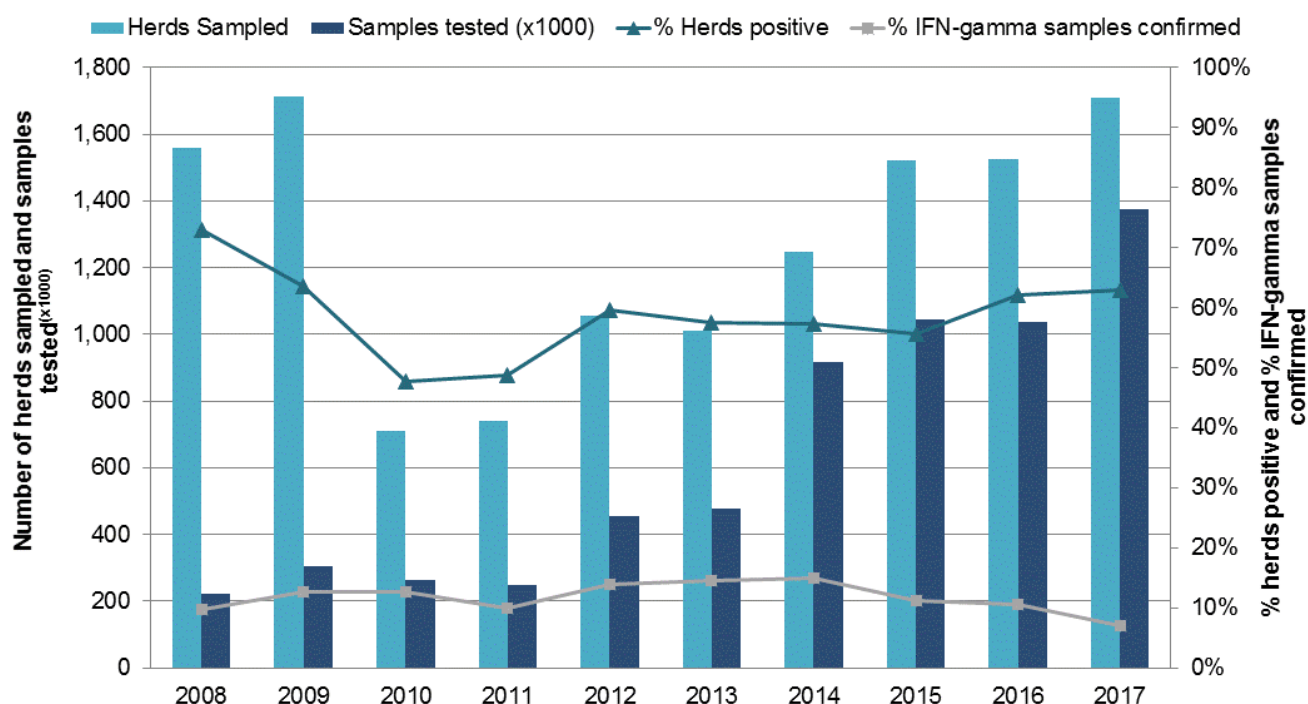


Figure 4.5.4. Number of samples tested, herds sampled and proportions of herds positive and IFN- γ test positives, 2008 to 2017.

Another discretionary use of the IFN- γ test in parallel use with the skin test is its application to OTF-S incidents in the Edge Area. In 2017, 156 samples (four submissions) were tested (parallel test - OTF-S) and nine were IFN- γ positive. This suggests this policy option could usefully be used more widely, as shown by the evidence presented above where gamma tests in 63% of herds revealed additional infected animals.

IFN- γ tests are also used in persistent incidents, as part of the enhanced incident management procedures. In 2017, 281 submissions were made (parallel persistent infection) totalling 24,857 samples taken and 1,937 IFN- γ reactors were detected. The test can also be used to inform depopulation procedures.

Enhanced TB incident management procedures

Persistent incidents

If a TB incident in a herd is persistent (duration over 550 days or 18 months) or if it is explosive (several reactors initially disclosed), it is eligible for enhanced incident management measures. Such procedures include tailored advice and support to the farmer and enhanced sensitivity of testing to increase the chance of detecting infected cattle (stricter interpretation, use of additional testing, etc.). Persistent herds are described further in [Section 4.4](#).

Depopulation

An extreme way of dealing with an infected herd is the removal of all cattle in the herd or in certain groups. This is an exceptional measure in severe incidents and subject to certain criteria being met, veterinary risk assessment carried out and approval granted. This usually involves a large number of infected cattle, as well as additional suspects on the farm. Additional testing (i.e. IFN- γ) to gather more information can be carried out before this is undertaken. Twenty-three partial herd depopulations were authorised in the HRA to deal with infected herds in 2017.

Limiting spread and containing disease when found: efficacy of additional surveillance

As discussed in [Section 4.3](#), surveillance carried out due to an increased likelihood of infection being present ('Area & Herd risk' tests) is the most successful at finding infected herds, and in 2017 this surveillance stream disclosed 46% of all TB incidents and 44% of confirmed TB incidents. This section describes the relative success of these tests. Data on surveillance streams are presented in Table 4.3.1 in [Section 4.3](#).

Contiguous test efficacy

Contiguous tests (CON, CON12) are used to detect infection in herds in the vicinity of a herd with an OTF-W TB incident in the HRA and Edge Area (except Derbyshire Edge Area, where radial testing takes place, and Cheshire Edge Area where six-monthly routine WHT is carried out instead) and fall within the 'Area and Herd Risk' surveillance stream (Table 4.5.1). Nearly all (99%) contiguous tests were carried out in the HRA, detecting 15.1 incidents per 100 herd tests and 3.8 reactors per 1,000 cattle tests.

Table 4.5.1. Contiguous tests: total and proportion of cattle and herd tests, reactors and TB incidents by risk area.

Contiguous Tests	Cattle Tests (%)	Reactors (%)	Herd Tests (%)	Total TB Incidents (%)	Confirmed TB Incidents (%)
HRA	346,546 (98.7)	1,326 (99.9)	2,989 (98.7)	450 (99.6)	323 (99.7)
Edge Area	4,307 (1.2)	2 (0.1)	34 (1.1)	2 (0.4)	1 (0.3)
LRA	305 (0.1)	0	5 (0.2)	0	0
Proportion Of Area & Herd Risk Surveillance Stream	18.76%	22.17%	12.64%	26.00%	28.22%
Proportion Of All Surveillance	6.49%	13.37%	3.69%	11.85%	12.46%

Radial test efficacy

Radial tests (RAD, RAD6 and RAD12) have been used since 2013 to test herds within 3 km of an OTF-W TB incident in the LRA and in small parts of the Edge Area, i.e. the east of Derbyshire and until January 2015, the Edge area of Cheshire (Table 4.5.2). Nearly all (98%) radial tests are carried out in the LRA, detecting 1.8 incidents per 100 herd tests and 0.1 reactors per 1,000 cattle tests.

Table 4.5.2. Radial tests: total and proportion of cattle and herd tests, reactors and TB incidents by risk area.

Radial tests	Cattle Tests (%)	Reactors (%)	Herd Tests (%)	Total TB Incidents (%)	Confirmed TB Incidents (%)
HRA	1,878 (0.6)	0	17 (0.7)	0	0
Edge Area	5,336 (1.7)	8 (21.1)	61 (2.6)	3 (6.7)	1 (16.7)
LRA	315,683 (97.7)	30 (78.9)	2,287 (96.7)	42 (93.3)	5 (83.3)
Proportion Of Area & Herd Risk Surveillance Stream	17.25%	0.63%	9.88%	2.59%	0.52%
Proportion Of All Surveillance	5.97%	0.38%	2.88%	1.18%	0.23%

Tracing test efficacy

Tracing tests (forward (TR) and backward (CT (E-M))) are triggered from a confirmed TB incident to check the possible source of infection or whether it had spread and are therefore very important to contain disease (Table 4.5.3). Most (68%) tracing tests were carried out in the HRA and the remainder in the Edge Area (10%) and the LRA (22%). In 2017, tracing tests detected 0.9 incidents per 100 herd tests and 10.8 reactors per 1,000 cattle tests. These numbers are an underestimation, as if a tracing test is carried out at the same time as a surveillance herd test, only the latter would be recorded.

Table 4.5.3. Tracing tests: proportional distribution and reactors and TB incidents detected by risk area, as a proportion of the Area & Herd Risk surveillance stream, and of all surveillance streams

Tracing tests	Cattle Tests (%)	Reactors (%)	Herd Tests (%)	Total TB Incidents (%)	Confirmed TB Incidents (%)
HRA (%)	43,250 (68.3)	469 (70.7)	7,266 (72.2)	69 (51.5)	51 (57.3)
Edge (%)	6,173 (9.8)	68 (10.3)	1,347 (13.4)	24 (17.9)	15 (16.9)
LRA (%)	13,867 (21.9)	126 (19.0)	1,450 (14.4)	41 (30.6)	23 (25.8)

Proportion Of Area & Herd Risk Surveillance Stream	3.38%	11.07%	42.04%	7.71%	7.75%
Proportion Of All Surveillance	1.17%	6.67%	12.26%	3.51%	3.42%

In 2017, 98% of herds that had a tracing test, had a forward tracing test. Eighty-two per cent of TB incidents disclosed through tracing tests were detected by forward tracing tests; all Edge Area incidents (n=6) and just over half of LRA incidents (n=5). However, in terms of individual cattle tests, 60% of cattle in the LRA had a backward tracing test compared to a forward tracing test. In the HRA and Edge Area, 71% and 86% of cattle (tracing) tests were forward tracing compared to backward tracing.

In terms of performance, as would be expected, the backwards whole herd tracing tests detected more incidents (9 per 100 herd tests) and reactors (18 per 1,000 cattle tests) than the individual animal forward tracing tests (1 incident per 100 herd tests and 3 reactors per 1,000 cattle tests), which reflects their importance in value if not in volume.

Post-TB incident test efficacy

Diagnostic tests are imperfect and may miss infected cattle. There are area variations but in general, after a TB incident is resolved and movement restrictions have been lifted, post-incident tests are conducted six months later and, if this is negative, twelve months thereafter in order to detect any residual infection in the herd (Table 4.5.4). However, if a new incident is detected, it is sometimes difficult to say if this is due to residual infection or to a new infection with the same or different source and risk pathway, so measures to tackle both are necessary to prevent recurrence.

Although they only represent around a quarter of herd tests, they detect 64% of incidents and 66% of reactors disclosed within the Area and Herd Risk surveillance stream. They represent 6.5% of all herd tests in England but detect nearly 30% of all incidents and 40% of all reactors.

They are particularly important in the HRA, where 6 and 12 month tests disclosed 22 incidents per 100 herd tests and 4 reactors per 1,000 cattle tested.

Table 4.5.4. Post-TB incident tests: proportional distribution and reactors and TB incidents detected by risk area, as a proportion of the Area & Herd Risk surveillance stream, and of all surveillance streams

Post-incident (6m/ 12m)	Cattle Tests (%)	Reactors (%)	Herd Tests (%)	Total TB Incidents (%)	Confirmed TB Incidents (%)
HRA (%)	872,405 (86.7)	3,791 (95.5)	4,641 (87.5)	1,041 (94.2)	701 (100)
Edge (%)	106,931 (10.6)	177 (4.4)	527 (9.9)	60 (5.4)	0
LRA (%)	26,345 (2.6)	2 (0.1)	136 (2.6)	4 (0.4)	0
Proportion Of Area & Herd Risk Surveillance Stream	53.73%	66.30%	22.16%	63.58%	61.06%
Proportion Of All Surveillance	18.60%	39.97%	6.46%	28.96%	26.95%

Altogether, the tests mentioned above account for the vast majority of cattle tests carried out under the Area & Herd risk surveillance stream, however they do not include such tests when carried out in herds under restriction.

Hotspot procedures

There are other test types also used to mitigate the potential effect of infection once detected, as well as providing information on its origin. Hotspot tests (HS1 and 2) are used in low incidence areas³², in response to an incident of unclear origin. Hotspot tests apply to herds identified within 3 km of the index herd. Very few hotspot tests were applied in the HRA or Edge Area in 2017 (five and one respectively with no TB incidents disclosed). A total of 152 herd hotspot tests were carried out in the LRA in 2017 (totalling 27,441 cattle tests) with six reactors disclosed (four TB incidents, of which two were confirmed).

Summary of Area and Herd Risk tests' performance

Table 4.5.5 summarises the performance of all Area and Herd Risk tests as described alongside previous tables, in terms of incident and reactor detection as a proportion of herd and cattle tests.

³² Low incidence areas refer to the four-yearly testing area of England or the low incidence area in Wales.

Table 4.5.5. Summary of performance of Area and Herd Risk tests in unrestricted herds, regarding incident and reactor detection

Area and Herd Risk Tests	Incidents per 100 herd tests	Reactors per 1,000 cattle tests
Post-incident	21	4
Contiguous	15	4
Backward tracing	9	18.5
Forward tracing	1	3
Radial	2	0

Bovine tuberculosis in species other than cattle

TB in badgers

Although bovine TB can infect any warm-blooded mammal, the main wildlife reservoir in England is the European 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 five years in licensed areas, with areas licensed within the five year period (Table 4.5.6). Eleven new badger control areas were licensed in 2017.

Table 4.5.6. Table showing number of badgers removed in licensed badger control areas in 2017

BADGER CONTROL AREA	NUMBER OF BADGERS REMOVED
AREA 1-GLOUCESTERSHIRE (5 TH YEAR; 2013 START)	172
AREA 2-SOMERSET (5 TH YEAR; 2013 START))	91
AREA 3-DORSET (3RD YEAR; 2015 START)	257
AREA 4-CORNWALL (2ND YEAR, 2016 START)	213
AREA 5-CORNWALL (2ND YEAR, 2016 START)	358
AREA 6-DEVON (2ND YEAR, 2016 START)	727
AREA 7-DEVON (2ND YEAR, 2016 START)	246
AREA 8-DORSET (2ND YEAR, 2016 START)	1,166
AREA 9-GLOUCESTERSHIRE (2ND YEAR, 2016 START)	1,012
AREA 10-HEREFORDSHIRE (2ND YEAR, 2016 START)	394
AREA 11-CHESHIRE (1ST YEAR; 2017 START)	736
AREA 12-DEVON (1 ST YEAR, 2017 START)	1,874
AREA 13-DEVON (1 ST YEAR, 2017 START)	1,237
AREA 14-DEVON (1 ST YEAR, 2017 START)	708
AREA 15-DEVON (1 ST YEAR, 2017 START)	763
AREA 16-DORSET (1 ST YEAR, 2017 START)	3,450
AREA 17-SOMERSET (1 ST YEAR, 2017 START)	1,123
AREA 18-SOMERSET (1 ST YEAR, 2017 START)	489
AREA 19-WILTSHIRE (1ST YEAR, 2017 START)	2,252
AREA 20-WILTSHIRE (1ST YEAR, 2017 START)	1,040
AREA 21-WILTSHIRE (1ST YEAR, 2017 START)	1,229

*<https://www.gov.uk/government/publications/bovine-tb-summary-of-badger-control-monitoring-during-2017>;

2017 figures for Gloucestershire and Somerset;

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/670223/badger-control-monitoring-summary-2017-final.pdf 2016 figures were 252 for Gloucestershire and 217 for Somerset.

Badger removal results from 2017 indicate that eighteen of nineteen badger control areas undergoing intensive culling achieved the minimum number of badger removal required (Area 2 Somerset fell short of the minimum target). No area exceeded the maximum number based on badger abundance. Further information can be found at the [Summary of badger control monitoring during 2017](#)³³.

The OTF-W incidence and prevalence of bovine TB in cattle located within the badger control licensed areas can be found in the [Bovine TB in cattle: badger control areas monitoring report](#). TB in badgers is also controlled through the licensed use of injectable BCG vaccine (when available) in the HRA and Edge areas.

TB in other animals

Specific procedures are in place to deal with TB incidents in species other than cattle. Table 4.5.7 summarises statistics on TB in non-bovine species, which is an extract of data from [TB in non-bovine species 2011–2017](#)³⁴, updated on 15th August 2018.

In England in 2017, the highest proportion of premises with non-bovine species under movement restrictions due to suspect or confirmed bovine TB were South American camelid (SAC) premises (38%), followed by pig and goat premises (35% and 18% respectively). The highest proportion of TB confirmed premises were also in SAC (31%) followed by pigs (28%). Individual SAC samples made up the highest proportion of submissions to APHA (45%), followed by pig submissions (26%).

The highest number of samples positive for *M. bovis* were SAC (n=30, 31% of total positive) and deer (n=29, 30%). Along with pigs, these three animal groups made up 80% of all *M. bovis* positive samples. Regarding infected wildlife other than badgers, wild deer accounted for 55 individual samples submitted, of which 29 were positive for *M. bovis*.

Table 4.5.7. Data on bovine TB in species other than cattle in England in 2017

Reporting Period		England					
01-01-17 – 31-12-17		SAC	Sheep	Goats	Pigs	Deer	Other
For ease of reference	Total no. of premises under movement restrictions at the end of the 2017 due to suspected TB or a confirmed incident of <i>M. bovis</i> infection	53	7	30	41	17	6
No. of premises placed under movement restrictions in 2017 due to suspected TB or a confirmed incident of <i>M. bovis</i> infection		42	7	20	38	1	2
No. Of premises sustaining a new TB incident (breakdown) in 2017 which was confirmed by culture of <i>M. bovis</i> .		11	3	4	10	3	5

³³ www.gov.uk

³⁴ <https://www.gov.uk/government/statistical-data-sets/other-tb-statistics>

Number of <i>M. bovis</i> animals first diagnosed through passive post-mortem surveillance at slaughterhouses or at an APHA laboratory.		20	3	6	15	4	5
No. of animals removed as TB test reactors.		297	5	4	0	0	2
	(i) via blood tests	269	0	0	0	0	1
	(ii) via skin tests	28	5	4	0	0	1
No. of individual animal specimens submitted for post-mortem examination at APHA laboratories due to suspected TB this calendar year.		196	14	14	111	55	43
Of those the number that were positive for <i>M. bovis</i> . (Note that lack of a positive culture does not mean disease was not present in the animal)		30	3	7	19	29	10

5. Epidemiology of TB in each Surveillance Risk Area

5.1 High Risk Area

- Within the HRA, TB herd incidence increased by seven per cent in 2017 compared to 2016 (19.2 TB incidents per 100 herd years at risk in 2017, 17.9 in 2016), although this was not statistically significant ($p=0.2$), suggesting that disease incidence is plateauing.
- The number of TB incidents in 2017 also increased non-significantly from 3,229 in 2016, to 3,259 in 2017 ($p=0.7$).
- TB incidence per 100 herd-years at risk increased in 12 of the HRA counties in 2017. The Warwickshire HRA had the highest incidence of 32 incidents per 100 herd years at risk, followed by the Oxfordshire HRA and Gloucestershire. The lowest incidence rates were observed in the East Sussex HRA, the Derbyshire HRA and the West Midlands, which has been the case for the past five years.
- The highest herd prevalence rate in 2017 was seen in the Oxfordshire HRA with a total end year prevalence of over 20% of herds restricted due to a TB incident at the end of the year. The Warwickshire HRA had the second highest prevalence (17%) with Gloucestershire just behind (16%). All other areas were at or below 15%. The lowest prevalence rate was seen in the West Midlands (1%) then East Sussex (3.3%) & Derbyshire HRA (5%).
- The overall average monthly prevalence for the HRA increased from 10.7% in 2016 to 11.4% in 2017. Again this is not statistically significant ($p=0.4$).
- Devon and Cornwall have the highest population of herds in the HRA and account for around 39% of TB incidents
- Counties experiencing TB incidents with the longest duration of movement restrictions (for TB incidents that ended in 2017) included Oxfordshire (median duration of 241 days), Cornwall (210 days), East Sussex (207 days), Devon (204 days) and Dorset (202 days).
- For TB incidents closing in 2017, most persistent TB herds (with movement restrictions of >550 days) were located in Devon, Cornwall and Somerset.
- Tests in the HRA accounted for 22% of all IFN-gamma tests carried out in 2017 in England. Over 60% of these IFN-gamma tests were carried out in Devon, and Dorset.

The HRA extends from the western areas of the Midlands to the South and West of England (excluding the Isles of Scilly) and part of East Sussex. It has 16 counties, five of which are

mixed HRA/Edge areas³⁵. Defra's overall objective for the HRA is to reduce TB, seeking initially to stabilise incidence and then to start to reduce it. Local and national bespoke initiatives are being implemented; with challenges coming from the high volume of cases and finite resources to tackle them.

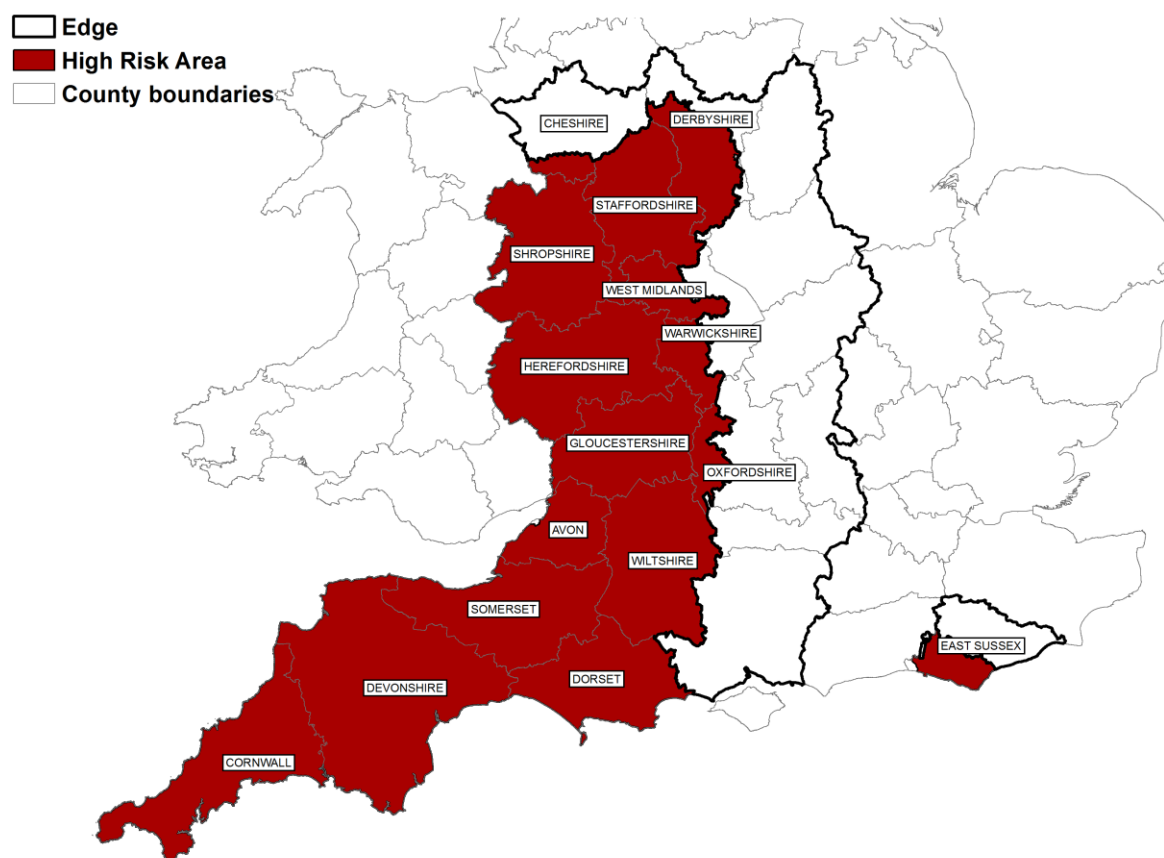


Figure 5.1.1. HRA county map, including the HRA sections of five counties with 'split' status between 2013 and 2017)

In this chapter, TB incidents are mostly reported with no distinction between status (fully confirmed (OTF-W) or strongly suspected (OTF-S)), due to the high positive predictive value³⁶ of the skin test in HRA, meaning above 90% of all TB test positive herds are infected³⁷.

The herd incidence rate in the HRA in 2017 was 19.2 TB incidents per 100 herd years at risk. Although the incidence rate increased by 7.3%, the change was not statistically significant ($p=0.2$, Table 5.1.1). This is further reflected when looking at the rate of new

³⁵ Counties with mixed HRA and Edge Area status are Cheshire, Derbyshire, East Sussex, Oxfordshire and Warwickshire. Data reported is for the HRA portion of these counties unless otherwise stated. From January 2018, these counties will fully move to the Edge Area.

³⁶ See Explanatory Supplement for description of PPV

³⁷ 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

breakdowns in section 4.1 (no significant change since 2011 so disease levels are plateauing, particularly in the HRA).

Table 5.1.1 Table of headline figures for the High Risk Area for TB in England

Year	Total number of new TB infected herds (TB incidents)	Incidence rate ¹	Median duration of TB incident (days) (interquartile range)	Prevalence ² (average monthly)
2017	3,259	19.2	172 (131 to 272)	11.4
2016	3,229	17.9	185 (146 to 289)	10.7
Change (%)*	+0.9	+7.3	-7.0	+6.3
Statistically significant*?	(p=0.7)	(p=0.2)	(p<0.01)	(p=0.4)

The z-test was used to compare incidence rates and prevalence between 2016 and 2017. The changes in total number of breakdowns and breakdown duration were compared using a chi-squared test.

¹ New TB infected herds per 100 herd-years at risk

² The percentage of herds under restriction due to a TB incident on average per month

County level risk for new infection with TB

The preferred measure of disease occurrence is incidence per 100 herd-years at risk, which reflects the rate at which new TB incidents are occurring. Figure 5.1.2 ranks counties and part-counties in the HRA by their incidence rate since 2013.

TB incidence increased in 12 HRA counties from 2016 to 2017. The highest incidence was observed in the HRA portion of Warwickshire (32 TB incidents per 100 herd years at risk), increasing by 65% since 2016. The absolute number of TB incidents increased from 26 in 2016 to 58 in 2017. This was followed by the Oxfordshire HRA, with 29 TB incidents per 100 herd years at risk, but again was based on lower absolute numbers of TB incidents. Whole HRA counties with higher TB incidence included Gloucestershire, Wiltshire and Avon, all showing an increase in 2017 compared to 2016.

Counties showing a decline in incidence in 2017 compared to 2016 were: Cornwall (-5%), Somerset (-1%) and West Midlands (-31% although only reflecting 3 TB incidents in total). The incidence rate in Devon did not change in 2017 compared to 2016. All other HRA counties had increased incidence rates in 2017 (between 4 and 65%).

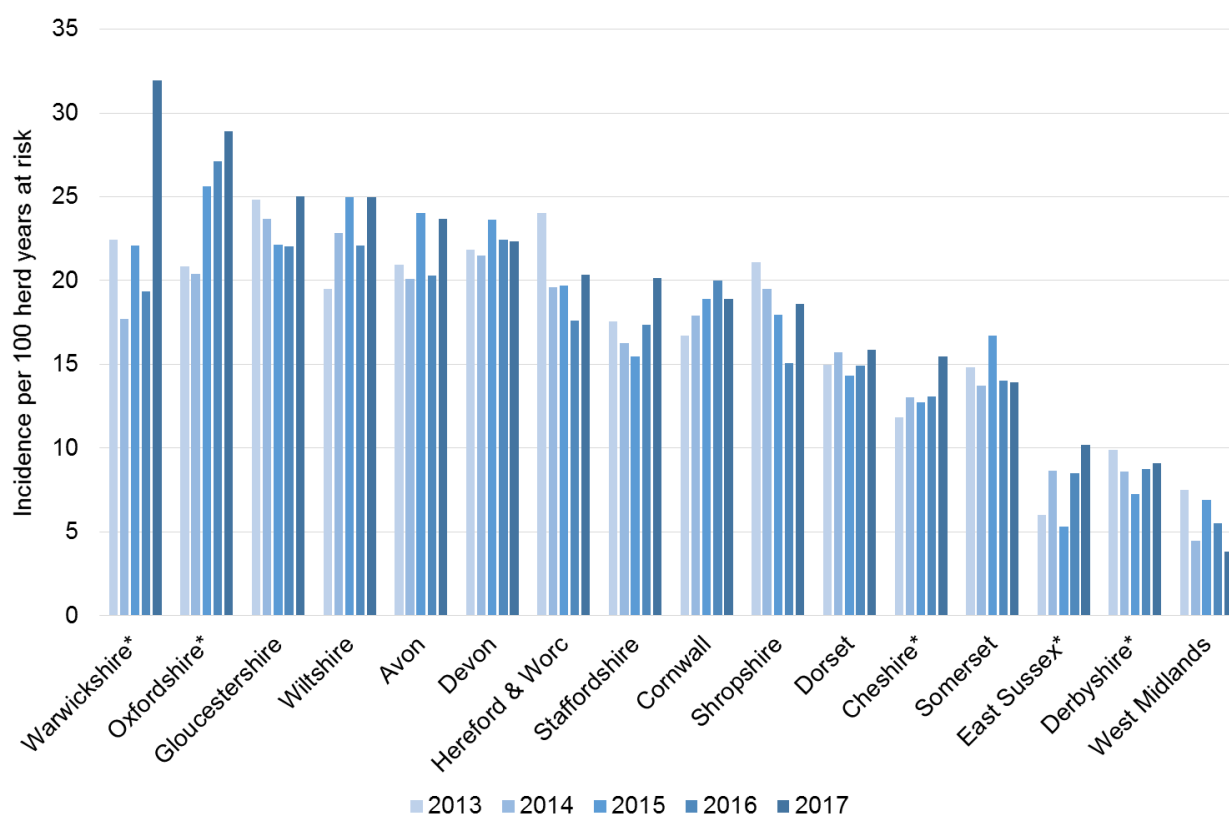


Figure 5.1.2. Incidence rate (per 100 herd-years at risk) from 2013-2017, by HRA county or part-counties (*) Areas ranked by incidence in 2017.

- Almost a quarter of herds in Gloucestershire, Wiltshire and Avon had a new TB incident in 2017.
- Incidence was higher in two split counties; Warwickshire and Oxfordshire, but the number of TB incidents was much lower compared to whole counties as they contain far fewer herds.

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 more cattle, the more TB incidents, but the extent of the proportional relationship varies between areas (Figure 5.1.3, also see 4.1.6a 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

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.

in the HRA were found, and 21% of herds (and 22% of cattle) are also located. This was followed by Cornwall, with 14% of TB incidents (and 12% of herds and cattle).

The different pattern seen between Figures 5.1.2 and 5.1.3 shows that incident rate is only partly associated with numbers of cattle and herds, and other factors are linked to TB infection. Thus despite these areas having lower numbers of both herds and cattle compared to other areas in the HRA, herds located in Oxfordshire HRA, Wiltshire, Gloucestershire, Avon and Warwickshire HRA have a high risk of becoming infected, as shown by the incidence rate (Figure 5.1.2).

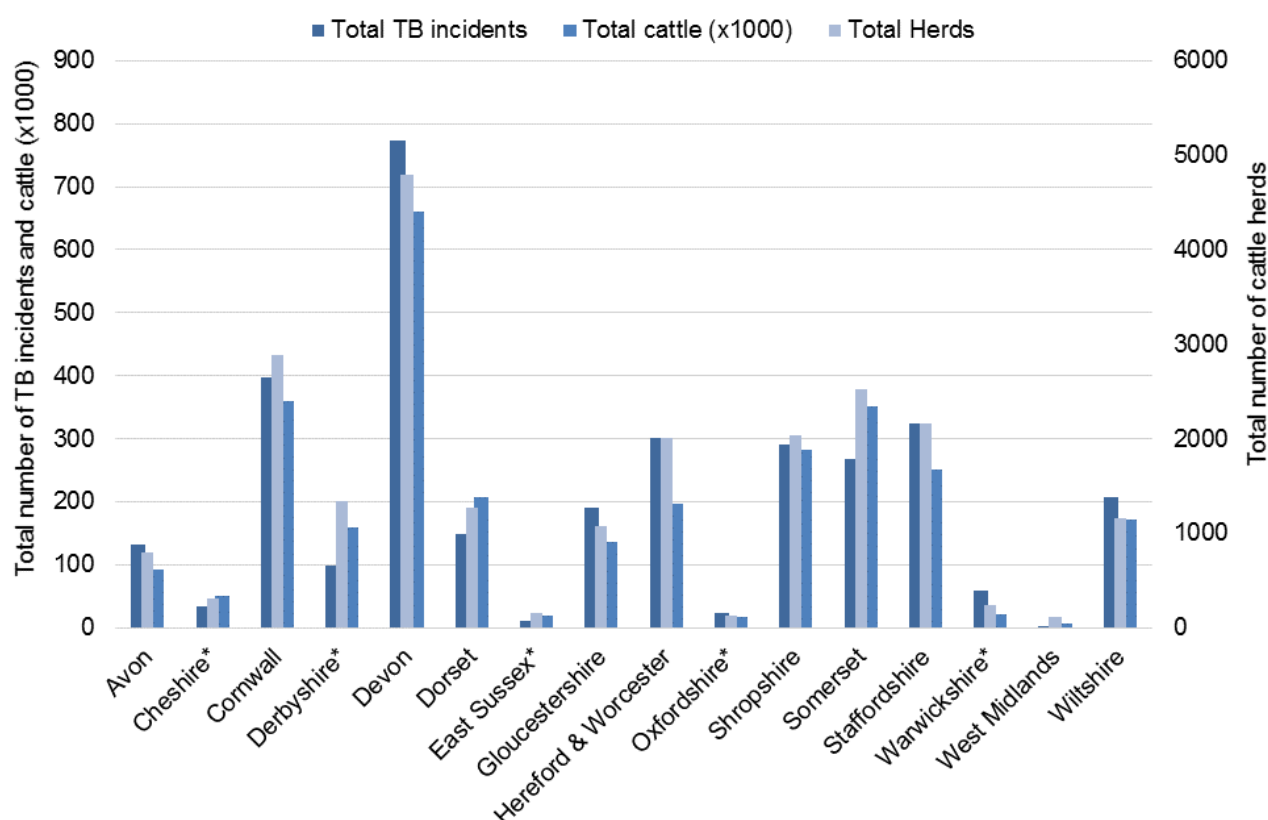


Figure 5.1.3. Number of cattle (x1000), herds and total TB incidents in 2017, by HRA county or split county (*)

- As expected, counties with larger numbers of cattle and herds, tended to have a greater number of TB incidents.

Figure 5.1.4 shows the relative numbers of herds, and proportions of large herds in the different areas of the HRA in 2017, 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 the area's incidence rate. Many areas with a high proportion of large herds have a relatively low incidence rate.

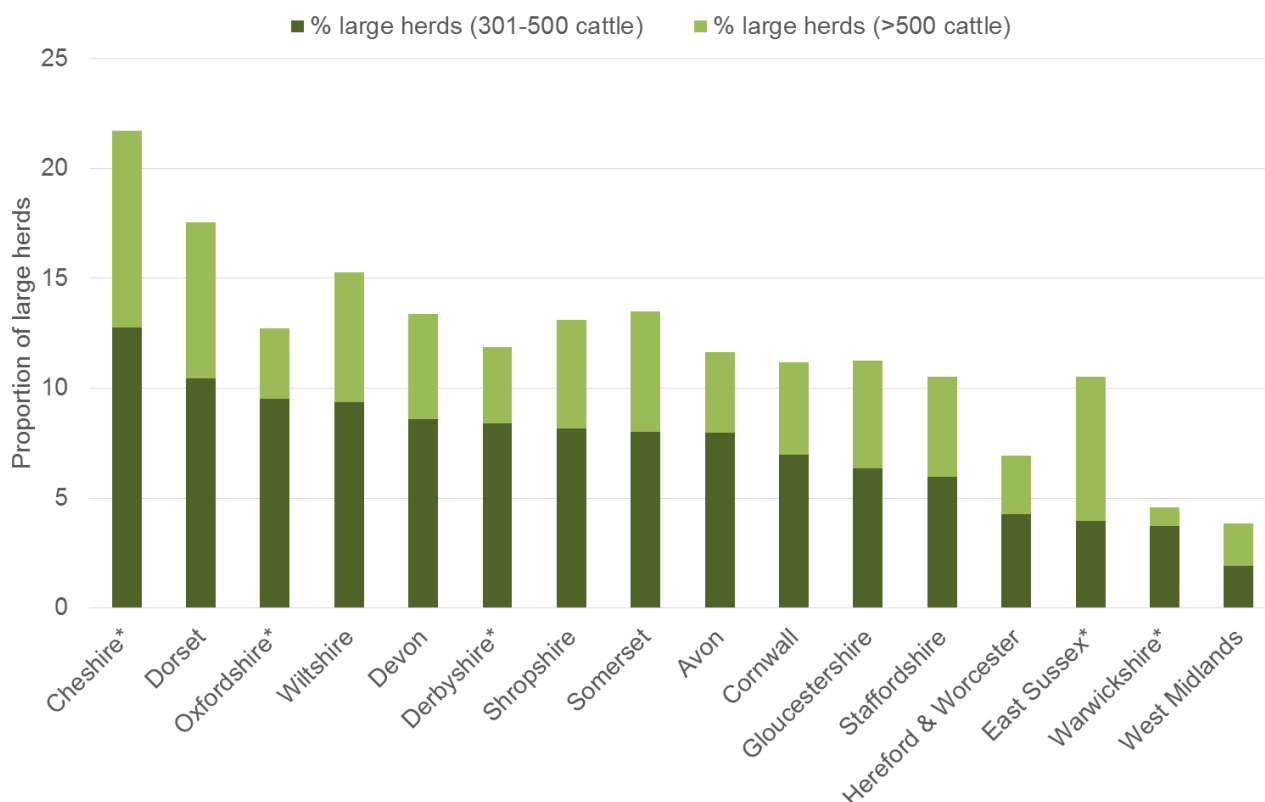


Figure 5.1.4. Proportion of large herds, by HRA county or split county (*) ranked by herds with 301-500 animals

- Cheshire HRA had the highest proportion of herds with greater than 300 cattle (19%) followed by Dorset (17%) and Wiltshire (15%).
- Three counties had a much lower proportion of herds with >300 animals: Hereford and Worcester (7%, 138 herds), West Midlands (3%, 3 herds) and Warwickshire (4%, 10 herds).

HRA counties are heterogeneous in terms of the abundance of dairy and beef cattle (see Figure 5.1.5a). Eight counties have higher numbers of beef cattle compared to dairy. Twenty-four per cent of beef cattle in the HRA are located in Devon (21% of dairy), which is not surprising as Devon holds more than 20% of all cattle in the HRA.

Half or more of beef cattle are beef finishing herds, rather than beef suckler herds in all except four HRA part-counties: Derbyshire (40.8%), East Sussex (42.3%), Oxfordshire (30.4%) and Warwickshire (47.0%).

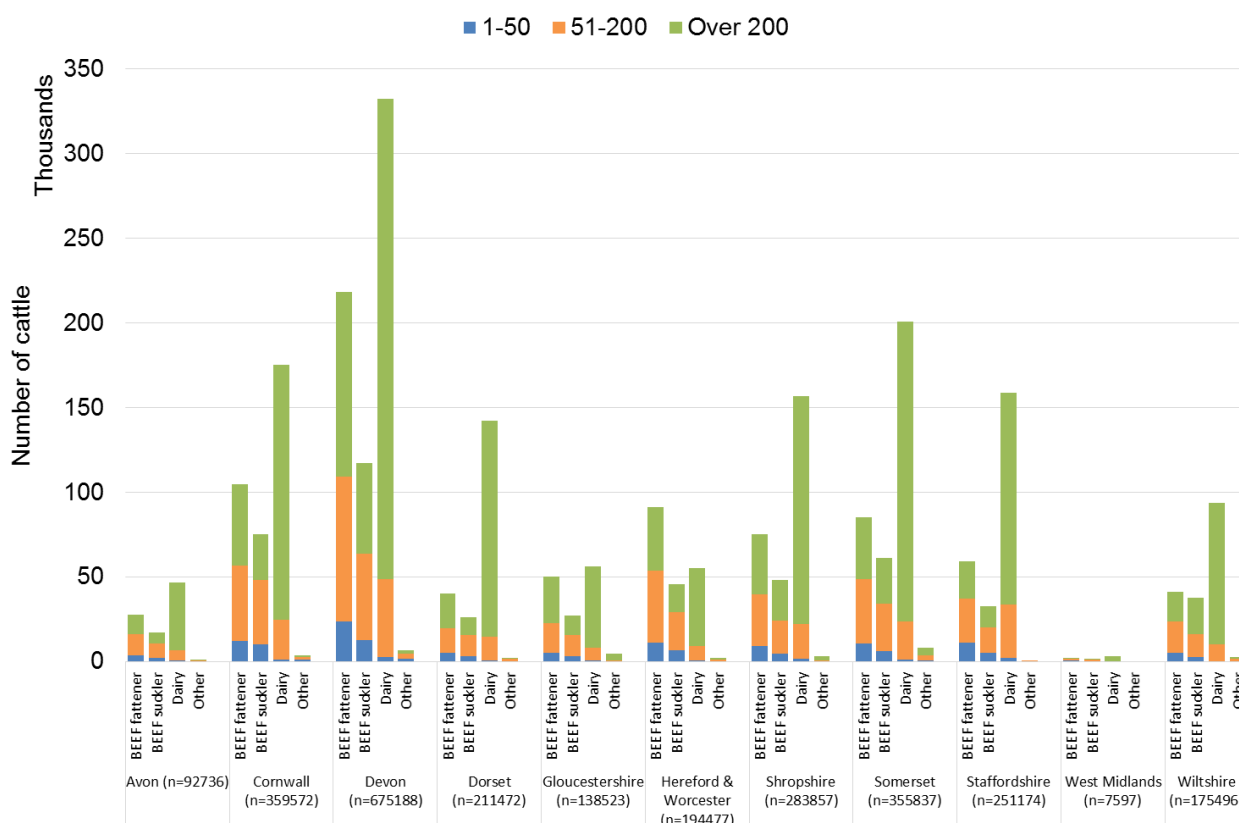


Figure 5.1.5a Demographic indicators at herd level by county in the HRA, 2017 (whole HRA counties)

- A larger proportion of larger herds (>200 cattle) tend to be dairy cattle.
- Beef herds are mostly small herds of 1-50 cattle.

The vast majority of cattle in small herds (1-50 cattle) are beef, ranging from a minimum of 81% of cattle in small herds in Cheshire HRA to 98% of cattle in small herds in Warwickshire HRA. In intermediate sized herds (51-200 cattle), the proportion of beef cattle remains fairly high (55-92%), apart from Cheshire HRA (47.2%).

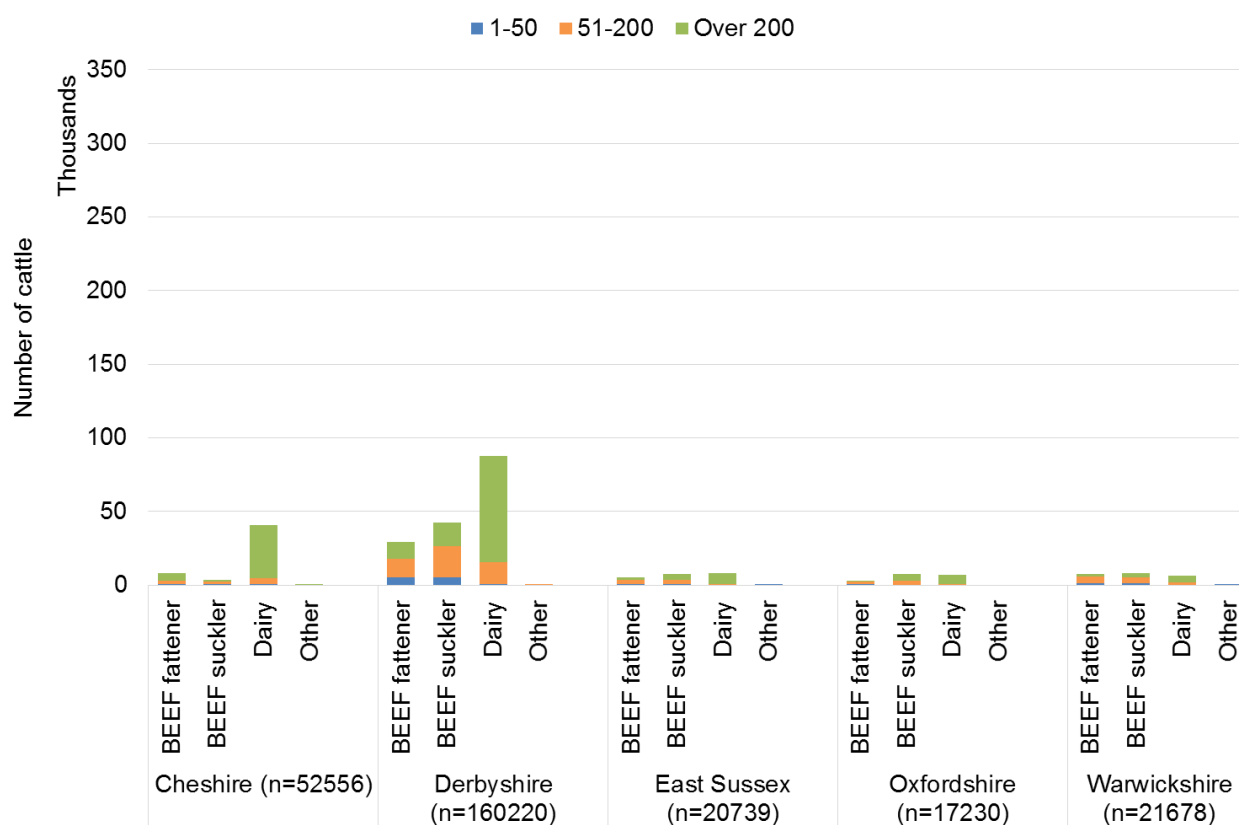


Figure 5.1.5b Demographic indicators at herd level by HRA split county, 2017

- The number of cattle are vastly lower in split HRA/ Edge counties but follow the same distribution pattern.
- Table 5.1.2 shows the total number of cattle by herd type and size for HRA/ Edge split counties in 2017.

Table 5.1.2. Demographic indicators at herd level by HRA split county, 2017

County	Herd type	1-50 cattle	51-200 cattle	Over 200 cattle
Cheshire (n=52,556)	BEEF fattener	933	2,000	5,117
	BEEF suckler	705	1,885	859
	Dairy	396	4,022	36,089
	Other	16	331	203
Derbyshire (n=160,220)	BEEF fattener	5,099	12,736	11,559
	BEEF suckler	5,257	21,352	16,093
	Dairy	856	14,508	72,182
	Other	135	443	0
East Sussex (n=20,739)	BEEF fattener	739	2,647	2,026
	BEEF suckler	410	3,113	3,847
	Dairy	96	389	7,407
	Other	65	0	0

Oxfordshire (n=17,230)	BEEF fattener	555	1,788	823
	BEEF suckler	198	2,526	4,528
	Dairy	0	465	6,347
	Other	0	0	0
Warwickshire (n=21,678)	BEEF fattener	1,427	4,293	1,555
	BEEF suckler	1,016	4,169	3,020
	Dairy	0	1,667	4,518
	Other	13	0	0

Characteristics of TB in the HRA and differences between counties

Number of new TB infected herds

The number of TB infected herds is important in terms of resource planning and number of businesses impacted. Up to April 2016, the management of fully confirmed (OTF status withdrawn – OTF-W) and highly suspected (OTF status suspended – OTF-S) TB incidents differed in the HRA, with the latter requiring fewer tests prior to lifting restrictions, leading to a shorter TB incident duration.

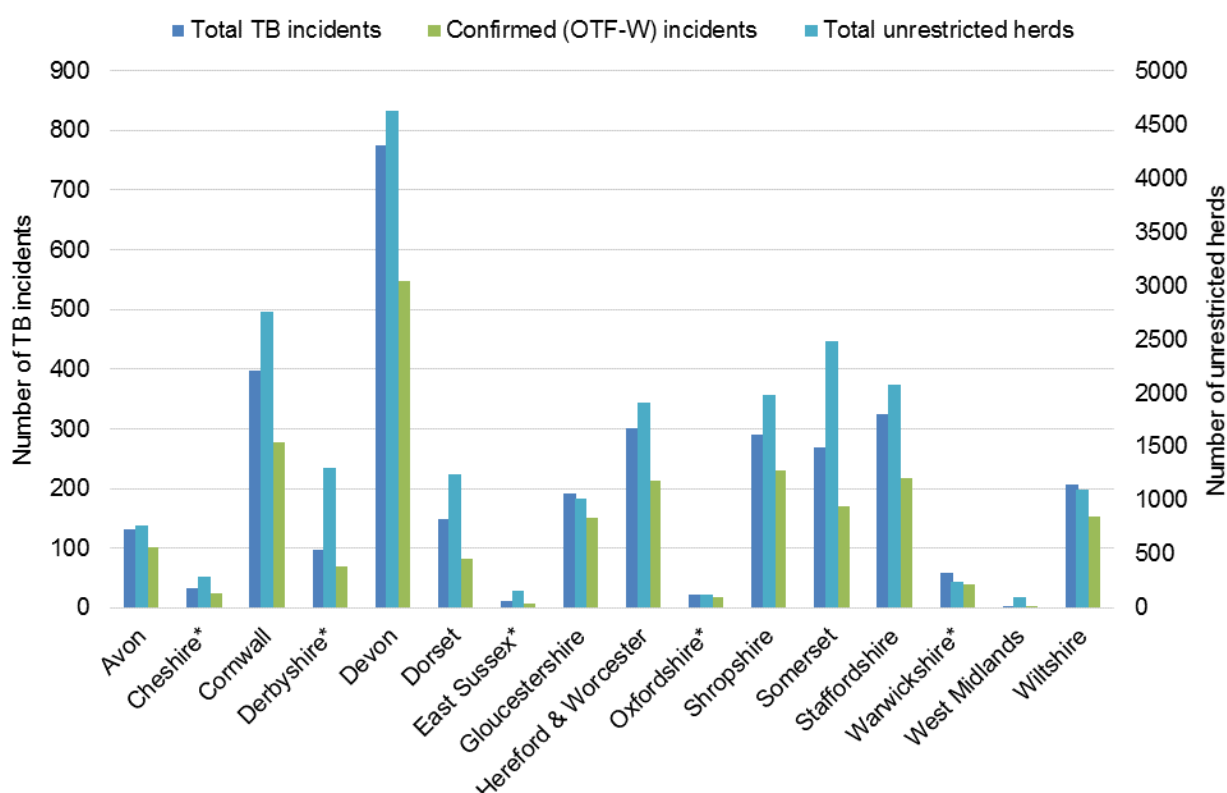


Figure 5.1.6. Comparison between the number of TB incidents (total and confirmed) and unrestricted herds in 2017, by HRA county or split county (*)

- Overall, there was a 0.9% increase in the total number of incidents in the HRA in 2017, compared to 2016. The proportion of TB incidents with OTF status withdrawn ranged from 56% in Dorset to 100% in West Midlands (n=3)

Prevalence reflects the proportion of herds that are infected with TB at a given point in time, and specifically when reporting at county level, prevalence is measured by calculating the proportion of herds under restriction (due to a TB incident) at the end of the year, divided by the number of herds in existence at the end of the reporting year. Further notes on the methodology of incidence and prevalence measures are described in the Explanatory Supplement³⁹.

Figure 5.1.7 presents prevalence figures for the past five years by HRA county. Differences in prevalence reflect both incidence and variations in the duration of the TB incident, as well as the timing of the start of the incident.

The split counties of Oxfordshire HRA & Warwickshire HRA had the highest total prevalence rates in 2017 (21% and 17% respectively). They are also amongst the most variable over the past 5 years due to their smaller number of herds. Gloucestershire had the highest whole county total prevalence rate in 2017 at 16%. Aside from these three county areas, all other areas were at or below 15%. The lowest total prevalence rates were seen in West Midlands (1%), East Sussex HRA (3.3%) and Derbyshire HRA (5%).

³⁹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/739944/tb-epidemiology-2017-suppl.pdf

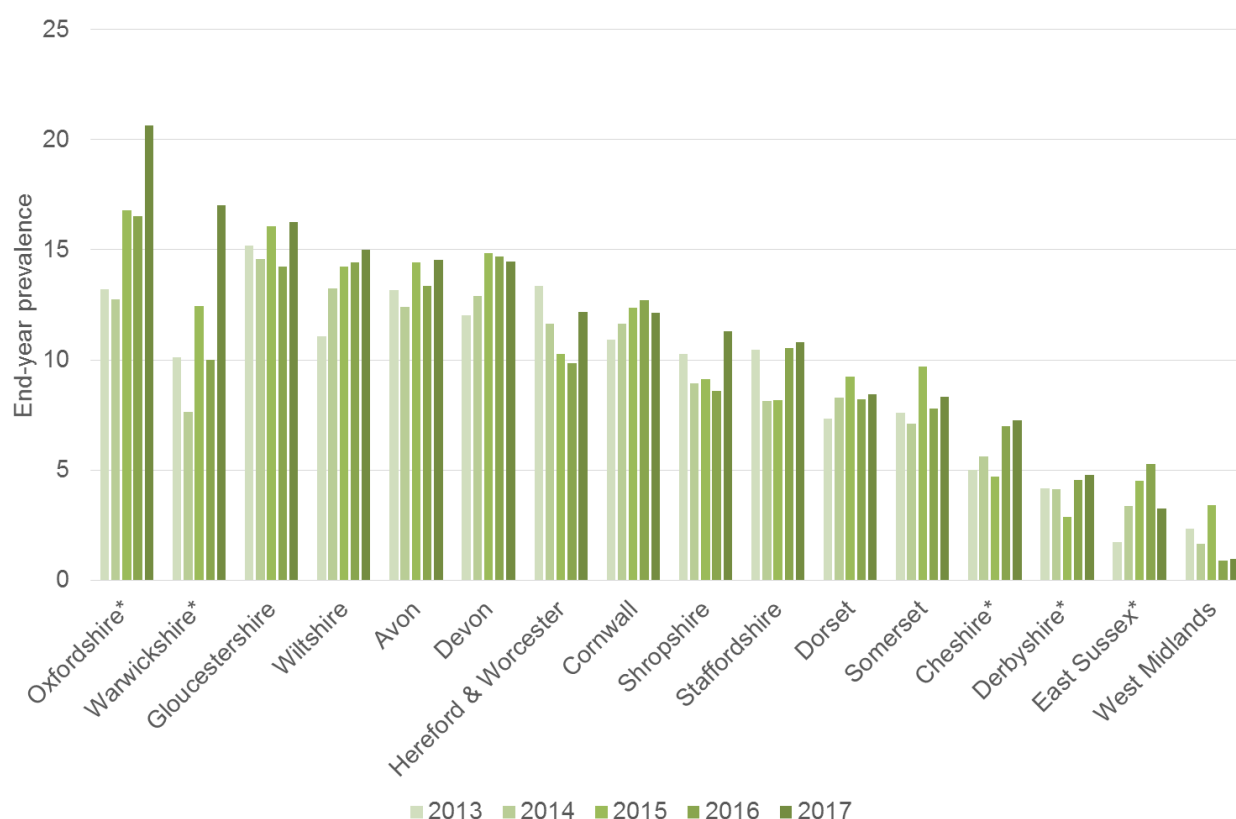


Figure 5.1.7. Total prevalence of TB in 2017, by HRA county or split county (*), ranked by prevalence in 2017

- The highest prevalence rates were observed in Oxfordshire HRA and Warwickshire HRA, and for whole counties, Gloucestershire.

TB incident duration and persistence

In 2017, there was a total of 3,126 TB incidents in the HRA that ended during the reporting year. Herds were under movement restrictions for longer in Oxfordshire HRA (median 241 days), Cornwall (210 days) and East Sussex HRA (207 days).

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

The high positive predictive value of the skin test in the HRA⁴⁰ together with the need to intensify the efforts to tackle disease in this area and reduce recurrence (57% in the HRA in 2017), justifies this measure. This, along with the increased use of the interferon-gamma

⁴⁰ 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

blood test in the HRA since April 2017, will help reduce recurrence due to recrudescence and may also reduce the severity of incidents. Other measures implemented in the HRA also contribute to reducing recurrence, for example encouraging good biosecurity and badger culling both target recurrence due to reinfection.

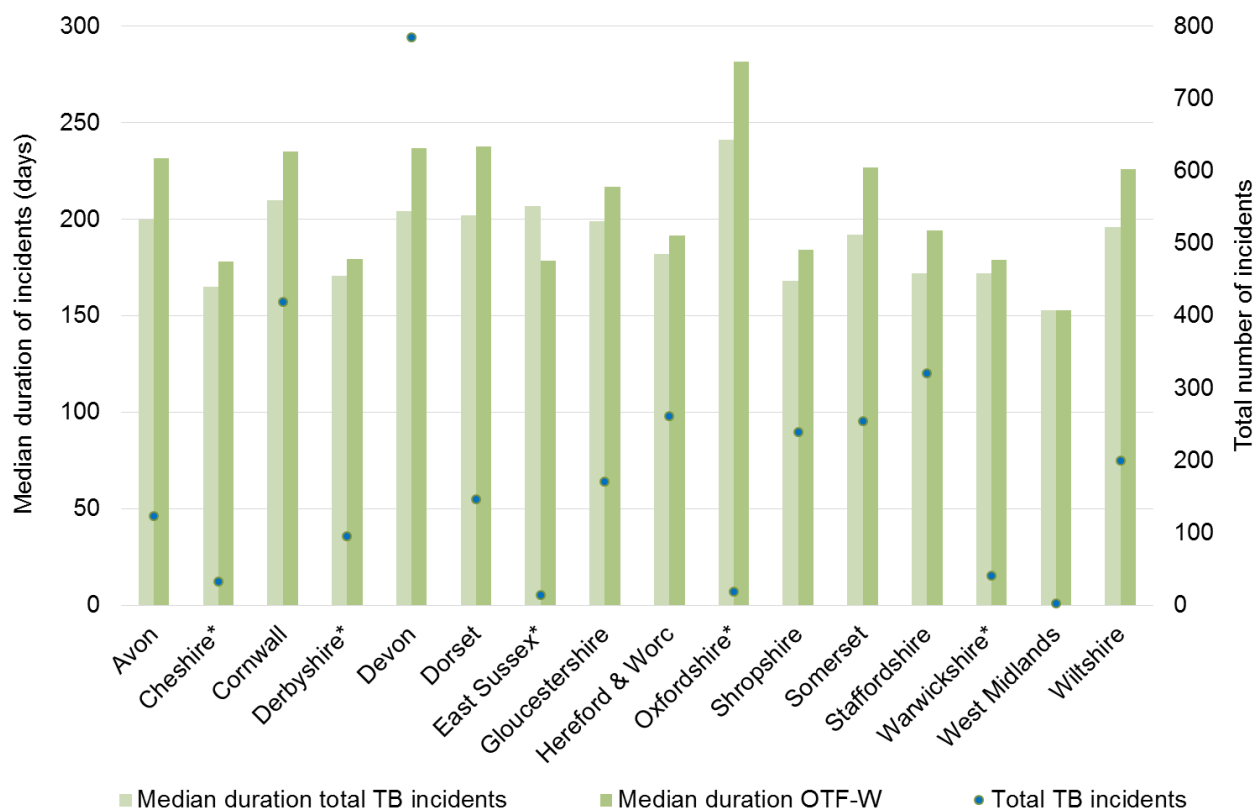


Figure 5.1.8. Total number of incidents that closed in 2017 and their median duration (days), by HRA county or split county (*)

- For most whole counties (apart from West Midlands where there were only three confirmed TB incidents), duration of herds under movement restrictions was higher in confirmed (OTF-W) incidents compared to total TB incidents.
- Median duration was highest in Oxfordshire HRA (282 days for confirmed TB incidents), but based on only 19 TB incidents.

Herds under movement restrictions for more than 550 days are deemed to be persistent and are eligible for enhanced management procedures (Figure 5.1.9). Of the total TB incidents in the HRA ending in 2017, 6.7% were persistent. Further details on persistent herds are described in [section 4.4](#).

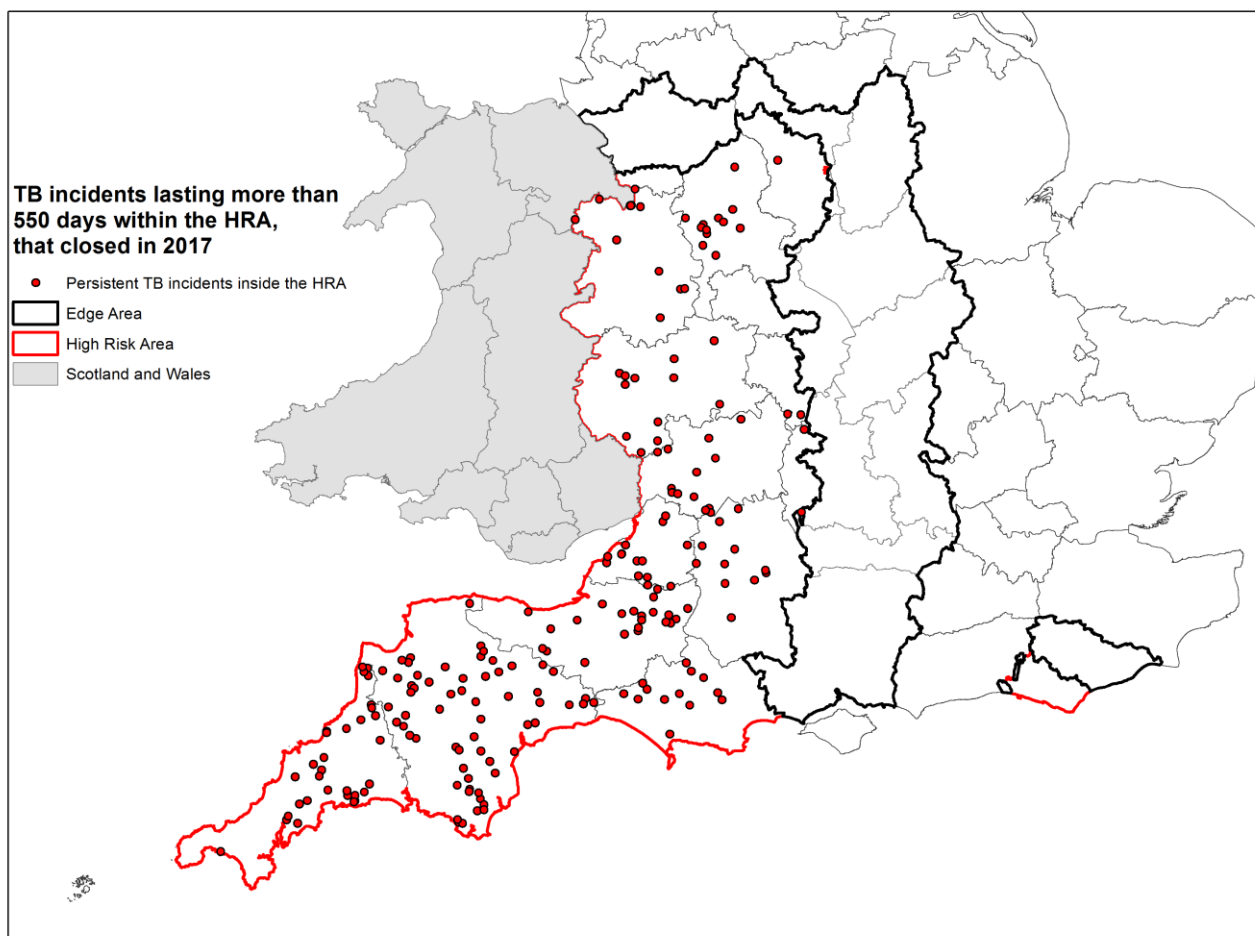


Figure 5.1.9. Distribution of persistent TB incidents (duration over 550 days) that closed in 2017 in the HRA

- None of the TB incidents that closed in 2017 were persistent in Cheshire HRA, East Sussex HRA and West Midlands.
- A large number of persistent TB incidents that closed were located in Devon, Cornwall and Somerset.

TB surveillance and incident detection

In the HRA overall, 11% of TB incidents were disclosed through slaughterhouse (SLH) surveillance with variation between counties, from 0% in Oxfordshire HRA and West Midlands, to 15% in Cheshire HRA (Figure 5.1.10).

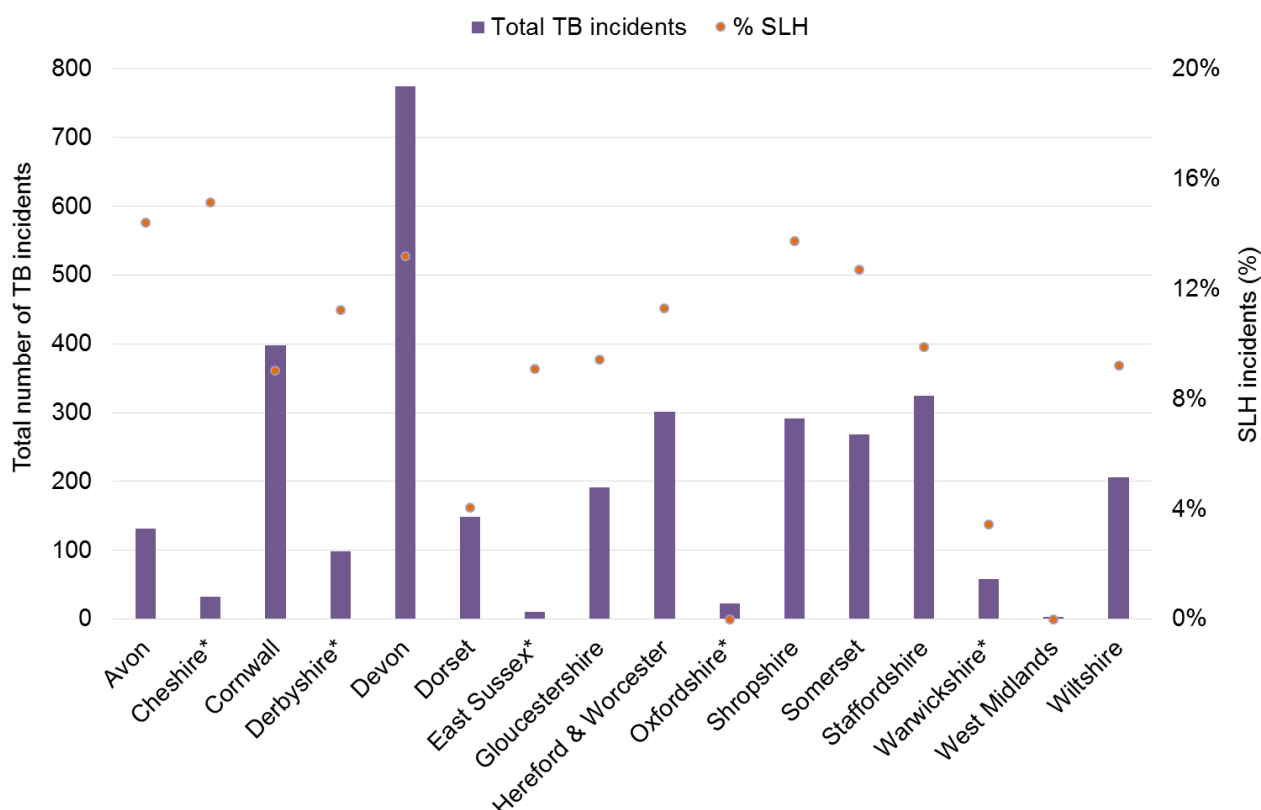


Figure 5.1.10. Total TB incidents and percentage disclosed by slaughterhouse inspection in 2017 by HRA county or split county (*)

Figure 5.1.11 shows the proportion of TB infected herds by surveillance stream and county. The highest proportion of incidents disclosed by Area & Herd Risk tests were in Warwickshire HRA (59%) followed by Avon (58%).

All three TB incidents in West Midlands were disclosed by routine testing. Nine of the 11 total incidents in East Sussex HRA were also disclosed through routine testing. Higher proportions of TB incidents disclosed by routine testing were in split HRA/ Edge Area counties: Cheshire HRA (48%), Derbyshire HRA (46%) and Oxfordshire HRA (39%).

The highest proportion of TB incidents disclosed by private testing was in Somerset and Shropshire (both 11%) and Derbyshire HRA (10%).

Oxfordshire HRA and West Midlands did not disclose any TB incidents through SLH surveillance; the highest proportions of TB incidents disclosed by this surveillance stream was observed in Cheshire HRA (15%) and Avon (14%).

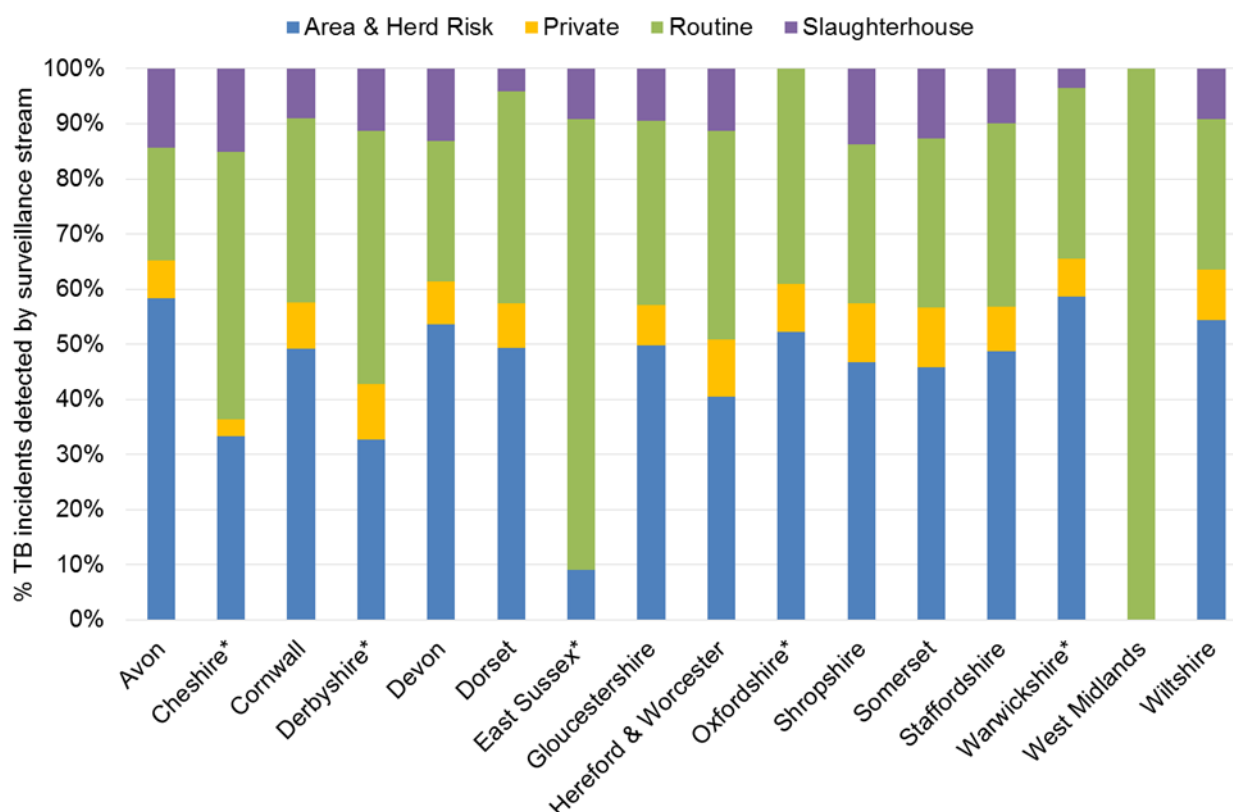


Figure 5.1.11. Proportion of TB infected herds in 2017 in each surveillance stream, by HRA county or split county (*)

Dealing with infected herds in the HRA

Since April 2016, all incidents in the HRA must have two consecutive severe interpretation skin tests with negative results before restrictions are lifted. The most efficient tests at detecting incidents within the Area and Herd Risk surveillance stream in the HRA were check tests carried out 6 months after restoration of OTF herd status (6M) disclosed 23 TB incidents per 100 herds tested, and check tests completed 12 months thereafter (12M) disclosed 22 TB incidents per 100 herds tested.

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 during TB incidents, which is the primary screening test. The total number of IFN- γ tests carried out in the HRA remains over 6,000 since 2012 and almost tripled between 2016 and 2017 (n=21,700).

Tests in the HRA represent only 5% of all IFN- γ tests carried out since 2009, and 22% of the 97,800 carried out in 2017. The majority of IFN- γ tests in 2017 were carried out in Devon (35% of total, 23% in 2016).

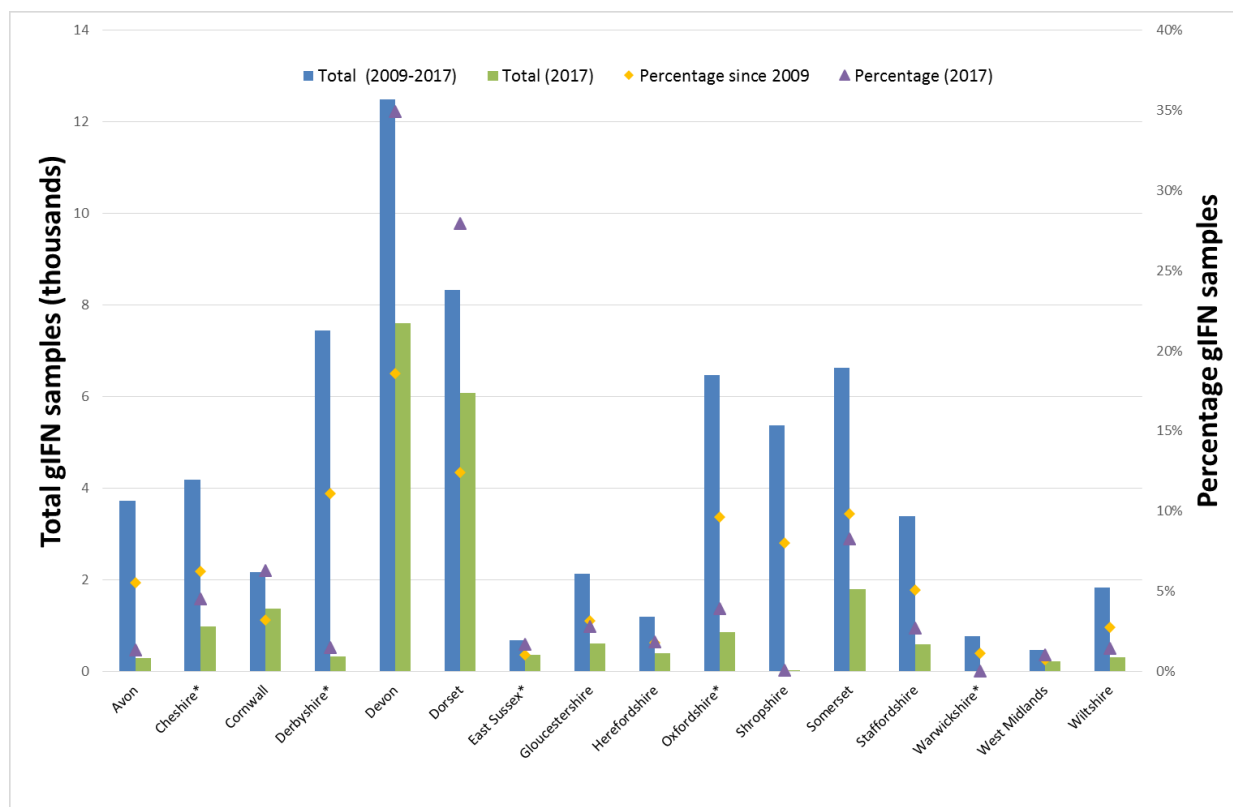


Figure 5.1.12. Number of IFN-γ samples per HRA county, or portion of mixed HRA/Edge Area County, since 2009

There is great variability between counties and years not only due to the discretionary application to TB incidents of the tests, but also to the fact that the number of samples taken in each TB incident depends on the number of cattle over six months present in the herd. In addition, sometimes only specific epidemiological groups are tested rather than the whole herd over six months of age. HRA IFN-γ reactors represented 40% of all IFN-gamma reactors in England (21% 2016), but their confirmation rate was much higher (15%, but down from 27% in 2016) compared to the confirmation rate in Edge and LRA (3%).

TB control in wildlife

Ten new badger control areas were authorised in the HRA and one in the Edge Area in 2017, giving a total of 21 licensed badger control areas as of the end of 2017 (including two areas in the HRA that had completed four annual culling seasons and entered a period of supplementary culls). Further information can be found in section [4.5](#).

5.2 Edge Area

- The Edge Area is the buffer zone of intermediate incidence and prevalence located between the HRA and the LRA and is made up of counties or part-counties (denoted by an asterisk prefix). Some of the disease surveillance and control measures in force in the Edge Area are stricter than those in the HRA.
- The TB epidemic continued to increase in the Edge Area in 2017, with the annual incidence across the whole area up from 6.7% to 7.7%. This was driven by increases primarily in Berkshire, Buckinghamshire and *Cheshire, and to a lesser extent by Northamptonshire and *East Sussex. In Nottinghamshire there was a notable reduction in incidence, while the remaining counties or part-counties have shown no change or a slight reduction. Oxfordshire continues to be the county with the highest risk in the Edge Area.
- Overall numbers of incidents remained low in most counties/part counties in the Edge Area compared to the HRA, with totals less than 50, apart from Oxfordshire (55 TB incidents) and Cheshire sections of the Edge Area (149 TB incidents).
- The only possible candidate county for OTF status in the foreseeable future is Nottinghamshire, although buying practices need to be improved to reduce the threat from undisclosed infection in purchased cattle.
- In most counties there is evidence that infected herds are being discovered sooner after infection is introduced than in the past, indicating some success in the surveillance strategy. However the increasing incidence confirms the need for additional controls, including those introduced in 2017 and 2018 (see Explanatory Supplement for details on enhanced TB control measures deployed in recent years).

Introduction

The Edge Area, one of the three management areas for TB in England, was established in January 2013 and was later incorporated into the Government's strategy to achieve Officially Bovine Tuberculosis Free (OTF) status for England by 2038. It sits within the annual testing area of England, creating a zone of increased surveillance between the HRA which has a much higher incidence of TB and the LRA where TB is close to eradication. Edge Area control efforts seek to slow down and reverse geographic spread and reduce the incidence rate, with the aim of obtaining OTF status for this area as soon as possible.

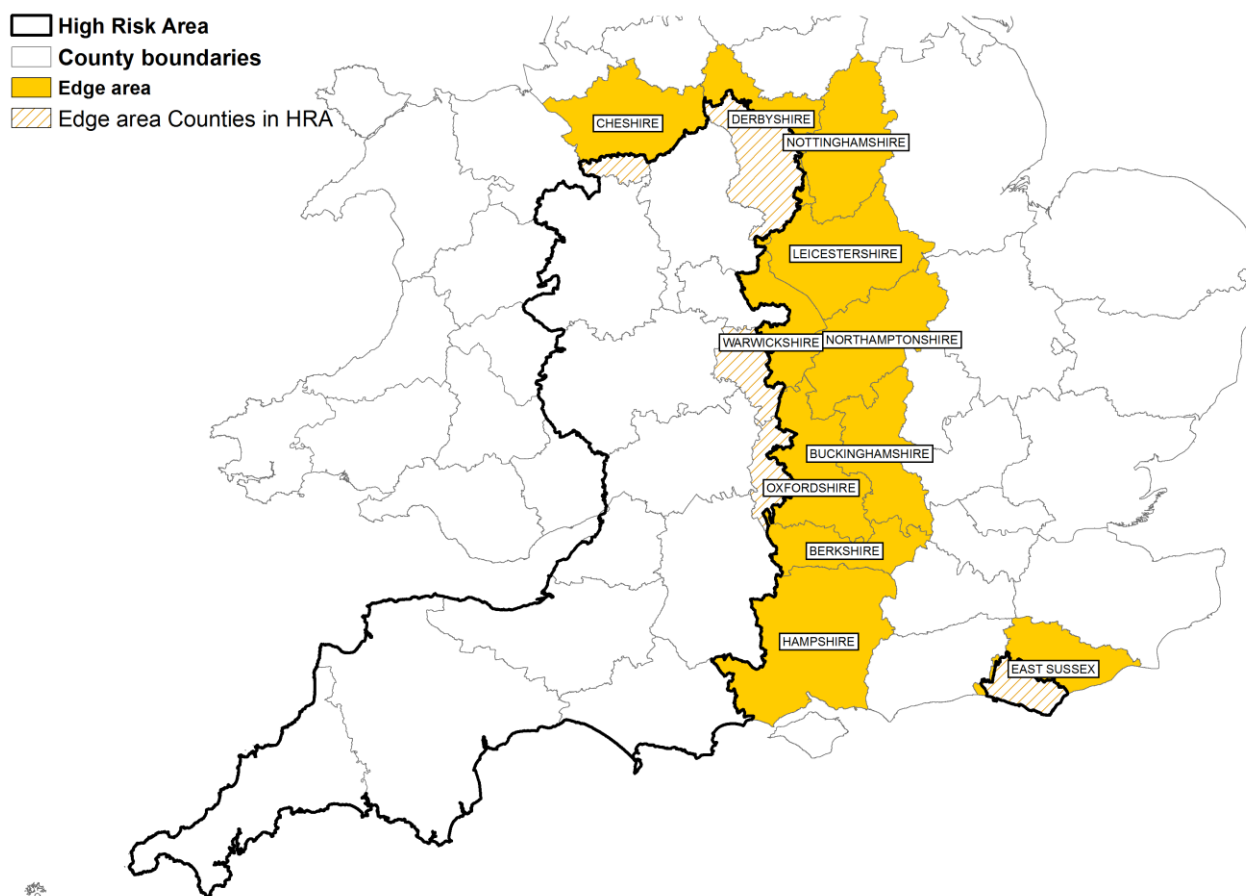


Figure 5.2.1 Counties and part-counties in the Edge Area

In 2017 the Edge Area consisted of six whole counties and five part-counties (identified by an asterisk prefix) as shown in Figure 5.2.1. The Edge Area extends up the middle of England from Hampshire to *Cheshire. Its extent was defined in 2013, at county level where possible. However, where there were substantial differences across a county only the relevant parishes of that county were included in the Edge Area. The aim was to set the boundary with the HRA at the outer edge of the area of known endemic disease and the boundary with the LRA to include areas where the incidence of TB was currently low, but that were at risk of the geographic spread of disease in the short to medium term.

Beef herds predominate in all counties in the Edge Area except *Cheshire, where dairy herds predominate. Leicestershire and Hampshire also have substantial numbers of dairy herds. In all counties, dairy herds tend to be large, while beef herds are small to medium, although there are some large beef finishing units.

Incidence and prevalence of TB in the Edge Area

The total number of TB incidents in each Edge Area county/part-county for the last five years is shown in Figure 5.2.2. There has been a generally increasing trend in seven of the eleven counties, the exceptions being *Derbyshire, Hampshire, Nottinghamshire and Warwickshire,

which have shown some yearly fluctuation but are either plateauing or reducing. In terms of burden of disease, the number of incidents in *Cheshire is much higher than in the other Edge Area counties.

Increases in the total number of incidents in 2017 compared to 2016 were observed in five of the 11 Edge Area counties; the exceptions were *Warwickshire (no change), *Derbyshire, Hampshire, Leicestershire, Nottinghamshire and *Oxfordshire (all decreases).

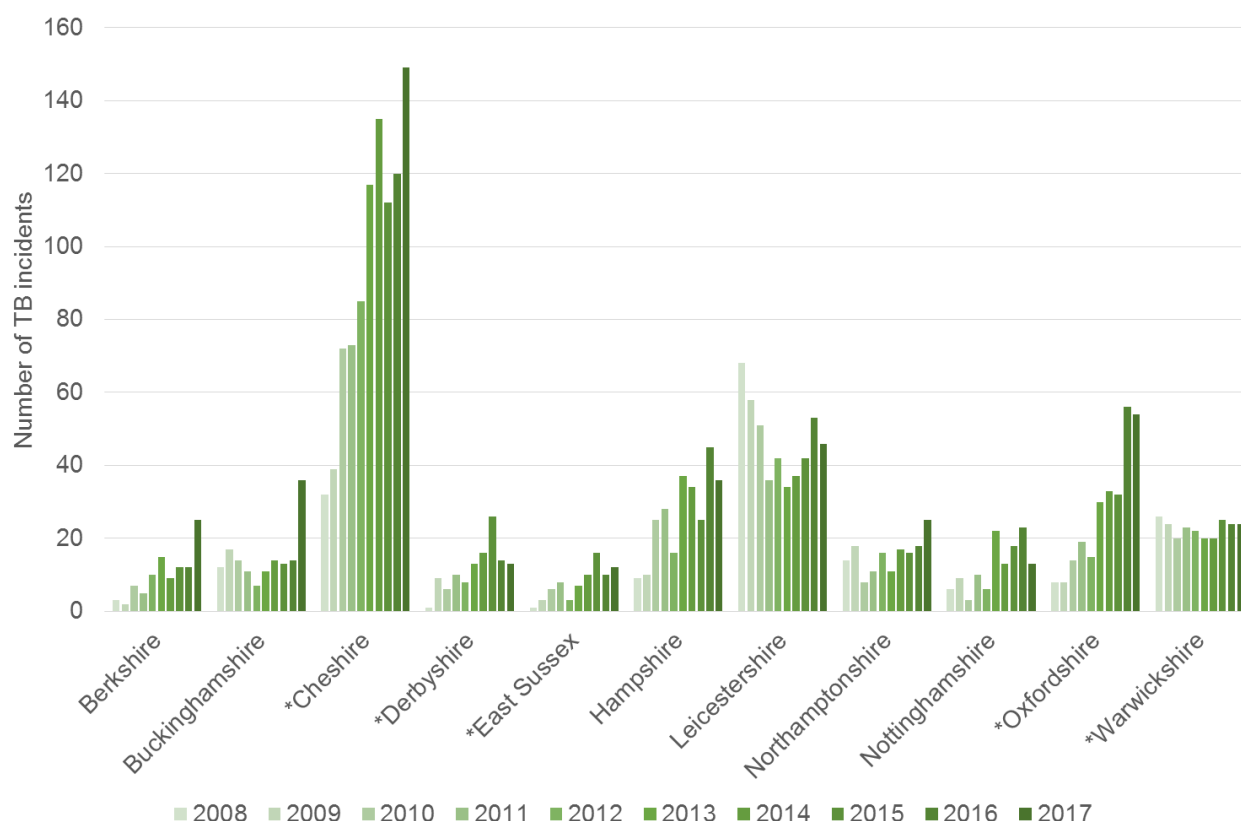


Figure 5.2.2. Number of TB incidents by Edge Area county or part county (*), 2008 to 2017

- The total number of TB incidents in the Edge Area has continued to increase overall, and by county. Increases in the total number of incidents in 2017 compared to 2016 were observed in five Edge Area counties/ part counties.

Across the whole Edge Area the 2017 incidence rate⁴¹ was 7.7, up from 6.7 in 2016 (15% increase) as shown below (Table 5.2.1).

⁴¹ In this report the incidence rate and the final estimate of prevalence are presented as the data are now available.

Table 5.2.1 Table of headline figures for the Edge Area of England

Year	Total number of TB infected herds	Incidence rate ¹	Median duration of TB incident (days) (interquartile range)	Prevalence ² (average monthly)
2017	434	7.7	186.5 (151 to 242)	3.9
2016	387	6.7	165.5 (140 to 238)	3.3
Change (%)	+12.1	+15.1	+12.7	+17.7

¹ TB infected herds per 100 herd-years at risk

² The percentage of herds under restriction due to a TB incident on average per month

However, there was wide variation between counties (Figure 5.2.2) with county-level (or part-county) incidence ranging from a high of 16% in *Oxfordshire down to 3% in Nottinghamshire and *East Sussex. The incidence rate in all counties remains above the level defined by the EU for OTF status, namely <0.1% annual fully confirmed ('OTF-W') incidence (note this target relates to the simpler measure of number of cases per 100 OTF herds tested). The EU definition also requires 99.9% of herds to have remained OTF for at least six consecutive years (equates to a point prevalence of <0.1%).

There were five Edge Area counties showing a decline in incidence in 2017 compared to 2016: *Oxfordshire, Leicestershire, Hampshire, *Derbyshire, and Nottinghamshire.

Six Edge Area counties had an increased incidence rate in 2017 compared to 2016, with notable increases in Berkshire and Buckinghamshire where the incidence rate more than doubled (although the total number of TB incidents was still fairly low). *Cheshire has shown a continued increase in incidence over the past five years and in 2017 was at its highest at 15 TB incidents per 100 herd-years at risk. Oxfordshire remained as the county in the Edge Area with the highest incidence rate (16 TB incidents per 100 herd-years at risk). The likely source of infection that has contributed to these increases is discussed below (Figure 5.2.6).

Figure 5.2.2 also displays the 2017 end-of-year prevalence. Prevalence⁴² rate reflects both the incidence of new disease and the duration of restrictions, and so to some extent reflects the requirements for lifting restrictions.

⁴² Prevalence is calculated as the percentage of live herds under restriction due to a TB incident at the end of the year

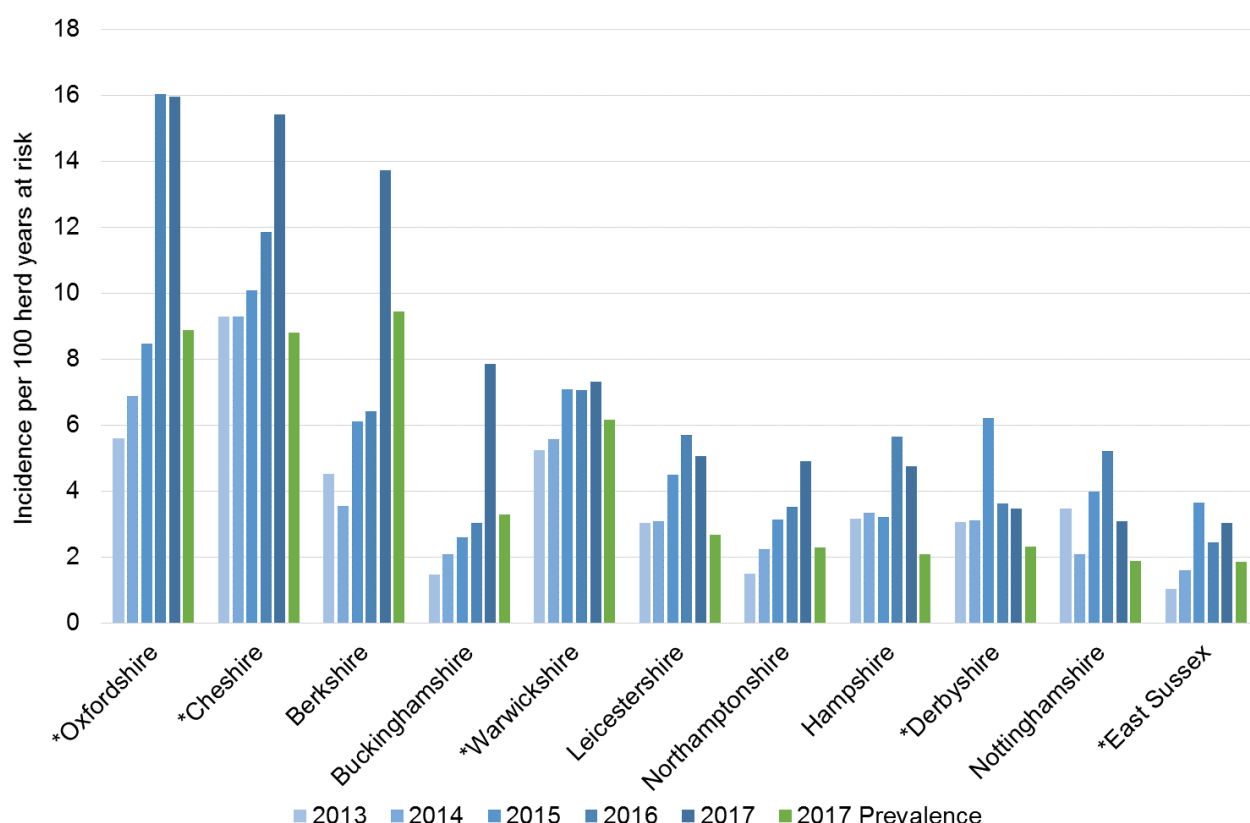


Figure 5.2.3. Annual incidence rate 2013 to 2017 & 2017 end-year prevalence, by Edge Area county or part county (*)

- Edge Area counties are ranked by 2017 incidence rates (per 100 herd years at risk); *part county.
- Given current policy and effective removal of infection, the end-year prevalence value should ideally be less than half the annual incidence value for each county/part county

The duration of restrictions reflects the level of evidence required to give confidence that infection has been removed from a TB incident herd (Figure 5.2.3). A new policy in the Edge Area was introduced in 2014, requiring all incident herds to have two consecutive herd tests with negative results at severe interpretation prior to lifting of restrictions, irrespective of post-mortem and bacteriological results (the same policy was adopted in the HRA in April 2016). This inevitably takes over four months⁴³, so at any one time prevalence will have a minimum value over one third of the annual (12 month) incidence, with increasing values above this suggesting a longer than average duration of restrictions. This is the case with *Warwickshire in particular, where low incident numbers, two persistently infected herds and almost 40% of incidents occurring in the latter 4 months of the year all have a visible impact on the prevalence calculation (Figure 5.2.3).

⁴³ Two clear tests at 60 day intervals are required to raise restrictions so all incidents inevitably have a duration of >120 days plus time for reactor removal, disinfection, administrative requirements, etc.

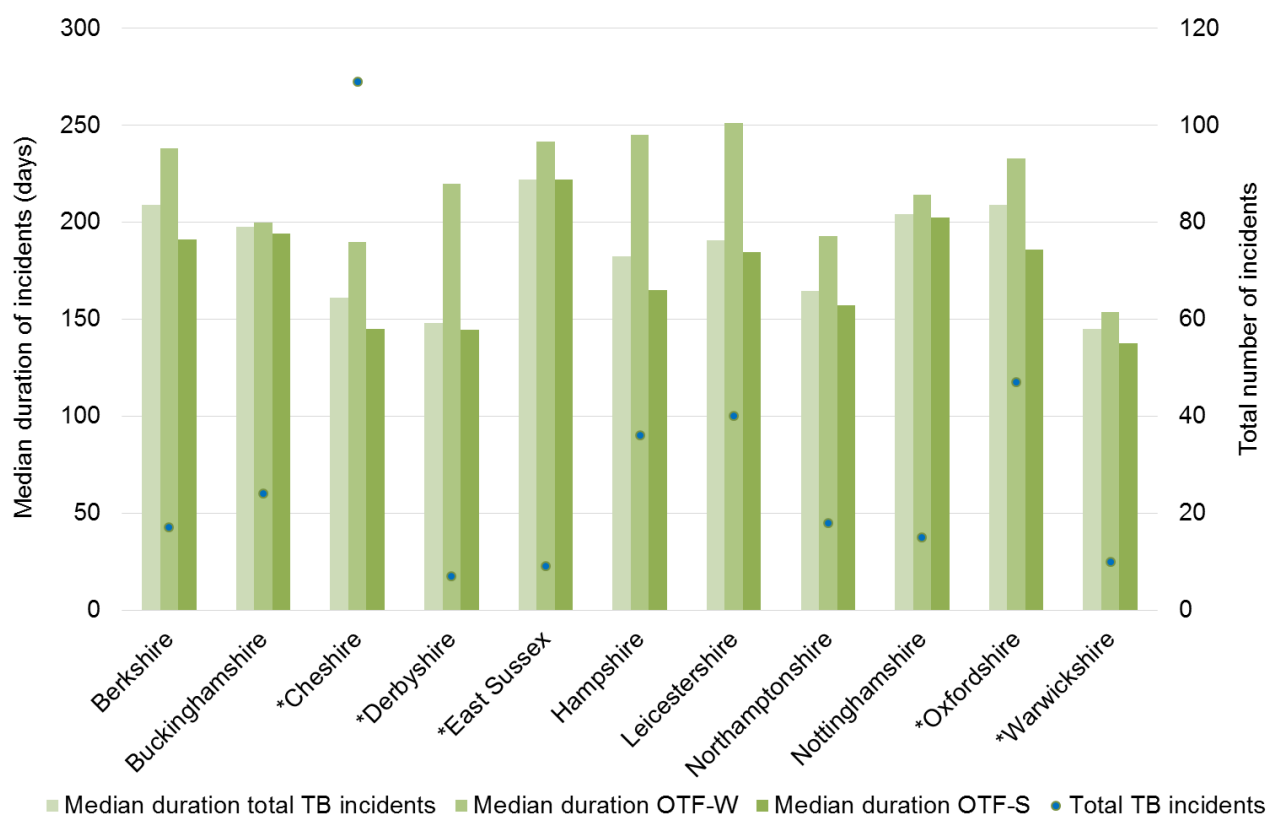


Figure 5.2.4. Total number of incidents that closed in 2017 and their median duration (days) by confirmation status, by Edge Area county or part county (*)

- The median duration of TB incidents is inevitably at least 120 days, due to the requirement of two tests with negative results at 60 day intervals to restore the OTF status of the affected herd.
- Median duration of confirmed (OTF-W) incidents is higher than that of suspected (OTF-S) incidents in all counties.
- Edge Area counties with median duration of 200 days or more (~8 months) was observed in Berkshire, *East Sussex, Nottinghamshire and *Oxfordshire.

Cattle herd demographics

Figure 5.2.5 shows the proportions of large herds (301-500 and >500 cattle), ranked by counties with the largest proportion of herds with 301-500 cattle. Edge Area counties have an average of 10% or fewer large herds, apart from *Cheshire (17% of herds with >300 cattle), Buckinghamshire (12%) and *Oxfordshire (11%).

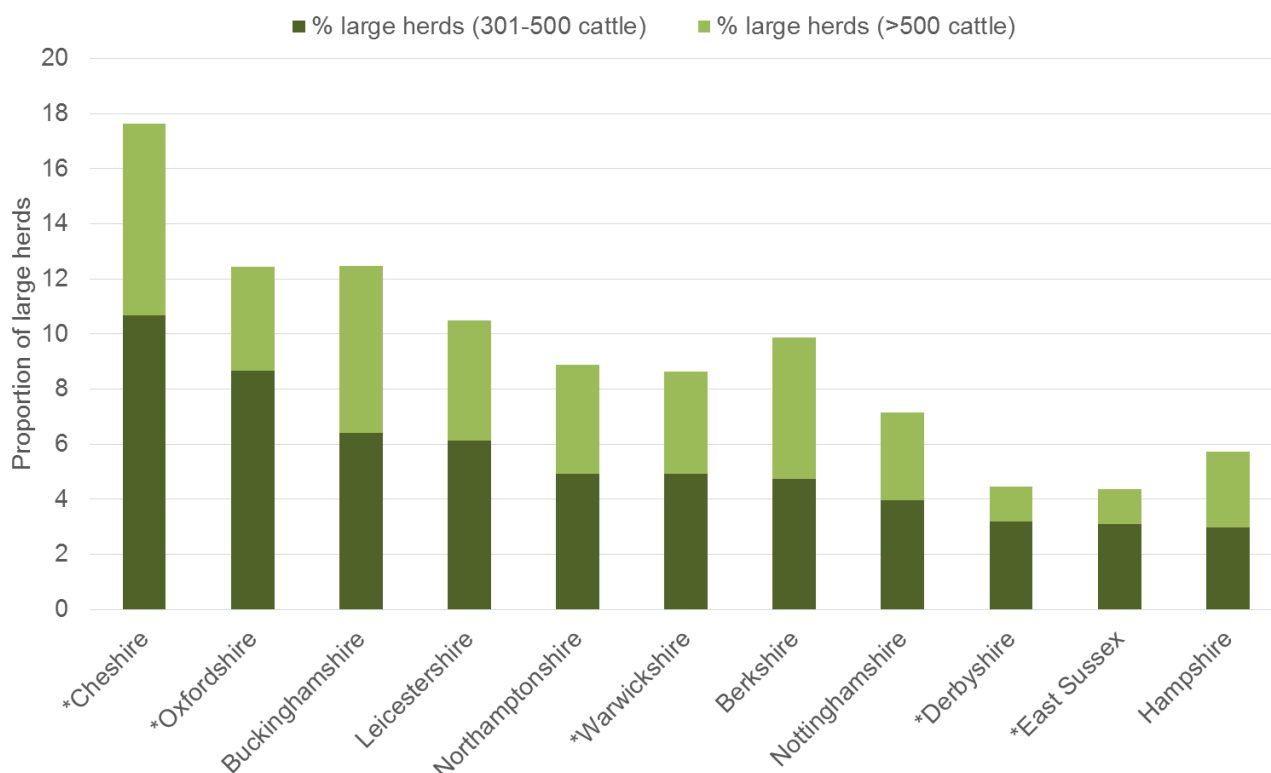


Figure 5.2.5. Proportion of large herds by Edge Area county or part-county (*) ranked by herds with 301-500 animals

- In the Edge Area overall, ten per cent of herds are considered large herds comprising more than 300 animals. There is some variation across counties, with *Cheshire Edge Area having a higher proportion than most with 17% of herds having more than 300 animals and Buckinghamshire with 12%.

Prospects for progress towards OTF status

The potential for OTF status of each county/part-county in the Edge Area depends absolutely on improvements in the management of the risk of introduction of TB through purchase of cattle with undisclosed infection. In some counties it is also dependent on limiting and reversing the development of endemic areas of infection, which are likely related to developing endemic infection in local badger populations.

There are no possible candidate counties for OTF status in the near future.

One county which shows an epidemic pattern that might enable achievement of OTF status but on a longer timescale, is **Nottinghamshire**, if improvements can be made to cattle-buying practices, as there is currently limited evidence of wildlife infection as a source for cattle incidents.

The other ten counties show little prospect of gaining OTF status in the near or medium term due to a moderate or high incidence and a likely more widespread badger infection and/or a substantial contribution from the purchase of undisclosed infected cattle. In addition, the

five part-counties became fully Edge Area from the 1st of January, 2018, which is likely to increase their annual incidence and prevalence in the short to medium term. In addition there is likely to be an increase in the number of cases where the infection source is attributed to an infected wildlife source because of endemic infection in local badger populations in the former HRA portion of those counties.

5.3 Low Risk Area

- Herd incidence and prevalence of bTB in the Low Risk Area of England (LRA) remained much the same in 2017 as in 2016, with the very low stable rates of disease and sporadic patterns of TB herd breakdowns observed in previous years continuing one more year.
- The only issue of some concern in the LRA was the persistence of a small cluster of breakdowns in east Cumbria associated with a specific strain of *M. bovis* known as 'genotype 17:z', which is present in Northern Ireland but had never before been found in Great Britain. TB surveillance in local wildlife conducted by APHA since late 2016 has identified the same genotype of the bacterium in roadkill badgers from the same area. Additional TB controls in cattle and badgers have been put in place to eradicate this hotspot of bTB.
- Current TB controls and surveillance regime appear to be effective in keeping the occurrence of bTB in the LRA very low despite the ongoing bTB epidemic in other parts of GB. The measures to protect herds in the LRA from bTB incursions have been enhanced recently by the introduction of compulsory post-movement skin testing (from April 2016), the phasing out of Sole Occupancy Authorities (SOAs) and Cattle Tracing System (CTS) links between the summers of 2016 and 2017, the adoption of a severe interpretation for all tracing skin tests (from April 2017) and the lifelong restriction of inconclusive reactor (IR) animals that are retested with negative results in the HRA, Edge Area and in TB breakdown herds in the LRA (from November 2017).
- As in previous years, substantial proportion (almost 60%) of all the new lesion- or culture-positive (OTF-W) breakdowns detected in 2017 were, once again, due to the introduction of infected cattle from higher risk areas of GB, confirming the need to remain vigilant and maintain the existing cattle movement controls.

The LRA was officially established on 1st January 2013 and the following year it was incorporated into the Government's Strategy for achieving Officially TB Free (OTF) status for England by 2038. The specific objectives for the LRA within that Strategy are to maintain or reduce the very low and sporadic incidence of bTB and deal quickly and effectively with any incursions of the disease, with a specific target of securing OTF status for all its counties by 2025.

This section of the report provides an annual overview of bTB surveillance in the LRA in 2017. More detailed in-year and annual field epidemiology reports for specific regions of the LRA have been published separately⁴⁴. Due to the timing of these regional reports, all data are extracted directly from the transactional database 'Sam' and so differ slightly from similar data quoted in other sections of this report for which the data have been reviewed to remove any duplicates and correct errors.

⁴⁴ See: <https://www.gov.uk/government/publications/bovine-tb-area-epidemiology-reports-2017>

Description of the LRA

The LRA comprises 24 contiguous counties in the North and East of England, as well as the Isle of Wight and the Isles of Scilly, all managed as one epidemiological unit for bTB control and reporting purposes. The LRA is bound by Scotland to the north and by the Edge Area of England to the south and west. It represents approximately 72,600 km² (55%) of England's land area and nearly 21,000 (41%) of its cattle herds. Cattle densities in the LRA are generally lower than those in the rest of England, although parts of Cumbria, Co. Durham, Lancashire and Yorkshire sustain substantial cattle populations.

Level of bovine TB in the LRA and origin of breakdowns

The incidence of TB in the LRA remained very low and stable in 2017. A total of 3,822 new bTB incidents ('breakdowns') were reported in cattle herds across England in 2017 compared with 3,769 the previous year, 3,973 in 2015 and 3,804 in 2014. As in previous years, the geographic distribution of those breakdowns was not uniform in 2017: although the LRA contains 41% of England's total cattle holdings, it only accounted for 123 (3.2%) of the total new TB herd incidents identified in England in 2017, a slightly lower proportion than in 2016 (3.5%) (see Figure 4.1.2a). This represented a herd incidence rate of 1.0 new herd incident per 100 herd-years at risk, the same as in 2016 (see Figure 4.1.3).

The number of cattle herds in the LRA under movement restrictions (i.e. OTF status suspended or withdrawn) at the end of 2017 due to an ongoing TB breakdown was 60 (48 herds at the end of 2016). This figure equated to a herd prevalence of 0.2% (same as at the end of the previous year).

However, in the LRA, like Scotland, due to the very low prevalence of *M. bovis* infection in cattle, the positive predictive value of the comparative intradermal tuberculin test is lower than in the rest of GB, if still high⁴⁵. This means that test reactors in the LRA with no visible lesions and negative culture results are more likely to represent false positive test results than in the HRA and Edge Area. Consequently, it is important to also consider the number and incidence of new herd incidents detected in the LRA that have been confirmed by post mortem tests ('OTF status withdrawn', OTF-W). As shown in Table 5.3.1 below, only 49 OTF-W incidents were found in the LRA, compared with 46 in 2016 and 52 in 2015 and representing a similar very small proportion of the total (see section 4.1 and Figure 4.1.2b). The OTF-W herd incidence rate in the LRA in both 2017 was 0.4 incidents per 100 herd-years at risk (almost unchanged from 0.3 per 100 herd-years at risk in 2016).

In 27 (55%) of the 49 herds sustaining a new OTF-W incident in the LRA last year there was conclusive evidence (from molecular and field epidemiological analyses) to show that TB was definitely introduced via movements of infected cattle from farms in higher incidence areas of England and Wales, without subsequent secondary spread to other holdings in the LRA. This percentage of 'imported' or 'non-native' cases in the LRA in 2017 was similar to previous years (Table 5.3.1). So, as in previous years, more than half of all the new OTF-

⁴⁵ See Goodchild et al. (2015), Veterinary Record: <http://veterinaryrecord.bmj.com/content/177/10/258>

W incidents in the LRA continued to be caused by translocation of infected animals from herds in higher risk areas of GB.

County-by-county analyses continued to show a sporadic occurrence of bTB in 2017, with no evidence of spatial clustering of cases or *M. bovis* genotypes. The vast majority of OTF-W herd breakdowns in the LRA were quickly resolved without recurrence, through the application of standard control measures including repeat (short-interval) skin testing at severe interpretation supplemented by interferon- γ blood parallel testing and, exceptionally, partial depopulation of infected farms in rare instances.

As in previous years, the proportion of herds sustaining recurrent TB breakdowns in the LRA was much lower than in the rest of England, so that typically around 10% of all herds experiencing a new OTF-W breakdown during the year had a history of bTB in the preceding 36 months (link relevant section). When recurrent herd breakdowns happen in the LRA, they are usually associated with large beef finishing units that regularly bring in cattle from the HRA, Edge Area, Wales or from Northern Ireland for fattening before slaughter. No breakdowns that ended in the LRA in 2017 had lasted more than 550 days (persistent incidents (see Figure 4.4.5b).

In conclusion, there was no material change in the overall incidence and prevalence of bTB in the LRA between 2017 and previous years, with the flat trend and sporadic pattern of breakdowns continuing for another year. The current controls appear to be effective in keeping the incidence and prevalence of bTB in the LRA very low and stable, despite the ongoing epidemic in other parts of the country. Cattle TB movement controls were tightened during 2016 and 2017, chiefly through the implementation of mandatory post-movement TB testing of cattle entering the LRA from other parts of England and Wales, the abolition of SOAs and CTS links, the severe interpretation of tracings tests and the lifelong restrictions for IR animals that are retested with negative results in the HRA, Edge Area and in TB breakdown herds in the LRA. These enhancements should help ensure that the LRA retains its favourable bTB status.

Table 5.3.1 Outcome of detailed epidemiological investigations into the origin of OTF-W breakdowns in the LRA of England (2010-2016)

Year	Total number of new TB breakdowns in the LRA with OTF herd status withdrawn (A)	Breakdowns considered to have been 'imported' based on a combination of molecular epidemiology and CTS data analysis (B)	Additional breakdowns regarded as introduced, based on further scrutiny by the local APHA teams (C)	Breakdowns listed under (B), but not validated as 'imported' by the local APHA teams (D)	Total 'native' breakdowns in the LRA (not clearly attributed to introductions of cattle) A - (B+C-D)	Total 'imported' breakdowns, i.e. judged as being clearly caused by introductions of infected cattle from outside the LRA (B+C-D)
Pre 2012 (active in period 2012-2017)	23	10	2	1	12	11
2012 (revised 2014)	41	11	8	0	22	19
2013 (revised 2015)	41	10	11	0	20	21
2014 (revised 2016)	38	7	13	0	18	20
2015 (revised 2017)	52	10	25	0	17	35
2016 (revised 2018)	46	6	20	0	20	26
2017 (provisional)	49	6*	22	1	22	27

* There were some *M. bovis* isolates for which genotyping and/or analysis were not available at the time when the assessments took place.

Cluster of TB in cattle and badgers in East Cumbria

The regional epidemiology reports from APHA field teams did not highlight any particular concerns about local spread of bTB or endemic infection in cattle or wildlife, apart from a geographic cluster of herd breakdowns that has emerged in East-Central Cumbria. Since September 2016 this localised bTB outbreak has been managed within a defined area southeast of Penrith straddling the M6 motorway, known as 'Hotspot 21' (HS21). This meant that herds of cattle and certain non-bovine livestock species within this area were subjected to additional bTB surveillance, which was also extended to include carcasses of badgers and wild deer found dead (and, in the case of deer, also shot) within HS21. This in turn led to the detection in the summer of 2017 of three infected badger carcasses in the centre of the affected area, out of a total of 35 examined by APHA. Since September 2017, following the detection of TB in local badgers, APHA has implemented exceptional TB surveillance and control measures in cattle herds across area HS21 over and above the normal response to OTF-W breakdowns in the LRA.

The index case in cattle was detected in November 2014 and further breakdowns have occurred on holdings with cattle herds within the defined area HS21, or holdings within their 3km radial testing zones, since then until the present time. In the three-year period from November 2014 to the end of December 2017, this geographic cluster of bTB included 24 breakdowns on 21 separate cattle holdings (Figure 5.3.1). In addition to the 24 cattle herd breakdowns within area HS21, APHA identified three other cattle herd breakdowns due to the same *M. bovis* genotype as a result of reported cattle movements out of this area (ie. spread tracings): one just outside HS21 in Cumbria and two in LRA counties of the North of England (Lancashire and North Yorkshire). In these three cases the infection was contained in the herds of destination with no evidence of secondary spread of bTB to other herds

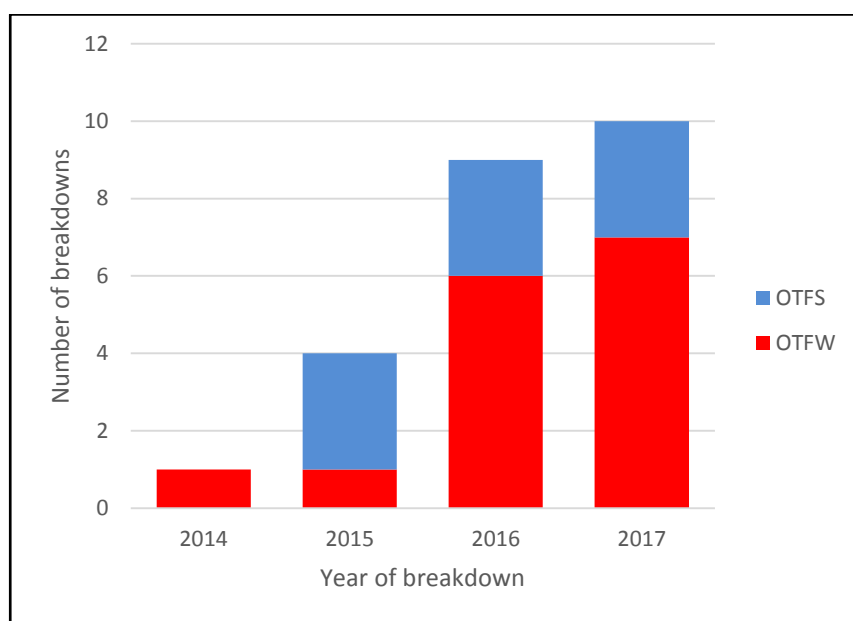


Figure 5.3.1 Temporal distribution of the 24 TB herd breakdowns identified in the East Cumbria cluster between 2014 and 2017

All the OTF-W cases in cattle identified in this cluster as well as the three TB positive badgers have been caused by genotype 17:z, a unique strain of *M. bovis* present in Northern Ireland, but not previously isolated in GB. The three badger isolates were all subsequently confirmed as genotype 17:z of *M. bovis* too. Field and molecular epidemiology investigations by APHA have concluded that bTB in HS21 was most likely introduced from Northern Ireland via cattle movements and then probably transmitted from infected cattle to the local badger population.

The size and persistence of this cluster of TB in cattle, despite the intensive surveillance measures in force, along with the detection of three infected badgers, is unprecedented for the LRA. The results from a badger population survey conducted across HS21 are being assessed together with the TB surveillance results from cattle and other farmed species and will be used to make recommendations for the most appropriate future disease control intervention methods for cattle and badgers in this area.