Animal &
Plant Health
Agency

Bovine Tuberculosis in England in 2021

Epidemiological analysis of the 2021 data and historical trends

November 2022

Data Protection:
For information on how we handle personal data visit www.gov.uk and search Animal and Plant Health Agency Personal Information Charter.

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

Any enquiries regarding this publication should be sent to us at

Department of Epidemiological

Sciences Animal and Plant Health Agency

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

National.TBEpi@apha.gov.uk

www.gov.uk/apha

APHA is an Executive Agency of the Department for Environment, Food and Rural Affairs and also works on behalf of the Scottish Government, Welsh Government and Food Standards Agency to safeguard animal and plant health for the benefit of people, the environment and the economy.

Contents

1. Executive summary

1. Bovine TB in England is subject to a statutory eradication programme based on the government's strategy, published in April 2014, which aims to achieve officially TB free (OTF) status for the whole country by 2038. Within the strategy, England is divided into three 'risk' areas as determined by the level of disease. The High Risk Area (HRA), spanning the west and south-west, accounted for three quarters of new TB incidents in 2021. As in previous years, the Low Risk Area (LRA) in the north, east and south-east had very few TB incidents in 2021. Approximately 31% of LRA incidents were fully confirmed by the presence of test reactors with typical TB lesions or one or more animals with positive bacteriological results, or both (OTF status withdrawn – OTF-W incidents). The Edge Area (EA), which lies between the HRA and LRA contained 20% of new TB incidents in 2021 in.
2. Eradication of bovine TB requires control of infection in both cattle and the main wildlife reservoir (badgers). In cattle, systematic active surveillance is conducted through tuberculin skin (SICCT) testing of herds, which aims to quickly identify and remove infected animals. This is supplemented by routine (passive) slaughterhouse surveillance and is coupled with pre- and post-movement testing to curb the spread of disease between herds through cattle movements. Infected cattle herds are subjected to movement restrictions, incident management procedures (e.g. tracings, cleansing and disinfection of cattle housing buildings and enhanced cattle testing (supplementary IFN-γ blood tests used in parallel with more frequent SICCT testing) to eliminate the infection. These measures aim to reduce the risk of disease persistence in the herd and allow the herd to regain their OTF status. The frequency of routine skin testing varies across England according to risk area. Most herds in the LRA are tested every four years, while in the Edge Area, most herds undergo routine annual tests. Six monthly testing applies to the higher incidence portions of the Edge Area, and the entire HRA (from July 2021). Eligible herds can apply for 'earned recognition' and remain eligible for annual tests. *M. bovis* infection in the main wildlife reservoir is controlled through licensed badger culling and vaccination.
3. The incidence rate of bovine TB in England increased steadily from 1986 to 2010 and has since plateaued. There has been a significant decrease in the herd incidence rate (new cases per 100 herd-years at risk; 100 HYR) from 9.5 in 2020 to 8.8 in 2021. In 2021 the herd incidence rate significantly decreased in the HRA for the fourth consecutive year and remained very low in the LRA. The incidence rate in the Edge Area significantly decreased for the first time since 2013, from 10.1 in 2020 to 8.9 in 2021. This represented a 12% decrease and was observed in both the annual (17%) and six-monthly (5%) testing parts of the Edge Area. The number of new TB incidents also decreased in England in 2021 and was seen across all three of the risk areas.

4. Over half of herds with new TB incidents in the HRA were recurrent incidents (had suffered another TB incident in the previous three years), confirming that recurrent infection remains an important driver of the epidemic in this risk area. A greater proportion of HRA herds were found to be infected in the six to 12 month period after regaining OTF status, compared to post-incident herds in other risk areas.
5. In 2021, as in previous years, herds located in the HRA (where there is high infection pressure from cattle and badgers), herds with over 300 cattle (which are more common in the HRA than elsewhere) and herds that had a history of previous TB incidents, were the most likely to sustain a new TB incident. Dairy herds were found to have an additional risk of infection that could not be fully explained by their herd size, testing history or location.
6. In 2021, there was a 1.6% increase in the number of interferon gamma (IFN-γ) blood tests completed in England. This was observed in both the LRA and HRA, whilst in the Edge Area the number of IFN-γ tests decreased. In the first half of 2021, IFN-γ tests were mandatory in the HRA for OTF-W herds located in Badger Control Programme (BCP) areas where at least two seasons of effective control had been completed. In July 2021, the mandatory IFN-γ test deployment policy was amended to those herds disclosing new OTF-W incidents within 18 months of regaining OTF status, as well as any chronic or persistent OTF-W incidents. Despite an increase (over 2020 tests) in the overall number of IFN-γ tests performed in the HRA in 2021, the number deployed was lower than anticipated. This was partly due to blood tests being postponed or cancelled due to social distancing measures imposed by the Government to fight the COVID-19 epidemic.
7. The most common risk pathways for each TB incident herd varied by risk area. Due to the diversion of APHA resources towards other critical business activities (highly pathogenic avian influenza outbreak and the urgent roll-out of the Ukrainian refugee pet import scheme), there is a backlog of DRF visits outstanding in 2021. Despite these pressures, the rigour and analysis of these pathways was not impacted. For England, the source of infection with the highest weighted contribution was badgers (49%), followed by ‘Other or Unknown’ sources (17%). The most frequently considered sources of infection in the HRA were badgers (52%) and ‘Other or Unknown’ sources (16%). In the Edge Area, badgers constituted 52% of the considered source, followed by cattle movements (17%). In the LRA, ‘Other or Unknown’ sources accounted for 46% of the weighted risk pathways, followed by cattle movements (22%). The relative percentages of each risk pathway are very approximate and only broad generalisations should be made from these data.
8. Between 2020 and 2021, there was an overall retraction of 1,172.72km^2 in the size of the area considered to be ‘endemically’ infected with *M. bovis* in England. The HRA continued to be a stable endemic area, as well as parts of the Edge Area particularly along the HRA border. In other parts of the Edge Area, there was significant retraction in the endemic area in a number of counties, but a large region of spread in Buckinghamshire. There were small areas of spread in the LRA, however Most of the

LRA remained free of endemic infection, although some small areas of spread where seen..

9. In 2021, WGS fully replaced genotyping (spoligo- and VNTR-typing) of *M. bovis* isolates in England. The most frequent clades based on 1,943 TB incidents in 2021 were b6-11 (22%) followed by b3-11 (19%) and b6-85 (17%). These three clades cover extensive areas in the Southwest and West (Midlands) of England.

Table 1.1 Key bovine TB epidemiological parameters for all TB incidents (OTF-W and OTF-S) in 2021, with selected 2020 values in parentheses

	HRA	Edge Area	LRA	England
Number of new TB herd incidents detected (*2020 figures*)	2,155 (*2,358*)	573 (*672*)	123 (*135*)	2,851 (*3,165*)
Number of new OTF-W TB incidents that were lesion or culture positive, or both (*2020*)	1,265 (*1,496*)	270(*357*)	38 (*42*)	1,573 (*1,895*)
Number of open (continuing) TB incidents at the end of the year (*2020*)	1,505 (*1,683*)	328 (*462*)	51 (*69*)	1,884 (*2,214*)
Herd incidence per 100 herd-years at risk (*2020*)	14.4 (*16.2*)	8.9 (*10.1*)	1.1 (*1.1*)	8.8 (*9.5*)
Average monthly prevalence (%) (*2020*)	8.9 (*9.1*)	5.6 (*5.5*)	0.4 (*0.3*)	4.8 (*4.8*)
Duration in days				
Median duration of restrictions for incidents that closed in 2021(25^{th}, 75^{th} percentiles)	202 (167291)	200 (165-273)	138 (98-199)	198 (166-280)
Median duration of restrictions for incidents that closed in 2020(25^{th}, 75^{th} percentiles)	196 (160294)	194 (159-274)	162 (98-220)	194 (160-286)
Percentage of incidents that ended in the year that were persistent, duration was greater than 550 days (*2020*)	5.5 (*7.4*)	3.4 (*5.5*)	0.0 (*0.8*)	4.8 (6.7)
Number of persistent incidents, with a duration greater than 550 days, ongoing at the end of the year (*2020*)	129 (*134*)	23 (*20*)	1 (*1*)	153 (*155*)
Recurrence				
Percentage of new TB incidents in the year in that occurred in herds that suffered another TB incident in the preceding 36 months	56.1 (*56.6*)	43.6 (*41.3*)	9.9 (*13.4*)	51.5 (*51.4*)

2. Preface

2.1 Intended audience

This report describes the level and distribution of tuberculosis in cattle herds in England in 2021. Tuberculosis in cattle and other animals is primarily caused by infection with the bacterium *Mycobacterium bovis* (*M. bovis*) and is referred to hereafter as TB. This report is primarily intended for those involved in the eradication of TB in cattle, both nationally and locally. This includes, but is not limited to farmers, veterinarians, policy makers and the scientific community.

This report for England is part of a suite of annual reports providing data and epidemiological analysis of TB in cattle in Great Britain. Other publicly available reports in the series include:

1. Bovine tuberculosis in Great Britain: Surveillance data for 2021 and historical trends (referred to hereafter as the 'GB TB data report'). This data report is published as an ODS file and provides supporting material in the form of detailed data tables and additional graphics. It presents all similar data for England, Scotland and Wales.
2. Year End Descriptive Epidemiology Reports for counties in the Edge Area and Low Risk Area of England. These reports provide a detailed epidemiological assessment of TB at a local level.
3. Bovine tuberculosis in Great Britain in 2021: Explanatory Supplement to the annual reports. This document provides more in-depth explanations about the data handling methodologies, terminology, surveillance and control measures used within Great Britain.
4. Analysis of bovine tuberculosis surveillance at routine slaughter of cattle in Great Britain, 2016 to 2019. This is a triannual report exploring the role of slaughterhouse surveillance in the detection of TB cases.

Data presented in these reports are derived from the same source as Defra's quarterly National Statistics on the incidence and prevalence of TB in cattle in Great Britain and other regular statistical reports on specific aspects of the TB surveillance regime, such as pre- and post-movement testing of cattle. Whilst the data sources are the same, additional time has been spent removing duplication and correcting other transactional data errors before compiling this report. As such, the data in this report may not exactly match the national statistics.

2.2 Purpose of this report

This epidemiology report includes commentary and analyses of cattle TB statistics in England, in the context of disease control and eradication policies. It reports both the frequency and geographic distribution of the disease in cattle herds in England in 2021, and its trends over time. It also explores the different TB surveillance streams employed to identify infected herds and the impact of the disease and its control measures.

Bovine TB surveillance and control is a complex process, and a wealth of jargon has emerged amongst those who seek to control and eradicate the disease. This report tries to limit the use of jargon, and to include explanatory text where required. Technical language is explained when first used, and there is a glossary within the Explanatory Supplement.

2.3 Interpretation of the data

The potential for finding herds infected with TB is directly related to (a) how hard we look (the type and frequency of surveillance), and (b) the underlying frequency of disease (prevalence of infection) in the cattle population, both of which differ by risk area.

Several factors also affect the probability of a herd becoming infected with TB, which are unevenly distributed in the cattle population. For example,

1. Herd size: large herds have an increased risk of infection.
2. Herd type: dairy herds have an increased risk of infection.
3. Presence of infection in the local cattle population, which increases the chance of local transmission between neighbouring cattle herds.
4. The existence of local reservoirs of *M. bovis* shared by cattle, badgers and other species; wildlife reservoirs of *M. bovis* are more common in the HRA and the western and northern parts of the Edge Area.

Furthermore, changes in surveillance intensity and control measures over time affect the measures used to track changes in the epidemic.

This report aims to take such factors into account when measuring the relative risk and frequency of TB in different herds. This enables more accurate assessment of the efficacy of disease control measures.

2.4 Eradication of bovine tuberculosis (TB) in England

Bovine TB is one of the most pressing animal health problems in England. It is an infectious and contagious bacterial disease of cattle and other mammals, with a significant wildlife reservoir (*i.e.* badgers) present in large areas of England. This complicates the eradication of infection in its natural host (cattle). TB threatens the cattle industry and presents risks to other susceptible livestock, wildlife, zoological collections and domestic

pets. TB in animals can also threaten human health, although the widespread use of pasteurisation of cows' milk largely protects the public from undisclosed cases of TB in cattle. Nevertheless, the TB epidemic in cattle and badgers, with occasional spill-over into other wild and domestic species, represents a low but ongoing public health risk.

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

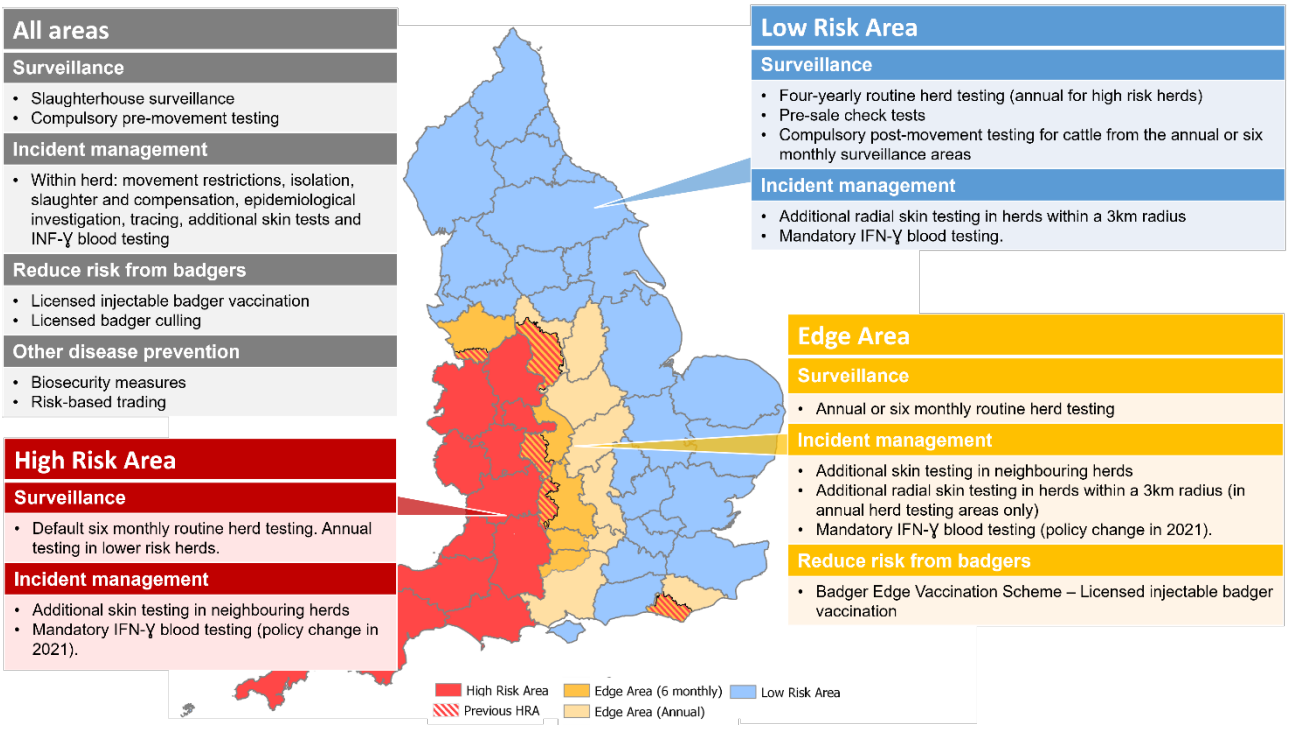


Figure 2.1 Summary graphic of the England TB Eradication Strategy

The Strategy defines disease control measures that aim to achieve officially TB Free (OTF) status for England incrementally by 2038. These measures are designed to be effective, whilst maintaining trade and, critically, an economically sustainable livestock industry. One of the key features of the current strategy is the division of the country into three 'risk areas'. These risk areas are defined by the level of TB, with bespoke surveillance and control measures. Mandatory TB controls are based on the regular testing of herds, slaughter of positive animals and the imposition of movement restrictions following a non-negative test result. Movement restrictions remain in place until there is sufficient evidence that *M. bovis* infection has been removed from the herd through further testing. Such evidence will differ according to local circumstances, in particular the risk area in which the herd resides.

In 2018 the government commissioned an independent review of the 2014 TB eradication strategy, the Bovine TB strategy review. The government considered the review in partnership with stakeholders and published its response in March 2020. The response sets out five priorities for the next five years, which are summarised below. Full details can be found in the government's response to the review.

Output 1: Acceleration of work to develop a deployable cattle TB vaccine, as part of a wider programme of TB research.

Output 2: Evolving the strategy for preventing the spread of TB from wildlife. The government envisages that the current intensive culling policy would begin to be phased out in the next few years, gradually replaced by government-supported badger vaccination and surveillance. Culling would remain an option where epidemiological assessment indicates that it is needed.

Output 3: Improving diagnostics, surveillance and epidemiology to root out TB more effectively. Increasing the sensitivity of cattle surveillance testing, strengthening the management of infected herds and roll-out of new epidemiological tools to understand better the likely source of TB and better target delivery of disease control policies.

Output 4: Incentivising the uptake of effective biosecurity measures and managing the TB risks posed by cattle movements to reduce the risk of spread of TB within and between farms.

Output 5: Establishing a new 'Bovine TB Partnership' between government and industry to encourage shared ownership, coordination and decision making on TB eradication and harness the collective will to eradicate TB.

2.5 Main changes to the TB surveillance and control measures introduced in England in 2021

The Tuberculosis in Animals (England) Order 2021: Coming into force on the 1st October 2021, this new Order incorporated the existing statutory controls for TB in domestic cattle, farmed Asiatic water buffalo, farmed bison and non-bovine farmed animals in England, and replaced the Tuberculosis (England) Order 2014 and the Tuberculosis (Deer and Camelid) (England) Order 2014.

CHECS TB Entry Level Membership: In summer 2021, CHECS launched a new TB Entry Level Membership for cattle farmers. It provided a baseline biosecurity standard, comprising of a range of easily achievable (no regrets) biosecurity measures set out in the Godfray Review. The scheme is recognised by the British Cattle Veterinary Association (BCVA), Defra and the Welsh Government to reduce the risk of a TB breakdown in herds.

TB Advisory Service (TBAS) Successor contract: The TB Advisory Service was extended to all areas of England (including the LRA), to cover cattle farmers as well as keepers of farmed non-bovine animals.

Six-monthly testing surveillance in the HRA: From July 2021, default six monthly testing was rolled out across the rest of the HRA, having been first introduced in Staffordshire and Shropshire in 2020. Cattle herds at lower risk of a TB breakdown have the option to remain on annual surveillance testing, if they meet one of the 'earned recognition' criteria.

Refinement to interferon-gamma testing in the HRA and Edge Area: A new policy for mandatory interferon-gamma testing of TB incident (breakdown) herds in England came into force in July 2021. Mandatory interferon-gamma blood testing is no longer linked to areas undergoing wildlife control measures and now applies to:

- New TB breakdowns with lesion and/or culture positive animals occurring within 18 months of the conclusion of a previous breakdown with lesion and/or culture positive animals in the same herd (HRA/ Edge areas on six-monthly surveillance testing regimen).
- All new breakdowns with lesion and/or culture positive animals in the LRA and annual surveillance testing parts of the Edge Area.
- Chronic and persistent breakdowns with lesion and/or culture positive animals anywhere in England.

Changes to movements on and from AFUs/AFUEs: From July 2021, cattle from AFUs in England and Wales were allowed to move to and be sold at Approved TB Dedicated Sales ("Orange Markets") in England and Wales.

Discontinuing COVID-19 temporary amendments to TB skin testing in Great Britain: In the summer of 2021, the temporary easements of the skin testing regulations in GB due to the COVID-19 epidemic came to an end as follows:

- Suspending APHA referrals of overdue TB skin tests in GB for COVID-19 reasons (ended 1st July 2021).
- Extending the short interval testing window by 30 days in England and Wales (ended 1st July 2021).
- Exempting calves under 180 days old from certain routine and targeted TB skin tests in England and Wales (ended 1st August 2021).

3. The TB epidemic in England

3.1 Incidence, geographic distribution, and trends over time

- In 2021, there were 2,851 new TB herd incidents in England, the lowest number disclosed since 2006. As in previous years, most new incidents (76%) in 2021 occurred in the High Risk Area (HRA), with 20% in the Edge Area and the remaining 4% in the Low Risk Area (LRA).
- The number of new TB incidents decreased across all regions in England in 2021 compared to 2020. This was driven by a decrease in the number of lesion- or culture-positive (OTF status withdrawn or 'OTF-W') TB incidents across the country.
- Significantly fewer cases of OTF-W incidents were disclosed in the HRA and Edge Area in 2021 compared to 2020. This follows a similar trend to the previous report. Although OTF-W cases also fell in the LRA during the period, this decrease was not statistically significant.
- Since the start of 2011 the epidemic has slowed in England. When considering the last four years (2017-2021), there is evidence that the epidemic is now declining (halving time of 9.47 years, p=0.001). However, the 2021 quarterly incident totals remain more than double the quarterly totals before the outbreak of foot-and-mouth disease in 2001.
- Within the HRA, in 2021, the TB herd incidence rate fell significantly to 14.4 incidents per 100 herd-years at risk (HYR), the lowest rate since 2007. The incidence rate fluctuated between 18 and 20 incidents per 100 HYR from 2011 to 2018 and has been falling ever since. Incidence per 100 HYR also fell significantly for the first time in the Edge Area to 8.9 (down from 10.1 in 2020), the first decrease since 2016. Incidence has remained very low and stable during the same period in the LRA (1.1 TB incidents per 100 HYR), the same as 2020. Overall, the TB incidence rate in England decreased significantly to 8.8 incidents per 100 HYR (from 9.5 in 2020), the lowest rate since 2014.
- Cattle with lesions typical of TB at slaughter, positive culture results for *M. bovis*, or both, were found in 59% of all new incidents in the HRA, 47% in the Edge Area and 31% in the LRA in 2021. This compares to 63% in the HRA, 53% in the Edge, and 31% in the LRA in 2020.
- There was a net retraction of 1,172.72 km^2 in the size of the overall area considered to harbour endemic *M. bovis* infection in England (2020-21), i.e., retraction of certain parts of the 'endemic TB area' exceeded expansion elsewhere.

Number of TB-infected herds

The number of Officially Tuberculosis Free (OTF) herds in which TB was detected in 2021 is referred to as the number of new incidents. The incidence rate shows the number of incidents within herds over time, taking into account periods when herds are not at risk of infection e.g., because they are already under restriction for TB (see Explanatory Supplement). However, the number of cattle herds in existence, herds that are tested, herds already under TB restrictions (non-OTF) and the types of test used change between years and TB risk areas. These all affect the number of new TB incidents detected. Consequently, the herd incidence rate is a better way of assessing temporal trends in the epidemic and the differences between regions. The herd incidence rate is reported and examined in a subsequent section of this chapter.

The number of herd incidents decreased significantly in England in 2021 (2,851) compared to 2020 (3,165). This was due to a reduction in the number of incidents, both total and OTF-W incidents, across the Edge and HRA. The largest decrease in incidents was seen in the Edge Area, where 15% fewer incidents were identified in 2021 than in 2020 (573 vs 672). OTF-W incidence reduced by over a fifth (22%) in the Edge Area compared to the previous period. In the HRA and LRA, the number of new incidents fell by almost 10% each, however this was only statistically significant ($p<0.001$) in the HRA.

As the incidence of TB and number of incidents in the LRA is low (1.1 incidents per 100 HYR and 123 new incidents in 2021), it is difficult to determine whether the fluctuations seen are explained by normal variations in the inter-year pattern of disease or not. Further information about TB is available at county level in the LRA reports.

The HRA and the LRA each contain 41% of the cattle herds registered in England, while the remaining 18% are registered in the Edge Area. Approximately one in ten herds had a new TB incident in the HRA in 2021, compared to one in 14 in the Edge Area. For both areas, this proportion decreased compared to 2020. In the LRA, one in 165 herds had a new TB incident in 2021 and one in 500 herds had a new TB incident that was OTF-W. However, it is important to note that only one in four herds in the LRA are routinely tested each year.

The relatively high prevalence of TB in both the Edge Area and HRA means that a positive skin test result (a test reactor) is a very good indicator of infection irrespective of post-mortem and laboratory results (see Explanatory Supplement for further details). The percentage of TB incidents that were OTF-W in the HRA and Edge Area was 59% and 47% respectively in 2021. This is the second consecutive year in which the percentage of OTF-W incidents decreased in these risk areas. In the LRA however, this remained stable (Table 3.1.1).

Table 3.1.1 Number of all new TB incidents and herd incidence rate in England, by risk area, during 2020 and 2021

	HRA	Edge Area	LRA	England
All new TB incidents in 2021	**2,155**	**573**	**123**	**2,851**
(Percentage of total for England)	**(75.6%)**	**(20.1%)**	**(4.3%)**	
All new TB incidents in 2020	2,358	672	135	3,165
(Percentage of total for England)	(74.5%)	(21.2%)	(43%)	
New TB incidents in 2021 that were lesion and/or culture positive (OTF-W incidents)	**1,265**	**270**	**38**	**1,573**
(Percentage of total incidents for risk area)	**(58.7%)**	**(47.1%)**	**(30.9%)**	**55.2**
New TB incidents in 2020 that were lesion or culture positive (OTF-W incidents)	1,496	357	42	1,895
(Percentage of total incidents for risk area)	(63.4%)	(53.1%)	(31.1%)	(59.9%)
TB incidence rate (OTF-W and OTF-S) per 100 HYR in 2021	**14.4**	**8.9**	**1.1**	**8.78**
TB incidence rate (OTF-W and OTF-S) per 100 HYR in 2020	16.2	10.1	1.1	9.5
Percentage change in TB incidence rate per 100 HYR from 2020 to 2021	**-11%**	**-12%**	**0%**	**-8%**

Temporal trends in the number of new herd incidents in England

From 1986 to 2000, before the foot and mouth disease (FMD) outbreak in 2001, the number of new herd incidents increased by around 14% each year. The interval for the epidemic to double in size was estimated at 5.3 years (see Figure 3.1.1a in Bovine tuberculosis in England in 2018).

Surveillance testing, control measures and movement patterns in cattle herds across GB were disrupted during and immediately after the FMD epidemic in 2001. The number of new herd incidents increased rapidly over this period, growing from 363 in the last quarter of 2000 to 662 in the last quarter of 2002, with a 25% annual rate of increase.

The rate of increase in TB incidents reduced once controls were re-established after the FMD epidemic (Figure 3.1.1b). From 2003 to 2010 the epidemic continued a steady but significant (p=0.005) upward trend. The annual rate of increase for all incidents at that time was 6% (doubling time of 12.8 years). Between 2011 and 2016 the epidemic plateaued in England as a whole. There is now significant evidence that the epidemic has been decreasing since 2017 (p=0.001). Between 2017 and 2021, quarterly TB incidents had a halving time of 9.5 years (p=0.001), and an average annual rate of decrease of 7%. Although this is encouraging, the current quarterly number of incidents is still more than double than that from before the FMD epidemic.

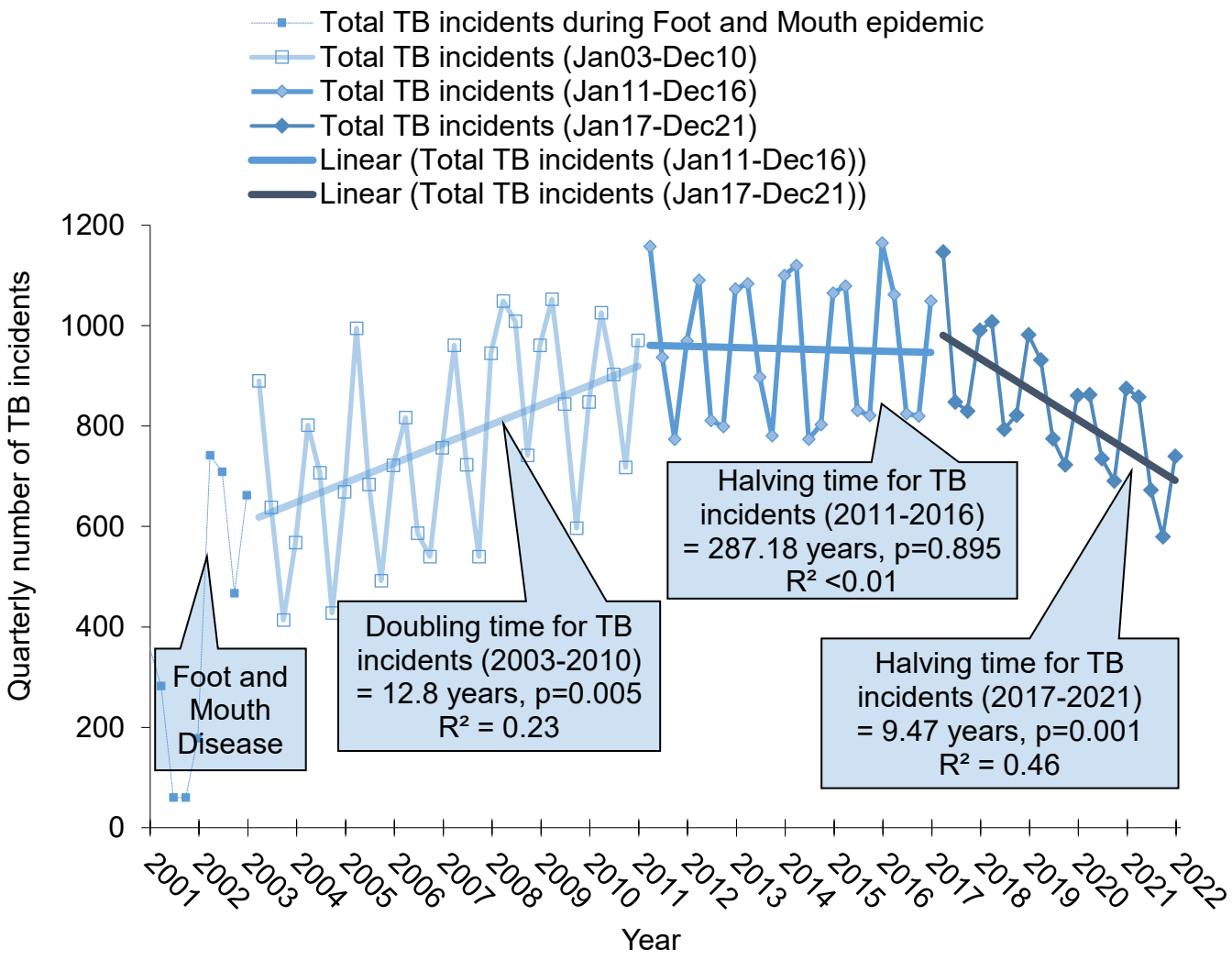


Figure 3.1.1 Quarterly total numbers of new TB incidents detected in England between January 2001 and December 2021

- Trend lines are shown for the three periods 2003-2010, 2011-2016 and 2017-2021. The doubling time for the period 2003-2010 indicates the time it would take for incidents to double in number, given the trend of the data. The R^2 value indicates 'goodness of fit' of the trend line to the raw data (an R^2 of 1 would indicate a perfect fit). The trend was quite erratic in all time periods, largely due to seasonal trends.
- The upward trend observed between 2003 and 2010 was statistically significant (linear regression, p=0.005), as is the decreasing trend for the period 2017-2021 (9.5 years, p=0.001).

The total number of new TB herd incidents in England fell for the fifth year running in 2021 to 2,851. This is the lowest level of TB in England since 2006 (2,701). Previously, the level of TB had been stable, remaining between 3,600 and 4,000 incidents per year between 2010 and 2018 (Figure 3.1.2).

The decrease in the number of incidents across England in 2021 reflects a reduction in the number of OTF-W TB incidents for all risk areas. The number of OTF-S TB incidents has remained similar (1,278 incidents in 2021 and 1,270 in 2020, Table 3.1.1). However, single inter-year changes should be interpreted with caution and multiple measures should be used to explore TB trends, rather than considered in isolation.

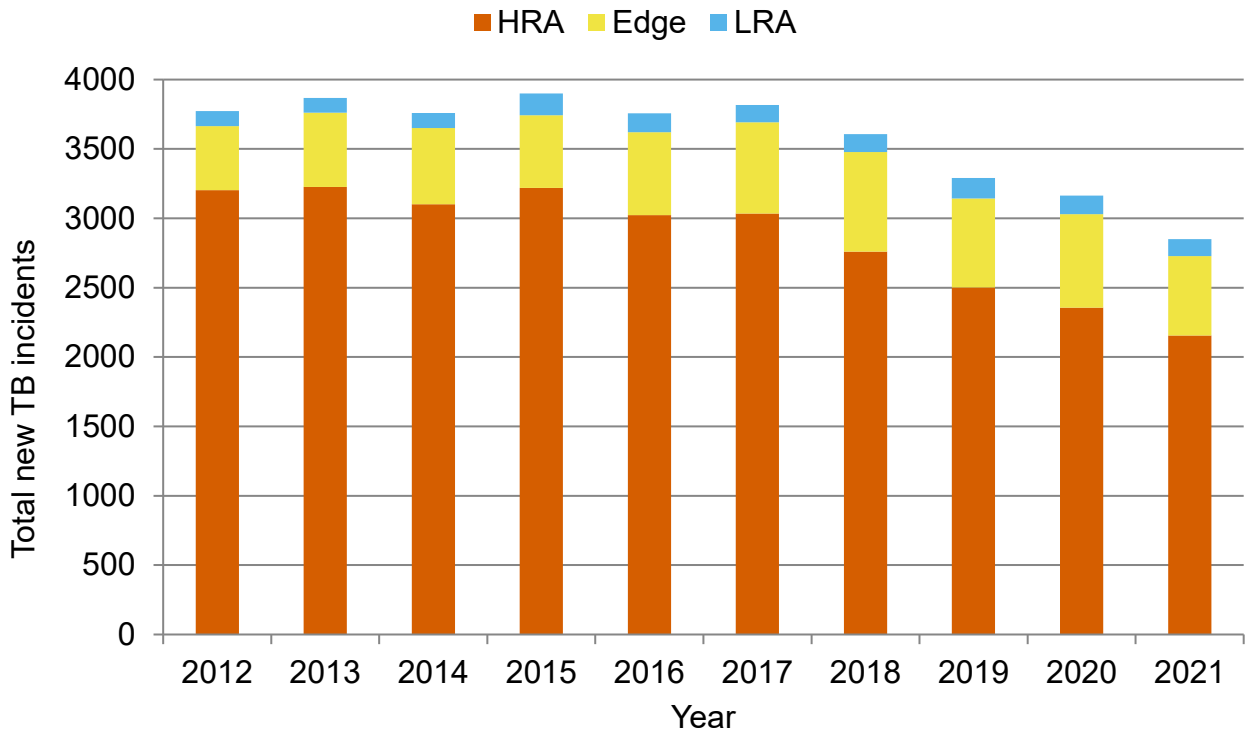


Figure 3.1.2 Annual trends in the total number of new TB infected herds, by risk area

- The total number of new TB incidents in England overall decreased for the fourth consecutive year.
- The number of new TB incidents across the HRA, Edge Area and LRA decreased in 2021, for the fourth, first and second consecutive year respectively.

In the HRA, almost all counties saw a fall in the total number of new incidents in 2021 compared to 2020 (see chapter 4.1 for more details). The exceptions were Hereford and Worcester and Avon, which saw a 5% and 3% increase in incidents respectively (242 and 99 incidents in 2021 compared to 231 and 96 in 2020). In Hereford and Worcester, there was a similar number of OTF-W incidents and time at risk across both years, but the percentage disclosed by slaughterhouse (SLH) surveillance increased in 2021 (27% in 2021 vs 15% in 2020). This suggests that residual infection may be being maintained in the herds and remained undetected until the presence of lesions was confirmed at slaughter. In Avon, the increase in incidents was driven by an increase in the number of OTF-W incidents (68 in 2021 and 61 in 2020).

Similarly, to the HRA, almost all Edge Area counties saw a decrease in the number of new TB incidents. The exceptions to this were Berkshire, Buckinghamshire and

Nottinghamshire, where incidents rose by 19%, 27% and 62% respectively in 2021 from 2020. The number of OTF-W incidents also increased in Nottinghamshire (5 in 2020 to 11 in 2021). Most of the OTF-W incidents (6 of 11) were considered to have an undetermined source of infection. This reflects uncertainty around disease status of potential wildlife reservoirs in Nottinghamshire. Continued surveillance of TB in found-dead wildlife will be crucial to assess the likelihood of the source of infection for incidents in the region.
In Buckinghamshire and Berkshire, incidents increased due to a growth in the number of OTF-S incidents. The number of OTF-W incidents decreased in Buckinghamshire (11 in 2020 to 7 in 2021) and remained stable in Berkshire (11 for 2020 and 2021). This means the increase in incidents is due to higher levels of OTF-S incidents in the area.

Although the number of OTF-W incidents in the LRA fell in 2021 (n=38) compared to 2020 (n=42), it remains above that observed in 2019 (n=36) and 2018 (n=37) (Figure 3.1.3). LRA counties with notable increases were: Lancashire (4 of 17 incidents in 2021, compared to 2 of 8 in 2020), Bedfordshire (3 of 4 incidents in 2021 compared to 1 of 2 in 2020), Hertfordshire (3 of 4 incidents in 2021 compared to 1 of 4 in 2020), and Cumbria (7 of 18 incidents in 2021, compared to 4 of 23 in 2020).

At the county level in the LRA, the picture is complex. Although most of the 24 counties saw a decrease in the number of total incidents, six counties experienced an increase. In four counties, the number of new TB incidents doubled or more (from very small numbers).

North Yorkshire was the only county where total incidents increased by almost a fifth, but OTF-W TB incidents halved during the same time (from 8 OTF-W incidents and 17 total incidents in 2020 to 4 and 20 in 2021, respectively). More detail about incidents in the LRA is available in Chapters 3.2 and 4.3 of this report, as well as in the individual LRA Year End Descriptive Reports for specific counties.

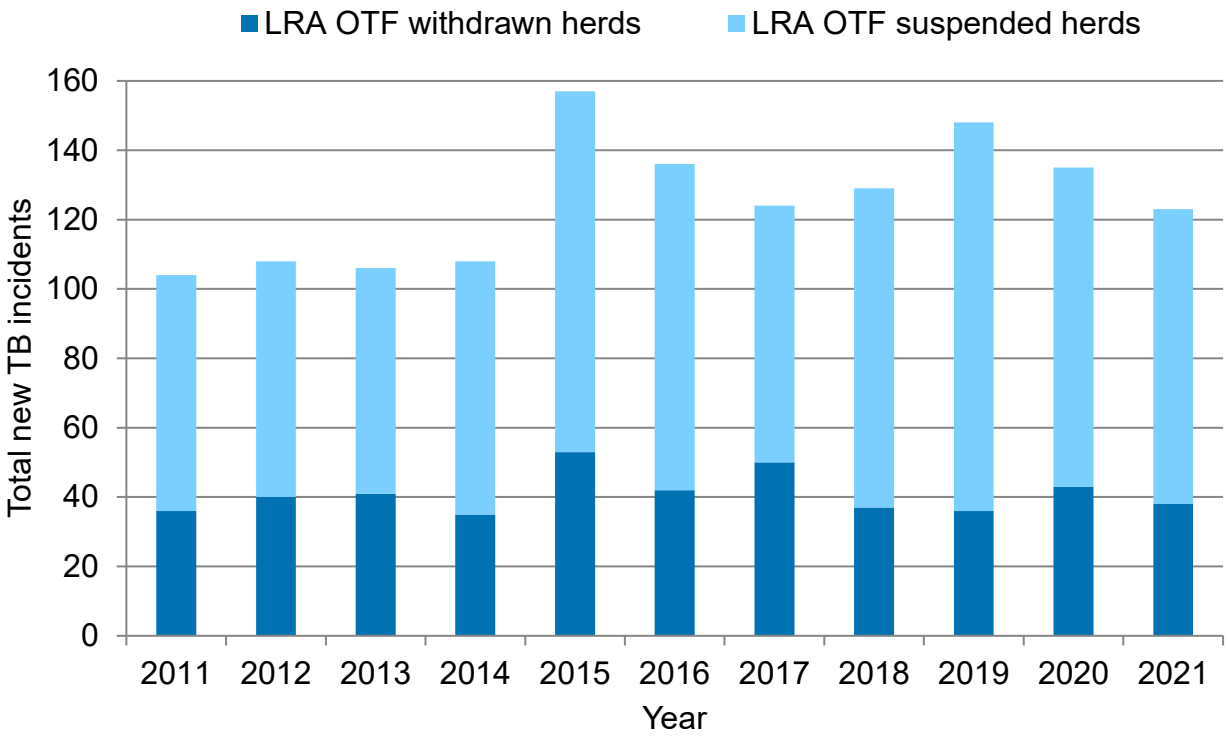


Figure 3.1.3 Annual total number of TB incidents in the LRA, by post-mortem result status (OTF-W and OTF-S)

- The number of herds in the LRA with laboratory confirmed *M. bovis* infection (new OTF-W incidents) decreased slightly in 2021 compared to 2020 (n=38 and n=43 respectively), but the numbers have been relatively stable over the last decade. Numbers were highest in 2015 (n=53), but there is no clear temporal trend.
- The percentage of new OTF-W incidents in the LRA remained stable in 2021 and 2020 (31%).

Annual herd incidence rate and geographical distribution of new TB incidents

The TB epidemic in England is also measured by the herd incidence rate. This is the rate at which herds experience new TB incidents. The incidence rate in this report is calculated as the number of new TB incidents per '100 herd-years at risk' (100 HYR). This measure adjusts for differences in the time that herds are at risk of infection. Herd-years at risk takes into account:

- the number of herds tested
- when and how often herds are tested
- periods when herds are under TB movement restriction due to test reactors or culture-positive slaughterhouse incidents (and therefore, not at risk of disclosing a new TB incident).

Whilst using HYR enables a more accurate comparison between areas than the number of new incidents disclosed, it is sensitive to changes in routine testing intervals within an area. This is particularly relevant when comparing incidence rate trends in those parts of the Edge Area that moved from annual to six-monthly surveillance testing in 2018. A detailed description of the methodology used to calculate the incidence rate per 100 HYR is available in the Explanatory Supplement.

Figure 3.1.4 shows the annual incidence rate for England and by risk area, from 2011 to 2021. Annual rates are also presented separately for the six-monthly and annual testing portions of the Edge Area (according to parish testing status in 2021). Overall, the incidence rate of TB in England in 2021 was 8.8 TB incidents per 100 HYR. This is the lowest rate since 2014 (8.6 TB incidents per 100 HYR).

The level and trend in TB incidence vary between risk areas in England.
In the Edge Area, the TB incidence rate has fallen for the first time since 2013 to 8.9 incidents per 100 HYR in 2021, from 10.1 incidents per year in 2020 (Table 3.1.1 and Figure 3.1.4). This represents a significant decrease of 12% compared to 2020 (p=0.03, test type). The fall in incidence in the Edge Area was driven by a reduction in the number of OTF-W incidents in 2021 compared to 2020 (n=270 compared to n=357, respectively).

In the LRA, incidence has remained stable in 2021 compared to 2020 (1.1 incidents per 100 HYR for both years, p=0.97).

Most incidents in the LRA (69%) were OTF-S incidents, where *M. bovis* infection could not be confirmed at post-mortem. There was also no change in the OTF-W incidence in the LRA (0.34 incidents per 100 HYR for both years (p=0.99)).

Incidence per 100 HYR in the HRA decreased significantly by 11% (p<0.001), from 16.2 in 2020 to 14.4 in 2021. Both the denominator (herd-years at risk), and the numerator (number of TB incidents) declined in the HRA in 2021.

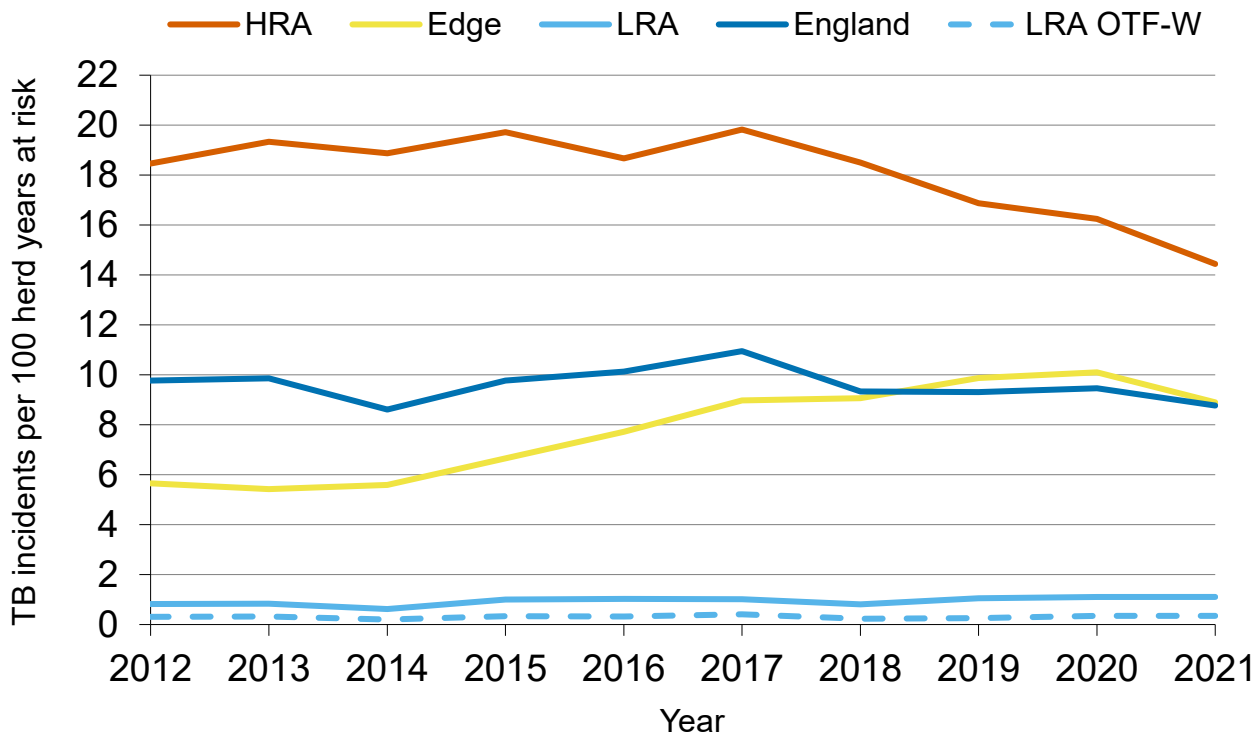


Figure 3.1.4 Annual incidence rate (per 100 HYR) for England and by risk area, from 2011 to 2021.

- The decrease in incidence rate in England overall was significant in 2021 compared to 2020 (p=0.003)
- The incidence rate decreased for a fourth consecutive year in the HRA, with a significant fall in TB incidents in 2021 compared to 2020 (p<0.001).
- The incidence rate also fell significantly (p=0.026) in the Edge Area in 2021 compared to 2020, to the lowest rate since 2016.
- In the LRA, both the total incidence rate and the OTF-W incidence rate fell marginally in 2021 compared to 2020,but neither were significant.

Figure 3.1.5 shows the incidence rate per 100 HYR for individual counties in England during 2020. The highest incidence rates were recorded in the HRA counties of Avon (18.0), Shropshire (17.9) and Hereford and Worcester (17.8).

For almost all counties in the HRA, the incidence rate per 100 HYR fell in 2021 and was at its lowest level since pre-2013. The incidence rate per 100 HYR increased in Hereford and Worcester compared to 2020 and 2019 (17.8 in 2021 compared to 17.4 and 17.3 in 2019 and 2020, respectively). This was due to a not statistically significant increase in the number of incidents in the county.

In the Edge Area, the incidence rate decreased in 2021 for all but three counties, Berkshire, Buckinghamshire and Nottinghamshire. The incidence per 100 HYR increased by 19%, 27% and 62% respectively in each of these counties but was not statistically significant. However, the inter-year time at risk for herds in these counties remained similar, suggesting that most herds were under restriction for only a short amount of time.

Incidence per 100 HYR remained low in the LRA. However, incidence per 100 HYR increased in Bedfordshire, Cambridgeshire, Durham, Essex, Greater Manchester, Lancashire, Lincolnshire and North Yorkshire, but this was not statistically significant.

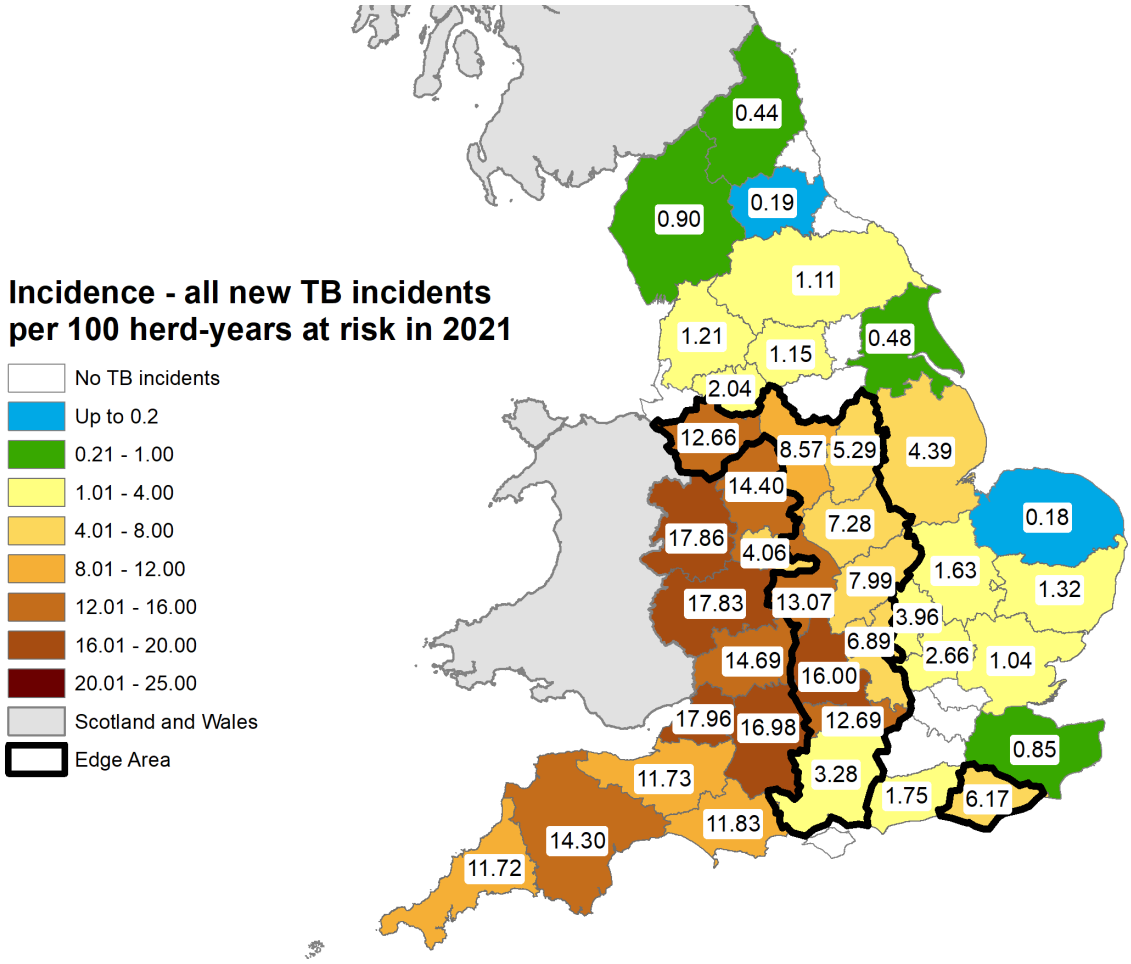


Figure 3.1.5 County herd incidence (all new TB incidents per 100 HYR) in England in 2021

- There continues to be a wide variation in incidence rates by county and risk area. Incidence was highest overall in the HRA counties of Avon, Shropshire, and Hereford and Worcester.

Spatial changes in the TB epidemic

Changes between 2020 and 2021 in the areas of England that can be defined as ‘endemically infected’ have been assessed (see Explanatory supplement for definition and

methodology for endemic infection). This methodology can be influenced by both low cattle density and local purchasing behaviour, and in isolated cases may give the appearance of spread or retraction as the result of these factors, rather than true endemicity of TB in cattle populations.

Overall, this comparison shows that the majority of the HRA is, and remained, 'endemically' infected, along with parts of the Edge Area, particularly where they border the HRA. However, in the Edge Area, there were large areas of retraction in the endemic area, particularly in Hampshire, Berkshire, Oxfordshire and Warwickshire. Of note, a large region of spread appeared in the mid-eastern part of Buckinghamshire.

Small areas of spread within the LRA were seen in North Yorkshire and Lincolnshire, and a new area of spread has appeared just north of the endemic region in eastern Cumbria (HS21) between 2020 and 2021. In North Yorkshire, the area of spread observed between 2019 and 2020 has now become endemic. The spread observed in Lancashire during 2019-2020 now appears to have retracted. As seen in previous years, most of the rest of England, particularly the LRA, remains free of endemic infection.

APHA veterinary assessment has highlighted that the small changes around the coasts, moorlands and conurbations in the South-West of England are associated with lower herd densities. This decreases the threshold for changes in potential spread and retraction during the period studied. True retraction appears to have occurred in HRA, specifically along the southeastern border of Dorset and South Wiltshire. In the Edge Area, the large area of expansion in mid-eastern Buckinghamshire is centred on a cluster of three incidents with genetically almost identical *M.bovis* isolates, which are almost identical to those from a cluster close by in 2017, and provides strong evidence for endemicity in the absence of local cattle movements to link these together (see the Edge County Reports for more information).

In endemically infected area of England spread by approximately 2,303.01 km² in some parts, but contracted by 3,475.73 km² in other parts, resulting in a net change of -1,172.72 km^2 from 2020-2021 (overall retraction). The net change 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.

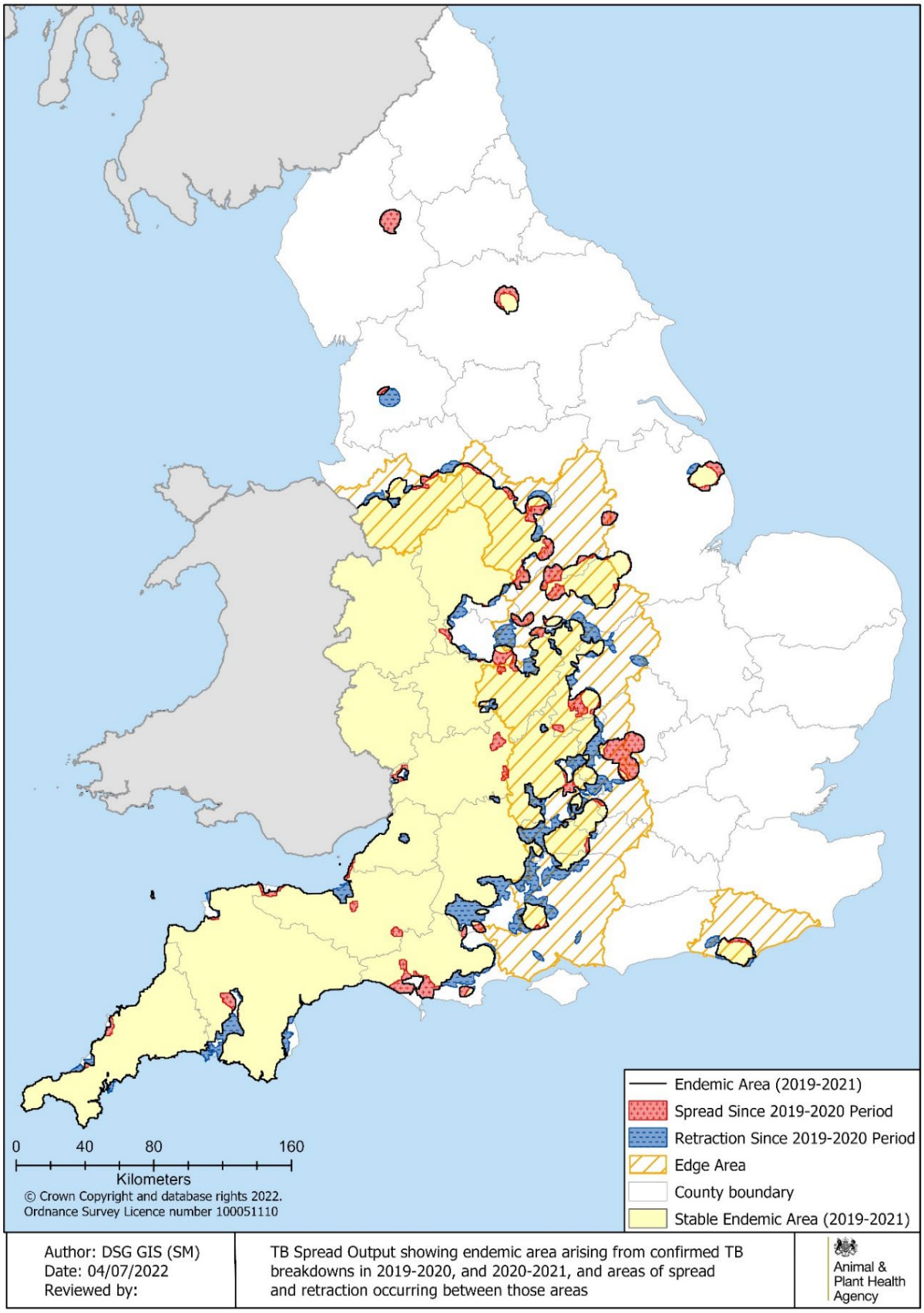


Figure 3.1.6 Spread and retraction of endemic TB areas in 2021 compared to 2020

TB in non-bovines in 2021

Mammals other than bovines are also susceptible to *M. bovis* infection and can develop TB. This section therefore aims to quantify the number of laboratory-confirmed *M. bovis* infections in non-bovine domestic farmed species (and deer) in England, using TB surveillance data collected by APHA. This includes *M. bovis* isolations from notified suspect clinical and post-mortem incidents of TB.

The number of total ante-mortem TB tests carried out on individual animals in England for all non-bovine species was 25,034, a 9% increase from 2020 (N=23,028). The biggest increase in testing was seen in farmed deer, where there was a 63% increase in the number of tests in 2021 compared to 2020 (N=2,132 in 2021, and N=1,308 in 2020). This is the highest number of tests in deer in England since 2011. There were also increases in the number of tests conducted in South American camelids, sheep, and goats.

The number of pig tests decreased slightly in 2021 compared to 2020 (4,082 and 4,149 respectively, a two percent decrease). Since 2011 the number of tests in pigs has been increasing in England, but this is the second highest number of tests in pigs in England since 2011.

The number of test-positive animals slaughtered for TB control reasons fell slightly by 6% in 2021. This reflects a general fall in numbers across all categories. The exceptions were deer and sheep, which saw the numbers of animals slaughtered increase by 322% (from 32 to 135 deer) and 78% (from 9 to 17 sheep) between 2020 and 2021. This increase in the number of slaughtered deer also reflects the increased number of tests, and laboratory confirmed TB incidents for deer in 2021 compared to 2020.

Overall, the number of culture positive tests (in individual animals) and laboratory confirmed TB incidents (in herds) remained similar in 2020 and 2021. Of note, culture positive tests in South American camelids increased by almost 50%, from seven in 2020 to twelve in 2021. In deer, the number of laboratory-confirmed TB incidents also increased from six to nine in the same period.

Table 3.1.2: Results of TB surveillance in farmed and captive animal species other than cattle in England in 2020 and 2021. Data adapted from the statistics of TB in non-bovine species, 2011-2021.

	2020	2021
Total ante-mortem tests		
South American Camelids	5,290	6,343
Sheep	2130	2,355
Goats	10,059	10,093
Pigs	4,149	4,082
Deer	1,308	2,132
Other[1]	92	29
Total for all non-bovines	23,028	25,034
Total TB test-positive animals slaughtered (%)		
SA Camelids	199 (3.6%)	92(1.5%)
Sheep	9 (0.4%)	16(0.7%)
Goats	20 (0.2%)	5(0.0%)
Pigs	2 (0%)	0(0.0%)
Deer	32 (2.4%)	135(6.3%)
Other[1]	2 (2.2%)	0(0.0%)
Total for all non-bovines	264	248
Total positive results from animal specimens subjected to bacteriological culture (%)		
SA Camelids	7 (0.2%)	12(14.5%)
Sheep	4 (0.5%)	1(14.3%)
Goats	4 (0.4%)	1(14.3%)
Pigs	5 (0.1%)	4(2.1%)
Deer	18 (0.5%)	20(48.8%)
Other[1]	4 (0.1%)	4(22.2%)
Total for all non-bovines	42	42
Total laboratory-confirmed TB incidents		
SA Camelids	3	2
Sheep	2	2
Goats	1	0
Pigs	3	3
Deer	6	9
Other[1]	7	4
Total for all non-bovines	22	20

1 The "Other" category includes mainly pets (cats and dogs) and the occasional sample from exotic mammals kept in zoos, safari parks.

3.2 Characteristics of herds found infected with TB

- Four key factors significantly increased the risk of a herd having a new TB incident in England in 2021 namely: i) having over 300 cattle, ii) being in the HRA, iii) being a dairy herd and iv) having experienced a TB incident in the previous three years. These factors often co-exist on many cattle farms. For example, herds in the HRA tend to be larger, and many dairy herds are large, located in the HRA and have a history of TB.
- There is a substantial population of cattle in the north of England that is not infected, showing that other factors are also important. These factors include the existing level of infection in the local cattle population and the presence of a reservoir of *M. bovis* infection in wildlife (particularly badgers) and their environment, to which cattle are exposed.
- Analysis shows that the probability of TB being found in a dairy herd was almost three times that of a beef herd. This is continued evidence that a large part of the burden of TB is carried by the dairy industry.
- Even after adjusting for both herd size and location (i.e. looking at any herd of a given size in a given TB risk area), dairy herds had a 32% greater risk of infection than beef herds ($p<0.001$, incident risk ratio). This contrasts with years prior to 2016, when the differences in risk between beef and dairy herds could be explained by their location and size.
- A history of TB infection was also an important risk factor in all risk areas. Across England, over half the herds (52%) that were disclosed in 2021 had sustained a TB incident within the previous three years (recurrent infection). Recurrence was highest in the HRA (56% of herds with new incidents in 2021), followed by the Edge Area (44%) and LRA (10%).
- The most likely source of infection for each new TB incident herd in 2021, based on an epidemiological veterinary assessment of introduction risk pathways, varied by risk area. Within the HRA, when weighted by the level of veterinary uncertainty, badgers constituted 52% of the attributed risk pathways. In the Edge Area, new TB incidents were still most strongly ascribed to badgers (52%), but cattle movements (17%) were also identified as a common source of infection. In the LRA there was a high degree of uncertainty around the source of infection. However, the weighted source pathways for new incidents were most commonly attributed to inward movements (purchase) of cattle with undetected infection (41%).
- Most TB incidents (81%) from which *M. bovis* was isolated and sequenced occurred within the 'home range' of the Whole Genome Sequencing (WGS) clade of the bacterium identified in the infected animals, indicating the clade was locally prevalent and not unexpected in that area.

Factors associated with the likelihood that a herd will become infected

Many factors may be associated with the risk of a herd becoming infected with TB. These include local herd density, herd size and type, TB history and the geographical location of a herd. Other factors that can contribute towards the distribution of TB include contiguous herds (and their TB history), herd management (such as cattle purchasing) and local environmental/wildlife factors.

Local herd density

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

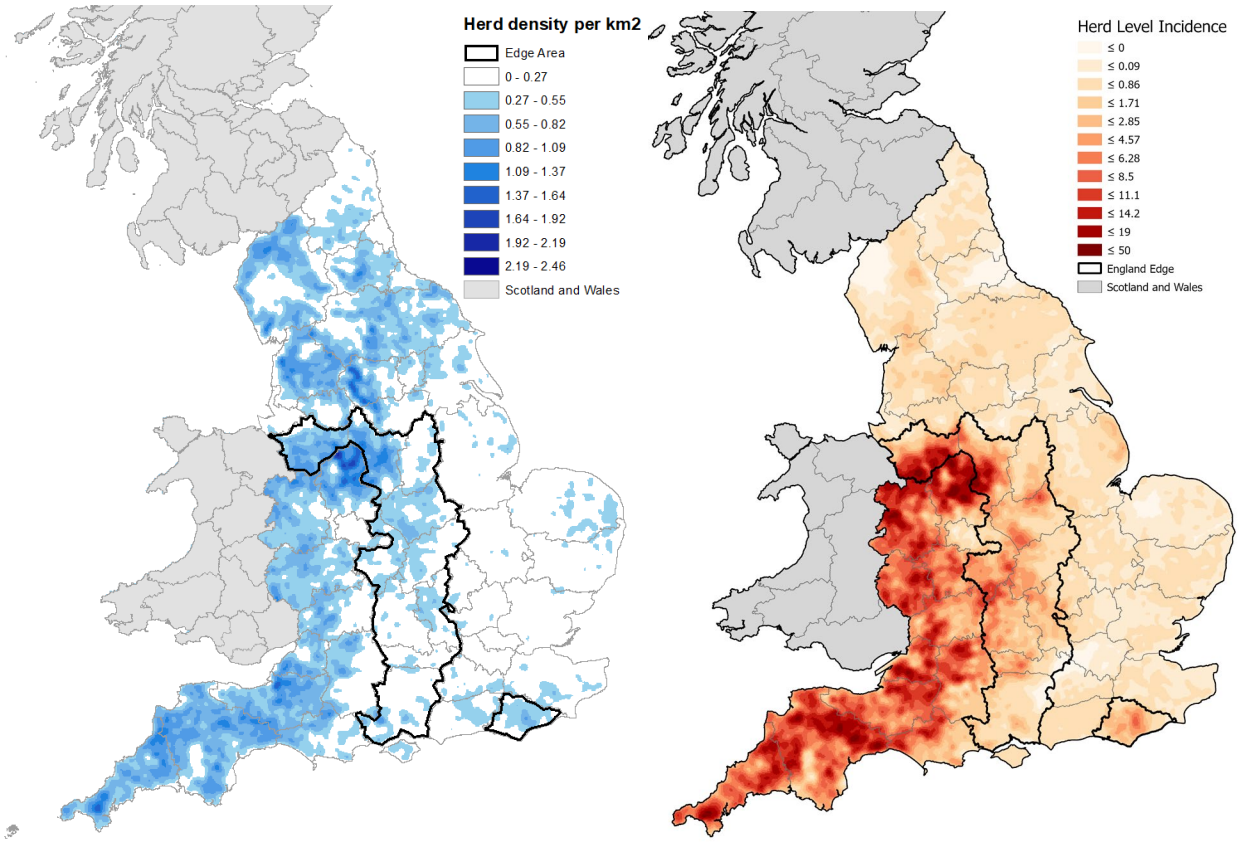


Figure 3.2.1(a) Herd density and (b) herd level incidence of TB in England in 2021. Herd density is measured as the number of herds per square kilometre; herd incidence is the average incidence in the 100 closest herds to each herd location which 'smooths' the effect of political boundaries.

- The highest numbers of cattle and herd density are primarily in the HRA and parts of the Edge Area. The lowest population in terms of both holding and cattle numbers is found in the eastern portion of the LRA.

- However, cattle demographics alone do not explain the geographic distribution of TB, as there is high cattle and herd density in parts of Northern England where TB incidence is low.

Other factors important in explaining the distribution of TB, including herd size, type and TB history, will be explored in greater detail.

Herd size and type

Figure 3.2.2 shows the distribution of herds within each surveillance risk area by size and type. This has remained similar in recent years. Large herds with over 300 cattle have been shown to have the highest risk of infection with TB. These constitute 12%, 10% and 8% of all herds in the HRA, Edge Area and LRA, respectively. This is comparable to observations in 2020.

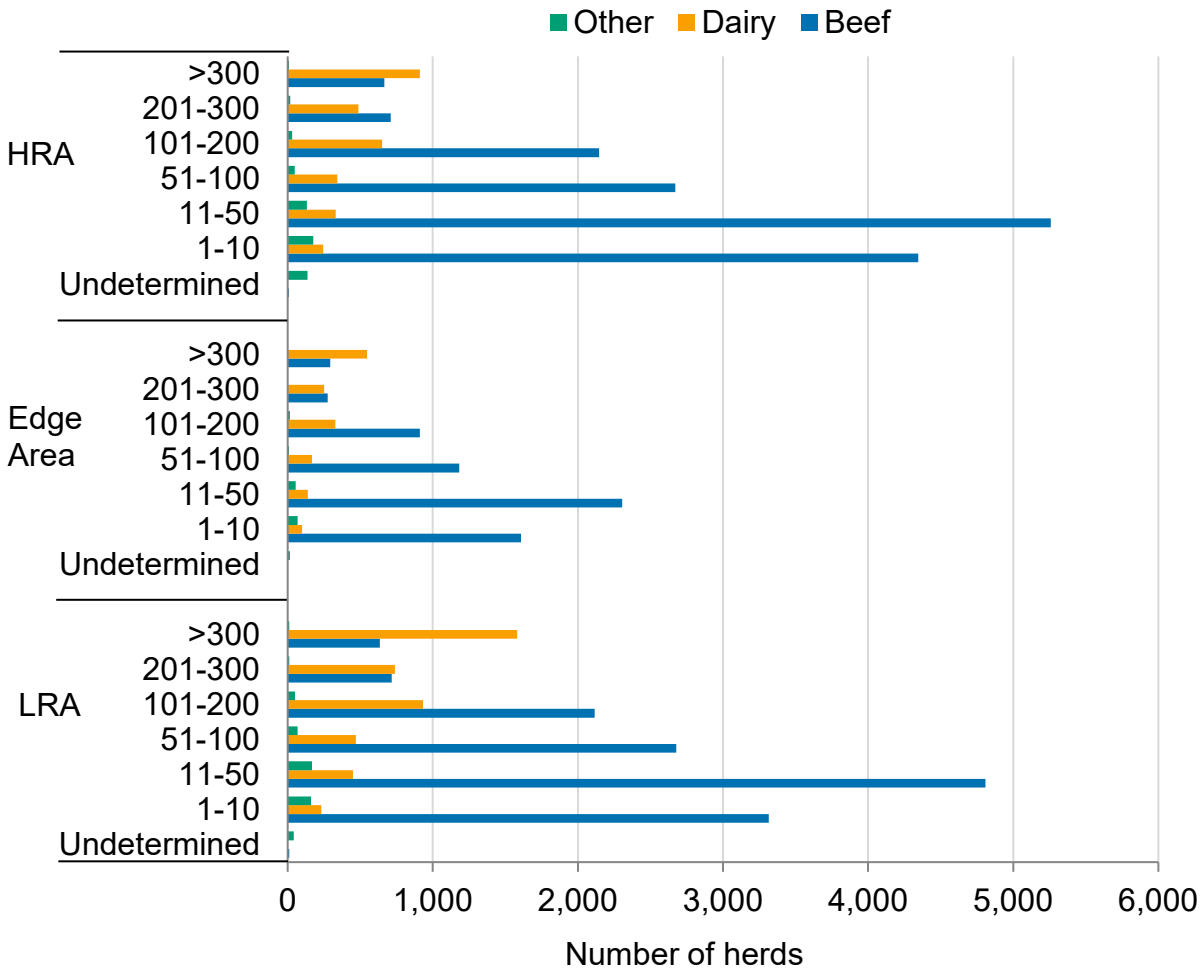


Figure 3.2.2: Number of herds by herd size and type in each risk area of England in 2021

- More large herds, and dairy herds are in the HRA compared with the other two risk areas. This may explain some of the spatial distribution of TB infection.

The percentage of TB incidents disclosed in beef (55%), dairy (~44%) and “other” (1%) herds in 2021 represented a decrease of ~1% in beef herds and an increase of over 1% in dairy herds compared to 2020. This decreasing trend in the percentage of TB incidents in dairy herds is consistent with previous years (since 2007).

As there are many more beef than dairy herds in England, the percentage of new TB incidents by herd type does not truly reflect their likelihood of becoming infected. Figure 3.2.3a shows the incidence rate according to different characteristics (size, production type and location) of herds in England. This demonstrates that dairy were nearly three times more likely to become infected with TB than beef herds in 2021. However, dairy herds also tend to be larger and are more often located in the HRA, both of which are risk factors for TB infection (Figure 3.2.2).

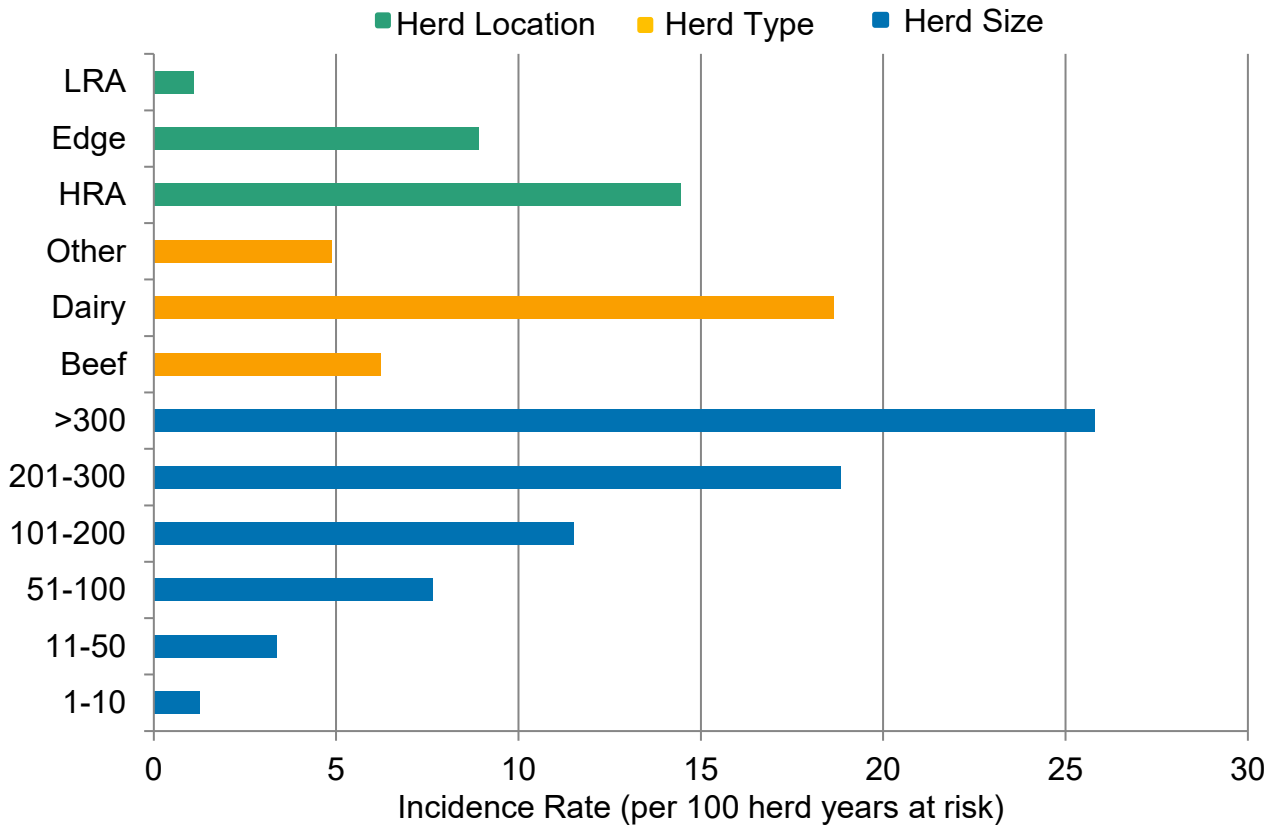


Figure 3.2.3a: Rates of new TB incidents in herds of different size and type, and in each risk area of England, in 2021

- All three factors of herd size, type and location are strongly linked to the risk of TB infection.
- Herd size was strongly associated with the likelihood of becoming infected with TB; herds with over 300 cattle had an incidence rate of approximately 26 new TB

incidents per 100 herd-years at risk in 2021, while it was under 4 in herds with 50 or fewer cattle.
- Dairy herds were almost three times more likely to suffer a TB incident in 2021 than beef herds.
- The herd incidence rate in the HRA was 1.6 times greater than when compared to the Edge Area and approximately 13 times greater than that in the LRA.

Potential risk factors are explored further by comparing incidence rate ratios (IRR; Figure 3.2.3b). This is the comparative proportion of herds in each category that become infected. Other factors that may affect the rate of infection can then be considered. These comparative ratios are shown in Figure 3.2.3b. The adjusted IRR demonstrate, if location and herd type are included when calculating the IRR for herd size, the rate ratio remains similar to the unadjusted IRR. This indicates that herd size may be a more important factor than herd type.

The adjusted IRR for herd size ranged from 0.06 to 0.75 times the rate of TB infection in herds with over 300 animals (the reference herd size range). As seen in previous years, the rate ratios increased with herd size.

The high incidence rate in dairy herds is largely because they tend to be larger and more often located in the HRA than beef herds. Adjusting for both herd size and location significantly reduced the estimated risk associated with being a dairy herd. However, as in previous years, dairy herds remained at higher risk of new infection in 2021 than beef herds of the same size and risk area (adjusted IRR=1.32, 95% CI 1.21-1.44, $p<0.001$).

The incidence rate was significantly lower in the Edge Area and LRA compared to the HRA, even after adjusting for the effects of herd size and type. This indicates that geographical (risk area) location remains an important risk factor. In 2021, the adjusted IRR for herds in the Edge Area compared to the HRA was 0.65 (95% CI 0.59-0.72). In recent years there has been an increase in the estimated risk for herds in the Edge Area compared to the HRA. In 2017, the adjusted IRR was 0.41 (95% CI 0.37-0.46), increasing to 0.49 (95% CI 0.45-0.54) in 2018, 0.6 (95% CI 0.55-0.66) in 2019 and 0.64 (95% CI 0.59-0.70) in 2020.

It is important to note that the Poisson regression analysis used to calculate the IRRs uses aggregated time at risk data. This aggregates the risk for herds that have had multiple whole herd tests in each year. The denominator value (time at risk) is slightly higher overall for the aggregated dataset (Figure 3.2.3b) than the non-aggregated dataset (Figure 3.2.3a). This results in slightly lower incidence rates. For more details about the Poisson analysis, see Appendix 4c in the 2015 report. Tabulated data can be seen in the GB data Report.

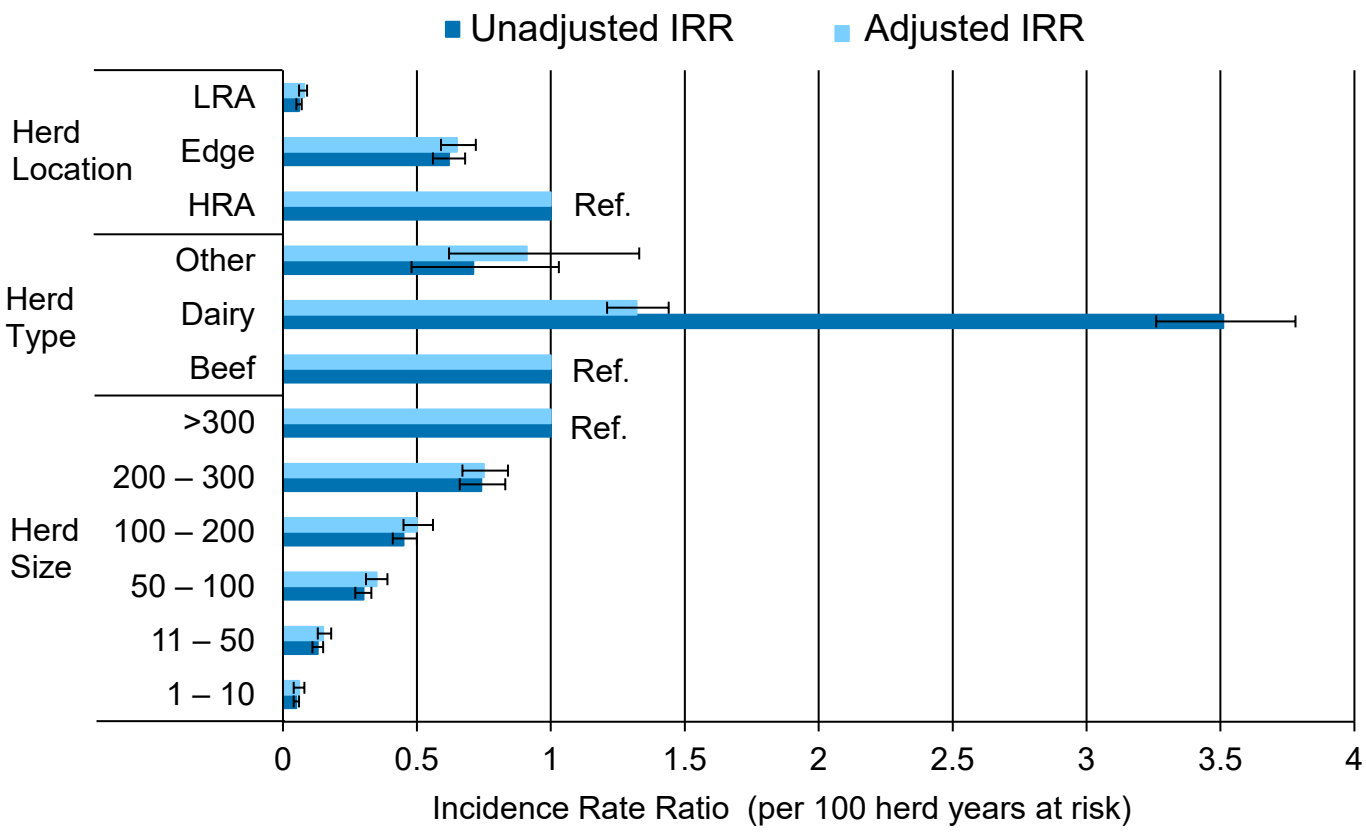


Figure 3.2.3b: Incidence Rate Ratios (Unadjusted and Adjusted) for new TB incidents (OTF-W and OTF-S) in herds of different size, type and risk area in 2021

- Herd size and location are the most important explanatory (risk) factors for the incidence rate.
- The incidence rate for herds in the Edge Area was almost two thirds the rate for herds in the HRA.
- The unadjusted incidence rate in dairy herds was over three times greater than beef herds. However, dairy herds are consistently larger, and more concentrated in the HRA than beef herds.
- After adjusting for herd size and location, dairy herds were 32% more likely to have a TB incident than beef herds (29% in 2020).

Recurrent TB incidents

A herd's history of TB is linked to increased odds of infection occurring in any given year. A new TB incident in a herd that had another TB incident in the previous three years is called a recurrent incident. The percentage of recurrent infected herds are explored in two ways.

1. The percentage of all herds *with* a history of TB that went on to experience a TB incident in 2021, compared to the percentage of all herds *without* a history of TB that went on to have a TB incident in 2021 (forward-looking recurrence).
2. The percentage of TB incident herds in 2021 that had sustained a TB incident in the previous three years (backward-looking recurrence).

The annual trend in the percentage of TB incidents in each year that had a history of TB is shown in Figure 3.2.4. Recurrence was consistently highest in the HRA, and lowest in the LRA. Recurrence in England overall was similar in 2020 and 2021 (51% and 52%, respectively). The percentage of recurrent incidents reduced marginally in the HRA (57% to 56%) but increased in the Edge Area (from 41 to 44%). In the LRA, the percentage of herds with a TB incident that had a history of TB was much lower than in the other two TB risk areas of England, at 10%, and decreasing with respect to 2019 (Figure 3.2.4).

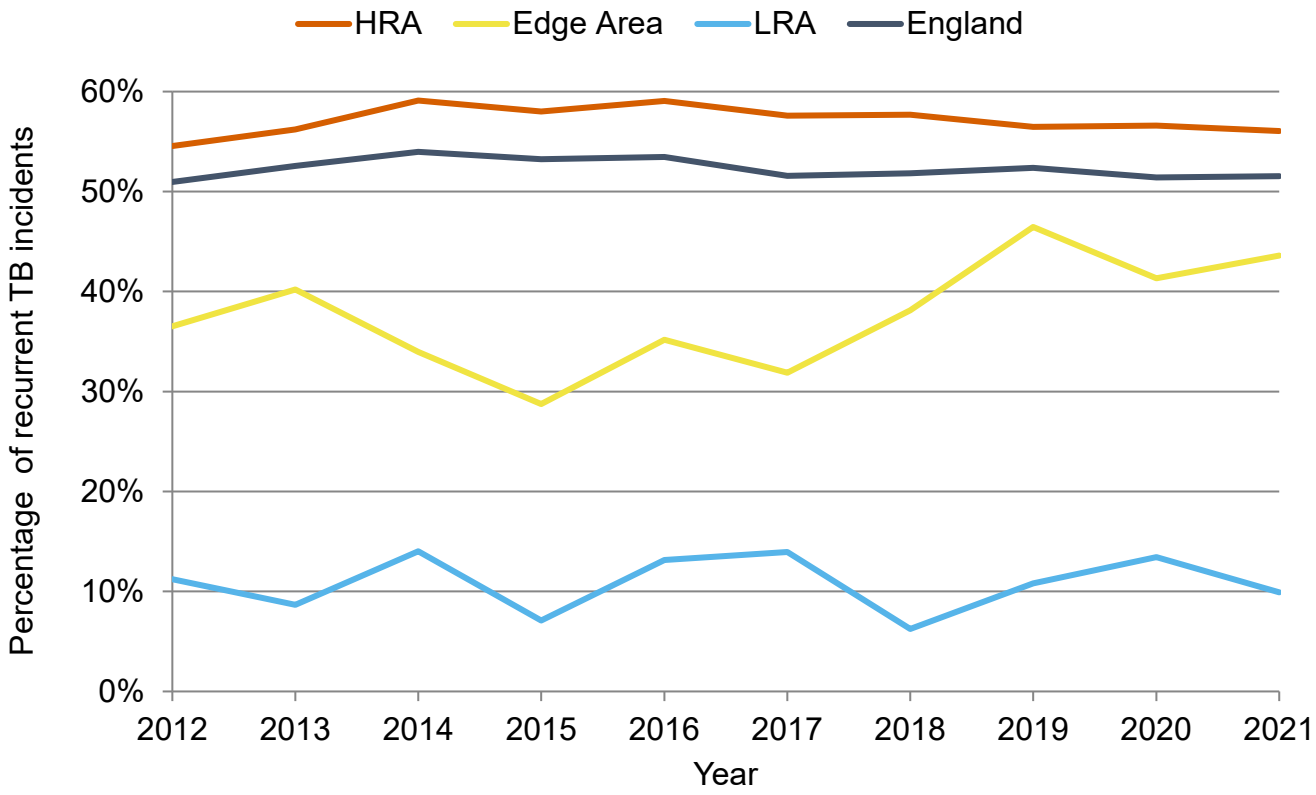


Figure 3.2.4 Annual percentage of TB incidents with a history of TB in the previous three years, by risk area, from 2012 to 2021

- The percentage of recurrent TB incidents has remained relatively stable in the HRA and LRA over the past ten years.
- The percentage of recurrent TB incidents increased again in the Edge Area in 2021 (44%) after the 2019 decrease (41%), the first decrease since 2017 (32%).
- In the LRA, the percentage of recurrent TB incidents decreases to 10% in 2021, following the increase between 2018 (6%) and 2020 (13%).

Forward looking recurrence

In 2021, the odds ratio for recurrent incidents compared to new incidents in herds with no history of TB (forward-looking recurrence odds ratio) was lowest in the HRA (OR 1.8, 95% CI 1.6-2.0). For the Edge Area, the odds were higher at 2.2 (95% CI 1.8-2.6). The recurrence odds ratio was highest in the LRA, albeit with wide confidence intervals (OR 3.8, 95% CI 2.0-6.9). Similarly, the odds ratios for recurrent incidents compared to new incidents in herds with a history of an OTF-W were lowest in the HRA (OR=1.7, 95% CI 1.58-1.94), increasing to 2.5 in the Edge (95% CI 2.0-3.1) and 3.5 in the LRA (955 CI 1.1-11.3).

The recurrence odds ratio has been relatively stable in the HRA in recent years (close to 2), but more variable in the Edge Area. In 2021, the Edge Area recurrence odds ratio

remained similar to the previous year (OR 2.3 95% CI 1.9-2.7 in 2020), after a period of increase from 2017 (OR 1.7, 95% CI 1.9-2.9) to 2019 (OR 3.5 95% CI 2.9-4.2).

Some parts of the Edge Area have endemic infection, whilst other areas have a low incidence of TB (i.e it is heterogenous). When recurrence is calculated for this area, the odds of herds with a TB history having a new incident in 2021 is higher than the odds in the HRA. However, the odds of TB in herds with no TB history is lower than the HRA. This causes a higher odds ratio for the Edge Area.

When comparing herd type, the odds of having TB was roughly two times higher in both beef and dairy herds with a TB history, compared to herds with no TB history. The odds of recurrent TB was higher in the ‘other’ category (any cattle other than those registered as beef or cattle herds, OR 4.5, 95% CI 1.9-10.8). The ‘other’ category only had 25 new TB incidents in 2021 (just below 1% of all incidents), and accounts for 2.7% of all herds in England. The odds ratio increased in comparison to 2020 (OR 2.5 95% CI 1.0-6.4), although the 95% confidence interval was wide in both years.

When the same analyses were run on herds which had suffered previous OTF-W incidents only (rather than OTF-W and OTF-S), the odds of a recurrent incident remained substantially the same. This is in contrast with 2020, when having any TB incident in the LRA was almost eight times more likely in herds with a history of OTF-W incidents, compared to herds with an OTF-S incident or no TB history (OR 7.8 95% CI 3.8-15.8).

The odds of having a TB incident in herds with a TB history, compared to herds without a history of TB incidents, varied between herd size categories (Figure 3.2.5a). This is opposed to 2020 when the odds of recurrent infection were around 2 for all the herd size categories. For small herds (10 cattle or less), the odds of having a TB incident in herds with a TB history compared to herds with no TB history was 4.9; for herds with 11 to 50 cattle the odds ratio was 3.0, for 51 to 100 cattle the odds ratio was 2; for 101 to 200 cattle the odds ratio was 1.5; for 201 to 300 cattle the odds ratio was 1.7; and for over 300 cattle the odds ratio was 1.8.

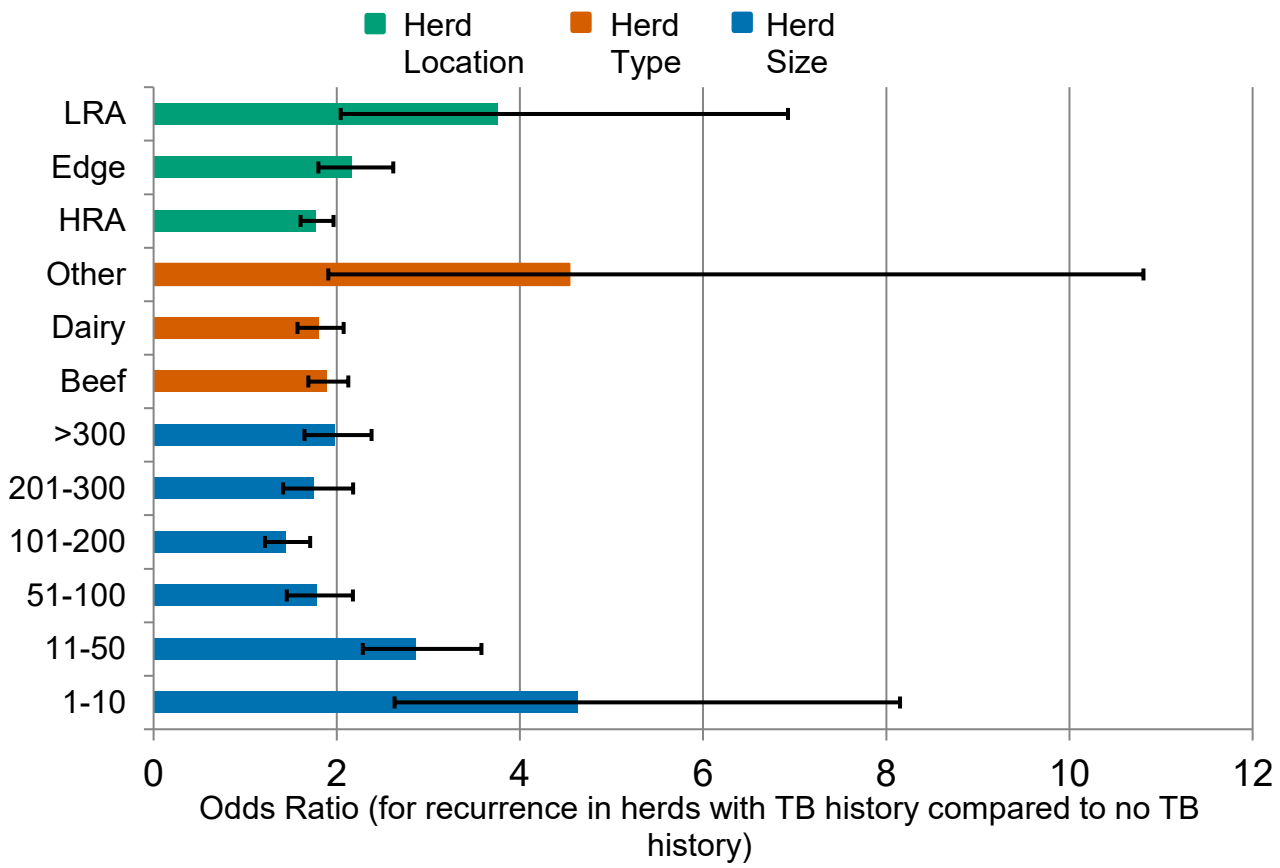


Figure 3.2.5a: The odds of recurrent infection in herds with a history of TB compared to herds with no TB history in 2021, by herd size, herd type and risk area (error bars show 95% confidence intervals)

- 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).
- Herds with different herd sizes have different odds of recurrent infection, however smaller herds (below 50 cattle) had higher odds compared to larger herds (above 51 cattle).
- In the HRA, the odds of recurrent infection in herds with a history of TB compared to herds with no TB history was just under double.
- In the Edge Area, the odds of recurrent infection were more than double for herds with a history of TB compared to herds with no TB history.
- In the LRA the odds of a TB incident in a herd with TB history were almost four times greater than herds with no TB history, however the confidence intervals were wide.

Backward looking recurrence

Backward-looking recurrence, as a percentage of all herds that were positive in 2021 only, was examined within each risk area and herd type category separately (Figure 3.2.5b). Herds with an incident were examined to see what percentage had sustained another TB incident in the previous three years. In all three risk areas, the percentage of recurrent TB

incidents was highest in dairy herds, with around half the percentage of beef herds experiencing a recurrent infection.

Recurrence may result from multiple factors: residual (undetected) cattle infection from a previous TB incident in the same herd, from continuous exposure to local infection in wildlife or cattle reservoirs, or from introductions of undetected infected cattle to a herd. 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' awareness of the risk factors involved in contracting TB in their herds may also help those keepers with a history of TB infection make informed decisions about their management and biosecurity practices, using initiatives such as the TB Hub.

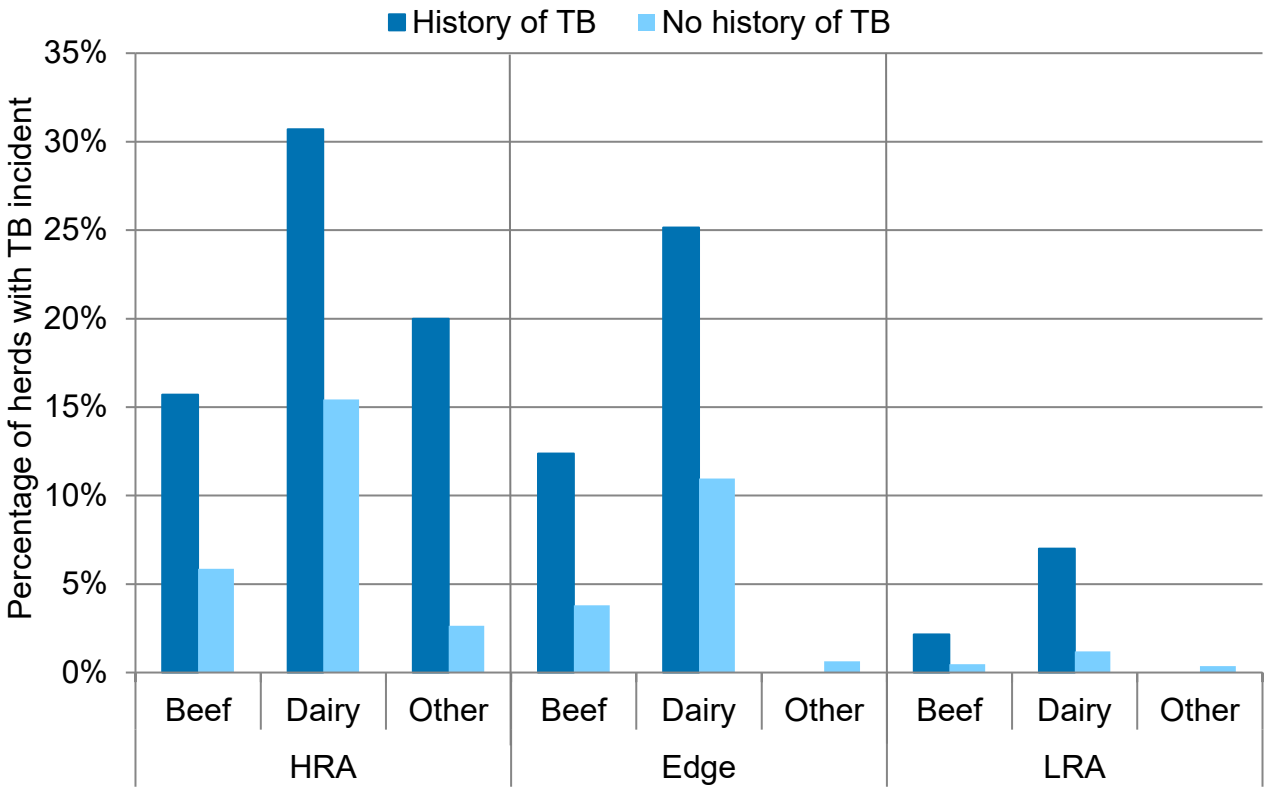


Figure 3.2.5b: The percentage of herds with and without a history of TB in the previous three years, that went on to disclose a TB incident in 2021, by risk area and herd type

- The percentage of beef and dairy herds with a TB incident in 2021 was higher among herds with a TB history in the previous three years than those without, for all risk areas.
- Dairy herds with a history of TB accounted for the largest percentage of recurrent incidents in all three areas compared to beef and 'other' herds, and this is consistent with previous reporting years.
- In the HRA, the percentage of TB incidents in 'other' herds with a TB history increased from 12% in 2020 to 20% in 2021.

- In the Edge Area, ‘other’ herds had no TB incidents in herds with a TB history, in contrast to 2020 where the percentage of TB incidents was almost 17%.
- In the LRA, the percentage of TB incidents in beef herds with a TB history decreased from almost 6% in 2020 to 3% in 2021.

Molecular typing

APHA attempts to recover *M. bovis* from all TB incidents and to submit at least one isolate per TB incident for genetic characterisation. Historically, this characterisation used a combination of spoligotyping and Variable Number Tandem Repeat (VNTR) typing generating a molecular type (genotype). In 2021, Whole Genome Sequencing (WGS) fully replaced spoligo- and VNTR-typing of *M. bovis* isolates at APHA.

WGS examines variation caused by mutations across the entire DNA sequence of the *M. bovis* genome (4.4 million nucleotide positions), whereas spoligotyping and VNTR-typing measure variation in only one and six small regions of the bacterial genome, respectively. WGS allows true evolutionary comparison of isolates. Where previously genotypes were reported in previous years, for 2021 WGS clades are reported.
A clade is a group of genetically related isolates, based on similarities between their whole genome sequence. Most genotypes can be ascribed to a single WGS clade, but this is not always the case. The combination of geographic location and clade detection frequency can be used to describe areas where particular clades are common (so-called ‘home ranges’). This then enables isolates from new TB incidents to be compared with the previous known distribution of that clade. The improved granularity provided by WGS data will help provide greater discrimination between strains of *M. bovis* than the previous genotyping method, allowing true evolutionary relatedness to be determined. This allows more accurate determination of transmission pathways and can confirm whether recurrent incidents have been caused by residual infection in the herd , or by a new introduction from a cattle or wildlife source.

Of the 1,938 isolates sequenced with a full clade identification in 2021, 1,573 (81%) were in their home range (365 isolates were out-of-home range). The most frequent clade found in England in 2021 was b6-11, which accounted for 22% of the *M. bovis* isolates subjected to testing.

The next most common clades identified were b3-11 (19%) and b6-85 (17%), based on 1,943 incidents (isolates with and without home range) starting in 2021 with a clade identified. These three clades accounted for 58% of all the *M. bovis* isolates that underwent WGS and cover extensive areas in the Southwest and West (Midlands) (Figure 3.2.6). Further information about WGS is given in the Explanatory Supplement. The assessments described in the next section on source of infection have been informed by knowledge of the genotype where available. Further statistics on the outcomes of *M. bovis* genotyping carried out in 2021 are included in the GB Data Report.

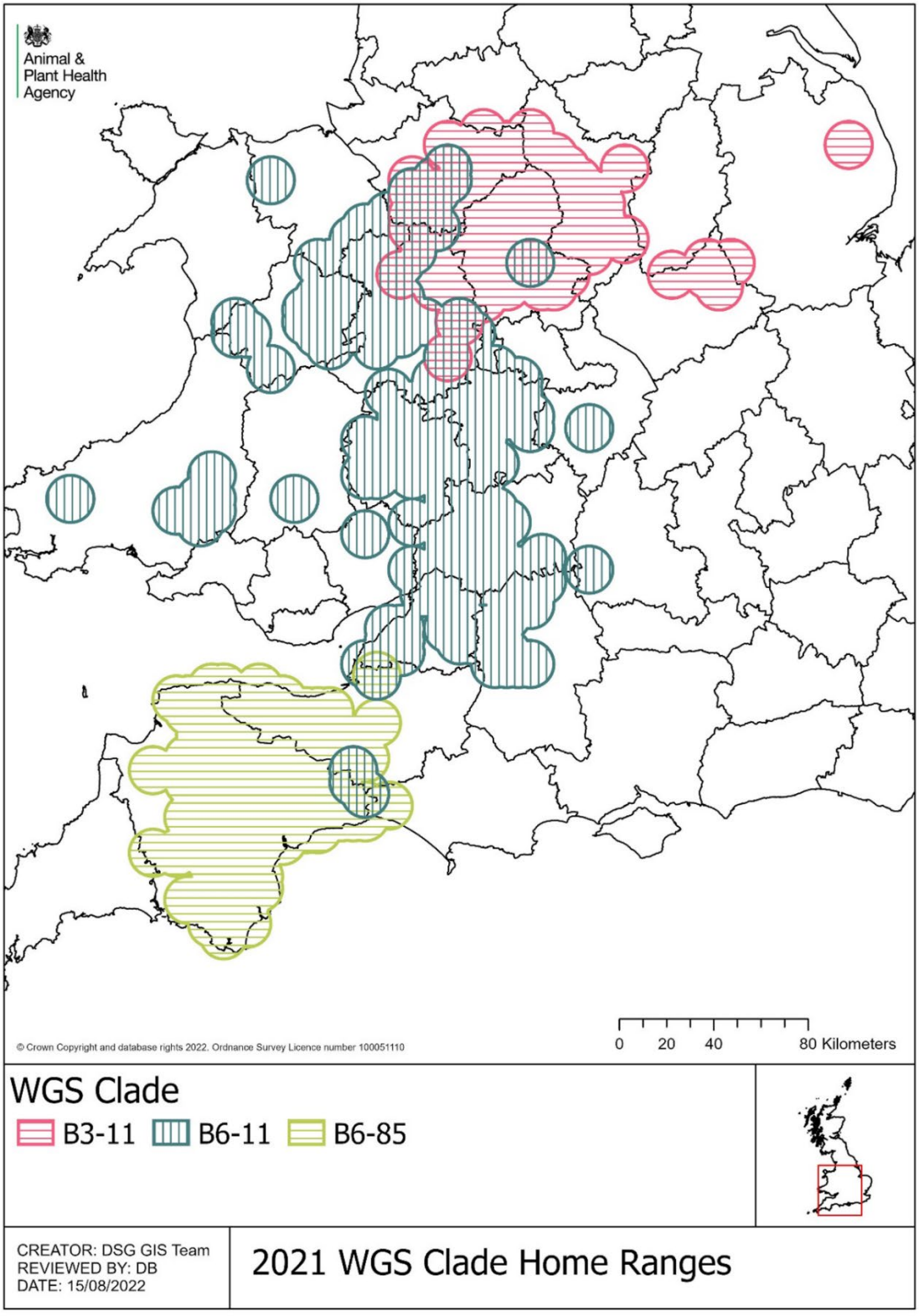


Figure 3.2.6. Homeranges of genotypes B3-11, B6-11 and B8-85 of *M. bovis*, based on data from 2021.

APHA veterinary assessment of the sources of infection for herds with a new TB incident in 2021

It can be challenging to retrospectively establish the route of infection for a TB incident herd. The aim for APHA field veterinarians (case vets) is to complete an epidemiological assessment for all TB incidents in the Edge Area and LRA (both OTF-W and OTF-S). However, where resource constraints exist, it may not be possible to investigate all incidents (especially in the HRA), so that a proportion will be randomly selected or 'triaged' for a visit. In the HRA one third of new incidents 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 in a single round of testing). Epidemiological assessments typically include a thorough on-farm investigation and scrutiny of routinely collected data such as cattle movement records, cattle testing and TB history and the results of molecular analyses where available. In 2020, some epidemiological assessments were carried out remotely, by telephone, to minimise contact due to COVID-19. Phone assessments continued to be carried out in 2021. Using available evidence examined in the assessment, up to three risk pathways of infection are selected for each herd with an indication of any uncertainty. These are captured on a Disease Report Form (DRF). There is a backlog of DRF visits outstanding in 2021 due to the diversion of APHA resources towards more pressing business needs (e.g., prioritisation of the concurrent high-pathogenic avian influenza outbreak control effort, urgent priority resourcing of Ukraine refugee pet import scheme, etc.). It is important to note that these competing pressures affected the number and method of DRF assessments, but not the rigour of the analysis of risk pathways included in this report.

The weighted source of infection

Each risk pathway is given a score that reflects the assessed likelihood of that pathway bringing TB into the herd. The score is recorded as either definite (score 8), most likely (score 6), likely (score 4) or possible (score 1). Risk pathway data is then explored both at the herd, county and risk area level. To consider the contribution of all sources of infection within an area, the source(s) for each incident are weighted by the certainty ascribed. Any combination of definite, most likely, likely or possible sources can contribute towards the overall picture for possible routes of introduction into a herd. If the overall certainty score for a herd is less than six, then the score is made up to six using the 'Other/Unknown Source' option. Buffering up to six in this way helps to reflect the uncertainty in assessments where only 'likely' or 'possible' sources are identified. Within the TB epidemiology reports, the terms likelihood and certainty are conflated and used interchangeably to describe the score ascribed to each risk pathway during the veterinary risk pathway assessment.

Figure 3.2.7 shows a comparison of risk pathway investigations that had a high degree of uncertainty in the selected risk pathway(s). Both the percentage of investigations with sufficient certainty, and those where additional 'other or unknown' source was applied are

shown. For OTF-W incidents in the HRA that were selected for an investigation, 78% had sufficient certainty, and 22% required some additional uncertainty buffering. In the LRA, there was more certainty around the OTF-W risk pathways; 49% did not have sufficient certainty and additional uncertainty was applied. In the Edge area, the uncertainty was applied to only 15% of the investigations. For OTF-S incident investigations, where no genotyping or WGS evidence is available, the percentage of investigations that had insufficient certainty was generally higher. This was true especially for the LRA where 60% of OTF-S investigations had uncertainty applied. In the HRA and in the Edge Area respectively 30% and 33% of the investigation carried out had an additional buffer of uncertainty applied. Overall, this demonstrates that the likelihood scores from the veterinary assessments of potential infection sources are highest in the HRA and Edge Area and lowest in the LRA. It is important to keep this in mind when interpreting the aggregated outputs in this section.

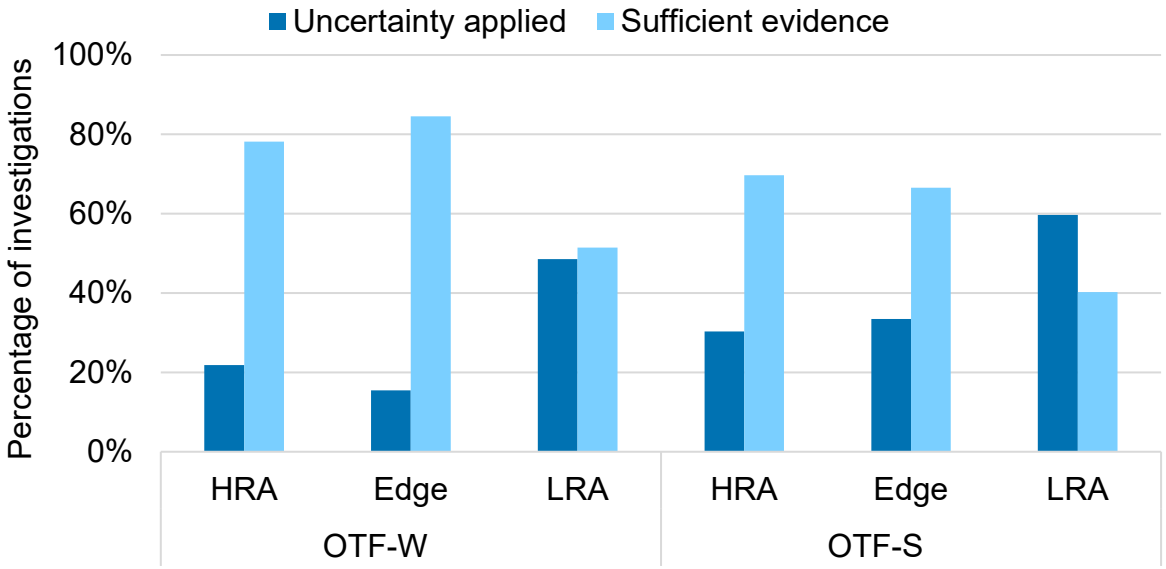


Figure 3.2.7: Comparison of risk pathway investigations (OTF-W and OTF-S incidents) that had sufficient evidence or required additional uncertainty to be applied in the LRA, Edge Area and HRA in 2021

The weighted assessments of infection source outputs in Table 3.2.1 and Figures 3.2.8 to 3.2.10 are produced by combining the data from multiple herds. This presents the percentage of pathways in which each source was identified, weighted by the level of certainty that each source caused the introduction of TB. The outputs do not show the percentage of herds where each pathway was identified (this is skewed by the certainty calculation). Sequencing of *M. bovis* isolates can be a powerful tool in helping identify a likely source of infection. However, by definition, WGS clades cannot determined for OTF-S herds, for which an *M. bovis* isolate is not available. The inclusion of OTF-S herd incidents in these calculations increases the uncertainty in the outputs. As a result, the relative percentages of each risk pathway are very approximate and only broad generalisations should be made from these data. A more detailed description of this methodology is provided in the Explanatory Supplement.

At county level, the most common source of infection attributed within the HRA was badgers, with over 65% in Cornwall (76%), Staffordshire (66%) and Shropshire (66%). The calculated percentage in the West Midlands was 100%, but this was based on one DRF investigation only (Table 3.2.1).

Within the Edge Area, the source of infection with the highest contribution varied between counties. Oxfordshire (56%), Derbyshire (56%), Cheshire (67%) and Northamptonshire (69%) all had more than half of the weighted source attributed to badgers. In some other Edge Area counties, the largest weighted proportion of source of infection was cattle movements, such as Buckinghamshire (41%) and Hampshire (47%, Table 3.2.1).

Investigations for the LRA are not aggregated to county level because of the low number of incidents and the high degree of uncertainty in each county. The most frequently represented sources of infection in the area were ‘Other or unknown’ (46%) followed by cattle movement (22%).

Table 3.2.1: Number of Disease Report Forms completed in 2021 (OTF-W and OTF-S incidents) and the weighted contribution each source of infection made to those incidents, by Risk Area and HRA and Edge Area county

County	Badgers	Cattle movement	Contiguous infection	Residual infection	Domestic animals	Non-specific reactor	Fomite source	Other wildlife	Other or unknown	No. of DRFs	Total TB incidents (% of incidents with DRF)
Somerset	31.0%	10.4%	0.2%	11.6%	0.0%	0.2%	0.4%	8.1%	38.1%	98	207 (47.3%)
Devonshire	45.7%	12.1%	2.9%	10.8%	0.2%	0.0%	0.5%	16.6%	11.3%	193	495 (39.0%)
Shropshire	65.7%	11.2%	0.3%	8.9%	0.0%	0.0%	0.9%	5.9%	7.1%	107	275 (38.9%)
Hereford & Worcester	45.3%	17.3%	1.2%	6.2%	0.0%	1.0%	0.5%	9.4%	19.2%	81	242 (33.5%)
Cornwall	76.0%	5.1%	0.0%	4.2%	0.0%	0.0%	0.3%	4.8%	9.6%	116	245 (47.3%)
Staffordshire	65.6%	16.7%	2.5%	7.7%	0.0%	1.3%	0.4%	2.2%	3.5%	87	241 (36.1%)
Dorset	44.8%	12.9%	0.2%	10.2%	0.3%	0.0%	0.3%	9.5%	22.0%	44	102 (43.1%)
Gloucestershire	45.9%	9.3%	2.3%	7.1%	0.0%	1.5%	1.0%	9.9%	23.2%	44	111 (39.6%)
Wiltshire	33.9%	12.1%	0.7%	9.4%	0.0%	5.7%	0.0%	7.1%	31.3%	51	135 (37.8%)
Avon	50.6%	10.4%	3.4%	7.9%	0.0%	0.0%	0.4%	11.5%	15.9%	26	99 (26.3%)
West Midlands	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1	3 (33.3%)
HRA Overall	**52.1%**	**11.6%**	**1.4%**	**8.6%**	**0.1%**	**0.7%**	**0.5%**	**9.0%**	**16.1%**	**848**	**2155 (39.4%)**
Hampshire	10.9%	47.4%	5.1%	19.3%	0.0%	0.0%	0.0%	4.4%	13.0%	18	21 (85.7%)
Warwickshire	49.7%	10.6%	0.0%	6.1%	0.0%	0.0%	1.9%	12.0%	19.7%	52	56 (92.9%)
Derbyshire	56.1%	12.8%	3.3%	12.1%	0.0%	0.5%	0.4%	3.6%	11.1%	79	115 (68.7%)
East Sussex	31.9%	19.8%	3.2%	18.1%	0.0%	0.0%	0.7%	1.3%	25.0%	25	27 (92.6%)
Leicestershire	46.7%	21.7%	1.9%	9.0%	0.0%	0.3%	0.5%	3.9%	16.0%	51	54 (94.4%)
Northamptonshire	68.9%	13.0%	3.3%	6.7%	0.0%	0.0%	0.0%	2.4%	5.7%	29	35 (82.9%)
Cheshire	66.6%	10.5%	1.6%	9.1%	0.0%	0.0%	0.9%	2.3%	9.1%	120	141 (85.1%)
Berkshire	26.6%	33.3%	0.8%	15.1%	0.0%	0.0%	0.0%	5.0%	19.3%	19	19 (100.0%)
Oxfordshire	56.0%	19.7%	0.0%	16.8%	0.0%	0.7%	0.0%	1.6%	5.2%	56	57 (98.2%)
Buckinghamshire	41.2%	41.4%	0.5%	5.3%	0.0%	0.0%	1.2%	0.5%	9.9%	27	27 (100.0%)
Nottinghamshire	32.7%	1.6%	0.0%	1.7%	0.0%	0.0%	1.0%	6.7%	56.2%	16	21 (76.2%)
Edge Area Overall	**52.1%**	**17.4%**	**1.7%**	**10.6%**	**0.0%**	**0.2%**	**0.7%**	**3.8%**	**13.5%**	**492**	**573 (85.9%)**
LRA Overall	**10.3%**	**22.3%**	**4.8%**	**1.2%**	**0.0%**	**6.6%**	**1.9%**	**7.3%**	**45.5%**	**107**	**123 (87.0%)**
England Overall	**49.1%**	**14.4%**	**1.7%**	**8.7%**	**0.0%**	**0.9%**	**0.6%**	**7.1%**	**17.4%**	**1447**	**2851 (50.8%)**

The calculated contributions of each source of infection for the HRA, Edge Area and LRA TB incidents are depicted in Figures 3.2.8 to 3.2.10 respectively. Within the HRA, badgers constituted 52% of the weighted opinion, while cattle movements accounted for 12% of the weighted opinion (Figure 3.2.8). In the Edge Area, the source was still most strongly ascribed to badgers (51%), but cattle movements (17%) were also identified as posing a high risk of introduction (Figure 3.2.9). Conversely, in the LRA the contribution of badgers was much lower at only 10%. Overall, TB incidents in the LRA were most strongly attributed to 'Other or Unknown Source' (45%), followed by cattle movement (22%; Figures 3.2.10). This finding is in contrast with what seen in 2020 where cattle movements represented the main source of infection (40%) and 'Other or Unknown' sources were less represented (30%).

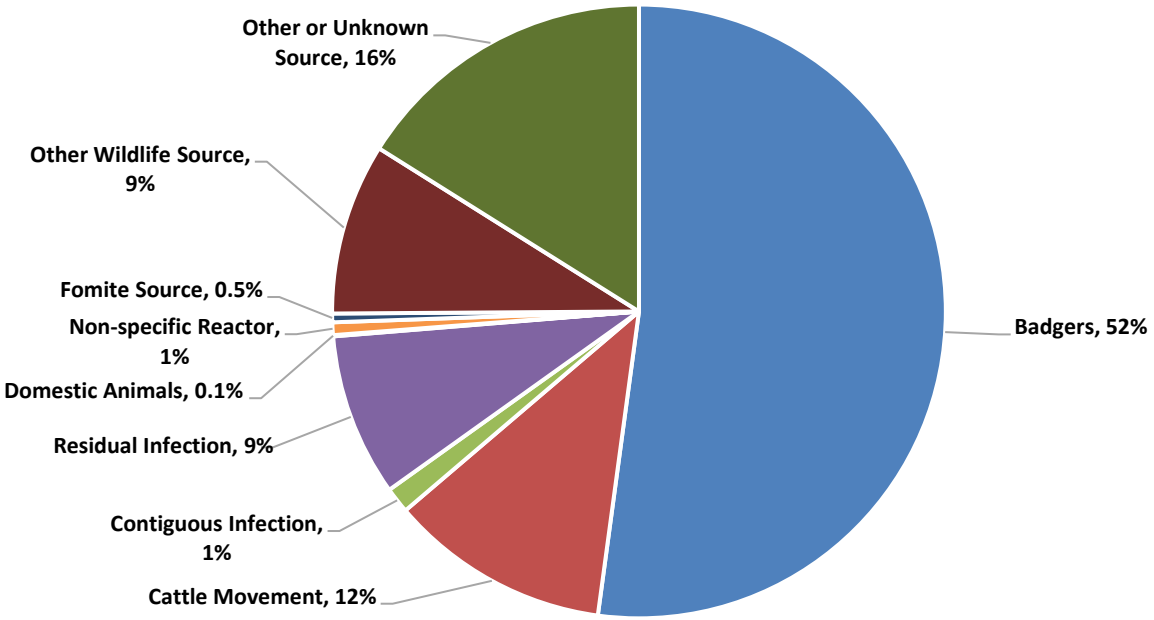


Figure 3.2.8: Summary of the weighted source of infection attributed for all TB incidents (both OTF-W and OTF-S) with a provisional or final pathway that started in 2021, in the HRA (n=848).

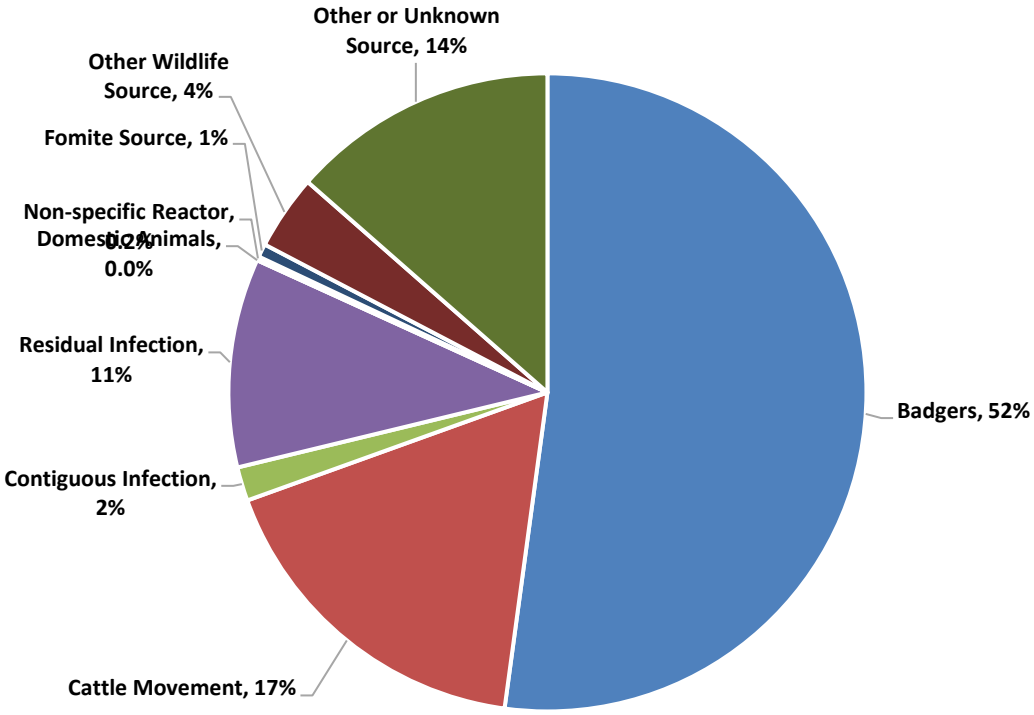


Figure 3.2.9: Summary of the weighted source of infection attributed for all TB incidents (both OTF-W and OTF-S) with a provisional or final pathway that started in 2021, in the Edge Area (n=492)

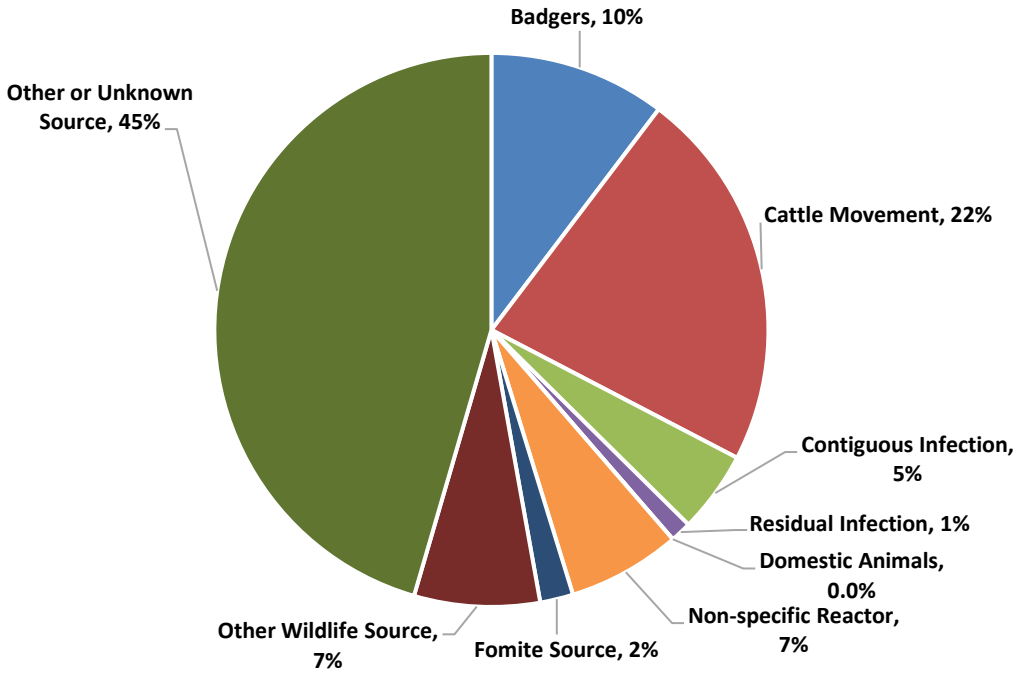


Figure 3.2.10 Summary of the weighted source of infection attributed for all TB incidents (both OTF-W and OTF-S) with a provisional or final pathway that started in 2021, in the LRA (n=107)

The most likely source of infection in individual TB incidents

The geographic distributions of the most likely source of infection for new TB herd incidents in 2021 are indicated in Figure 3.2.11. TB incidents that did not have a single source with more than 50% of the ascribed certainty are marked as an unclear source. Where two sources were ranked equally as the most likely source for an incident, the incident is also reported as 'unclear'.

TB incidents within the HRA were most often attributed to a wildlife source (from here onwards defined as the pooled estimate for badgers and 'other' wildlife source).

In the LRA, the percentage of incidents with an unclear source or 'Other' source were high, followed by cattle movements as the second most reported source of infection. This is not surprising as most TB incidents in the LRA are OTF-S, where no *M. bovis* isolates are available for genetic analysis.

A small number of incidents in the LRA with a likely wildlife source (including OTF-S incidents where the evidence may be limited) occurred in Cumbria, Greater Manchester, West Yorkshire and Lincolnshire. These are all located in potential or confirmed hotspot areas, or specific areas of concern identified in 2021. For more details see chapter 4.3 (Epidemiology of TB in the Low Risk Area).

Within the Edge Area, TB incidents bordering the HRA, and in the north of the area were more often ascribed to badgers, while those towards the LRA and in the south and east were more commonly linked to both badgers and the movement of cattle. Additionally, a few notable clusters of badger attributed infection persist close to the LRA border in Leicestershire and Northamptonshire, close to the southwest Lincolnshire hotspot area (known as 'HS23'). Further details on the relevant risk pathways for each county within the Edge Area and LRA can be found in the 2020 Edge Area and LRA year-end epidemiology reports.

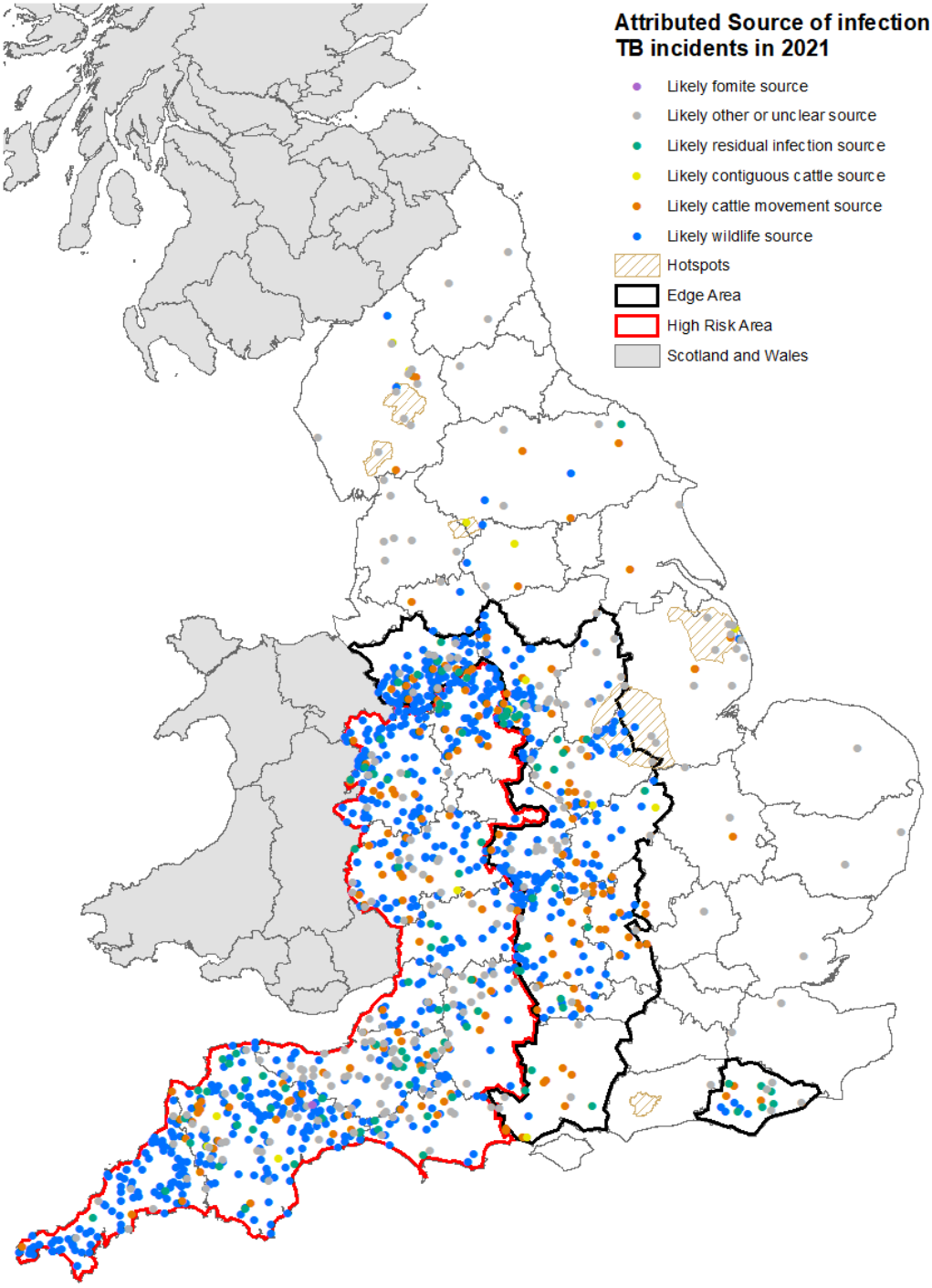


Figure 3.2.11. The source of infection recorded with the highest level of certainty, selected by informed veterinary opinion, for all TB incidents (both OTF-W and OTF-S) that started in 2021 and had the disease report form (DRF) survey completed.

- Wildlife was the most likely source of infection ascribed to TB incidents in the HRA.
- Unclear source or 'Other' source were the predominant most likely source of infection ascribed to new TB incidents in the LRA.

3.3 Finding infected herds: effectiveness of different TB surveillance streams

- In 2021, just over 4 million TB skin tests (and over 1.2 million carcases of commercially slaughtered non-reactor cattle subjected to *post-mortem* meat inspection) were carried out in bovine animals in England; half of which were in the HRA.
- In the HRA and Edge Area, TB incidents were most often disclosed by routine surveillance herd tests (43% annual and 56% six-monthly). In the LRA, 47% of all TB incidents and OTF-W incidents were detected by Area and Herd Risk surveillance.
- The total number of new TB incidents and the proportion of new OTF-W incidents disclosed by the slaughterhouse (passive) surveillance stream in England decreased between 2020 (366 and 29% respectively) and 2021 (337 and 21% respectively). In the HRA the proportion of TB incidents disclosed through slaughterhouse surveillance decreased by 0.3% in 2021 compared to 2020.In the LRA and Edge Area, it increased by 3.9% and 1.6% respectively.
- Within the Area and Herd Risk surveillance stream, 82% of TB incidents in the HRA, and 54% in the Edge Area, were detected by post-incident tests; compared to 12% in the LRA. This reflects the difficulty of clearing infection (and avoiding re-infection) in herds that disclosed a TB incident in the HRA and Edge Area. It also highlights the need for a better understanding of the factors that lead to recurrent incidents on cattle farms.
- Radial tests detected the majority (69%) of TB incidents from Area and Herd risk tests in the LRA, an increase on 2020 of 59%. Some of the incidents detected this way are likely to be the result of lateral spread. As such, reducing transmission from local cattle movements and contact with contiguous cattle herds could reduce TB incidence in the LRA.
- In the HRA, 40% of OTF herds that only disclosed inconclusive reactors (IR) went on to have a TB incident within the following 15 months. This was similar in the Edge Area (36%) and LRA (25%). This indicates that IRs are an important predictor of the presence of infection and supports the policy of restricting IRs that pass their 60-day re-test (‘resolved IRs’) to their disclosing herd for life.
- Trade and other surveillance tests (primarily pre-movement tests) disclosed only 6% of TB incidents in 2021. This was an 36% decrease from 2020.
- Cattle are predominantly moved within, rather than between, risk areas. A total of 176 new TB incidents were detected in 2021 by pre-movement tests, of which 86% occurred in the HRA; 13% in the Edge Area and 1% in the LRA.

Surveillance overview

Bovine tuberculosis (TB) is typically a slowly progressing disease in which infected individuals rarely display clinical signs, although they can spread infection when

subclinically infected. TB surveillance is performed using immunological markers of *M. bovis* infection in live cattle and inspecting for pathology (visible lesions) which are characteristic of TB in dead animals. The TB surveillance programme thus involves both active (TB testing of live farm animals) and passive (meat inspection of cattle carcasses for TB and other notifiable diseases at *post-mortem* in the slaughterhouse*)* surveillance. Slaughterhouse surveillance is carried out by the Food Standards Agency (FSA) meat inspectors and veterinarians. On-farm testing is usually performed by Official Veterinarians appointed by APHA, or occasionally by APHA vets or Animal Health Officers. The primary surveillance test is the Single Intradermal Comparative Cervical Tuberculin test (SICCT). Commonly referred to as the 'skin test', this measures the presence of a delayed type hypersensitivity (allergic) response to an injection of bovine tuberculin into the deep layer of the animal's skin in the neck, which is compared to the response to a simultaneous injection of avian tuberculin in an adjacent site. The comparative nature of the SICCT is to account for the common presence of environmental mycobacteria which can confound the bovine tuberculin reaction.

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

- **Routine:** active surveillance through systematic herd level (skin testing of OTF herds at a pre-defined interval of 6, 12 or 48 months.
- **Area and Herd Risk:** more targeted active surveillance with additional skin testing of OTF herds, or individual cattle because they are at greater risk of being infected; including contiguous herd, radial, hotspot, tracing and check tests following the conclusion of a TB incident.
- **Slaughterhouse:** *post-mortem* meat inspection of all cattle commercially slaughtered for human consumption, as well as cattle that die on farm and are disposed of at an animal by-products processing facility.
- **Trade and Other:** active surveillance through skin tests of individual animals moved between OTF herds. Generally conducted to reduce the risk of inadvertently trading infected cattle between herds, such as: compulsory pre- and post-movement testing of individual cattle, private tests requested by farmers and tests at artificial insemination centres. This surveillance stream was referred to as proactive surveillance in earlier reports.

Over 5 million cattle were kept in 44,009 active cattle holdings in England in 2021, with both the total number of cattle and active cattle holdings presenting a 2% decrease compared to 2020. Just over 4 million individual TB skin tests were carried out on live animals in OTF herds. Furthermore, over 1 million animals from cattle holdings in England underwent *post-mortem* meat inspection. These are all similar to the figures seen in 2019 and 2020, suggesting that the public health measures adopted to control the COVID-19

outbreak and the extensions granted by APHA for routine skin testing relevant until July 2021 (see Preface 2.1) did not disrupt the overall TB surveillance programme in cattle.

Overall, this equated to over 74,500 testing events in OTF cattle herds in 2021, which detected 2,851 new TB incidents.

The relative proportions of individual cattle tests, herd tests, test reactors and incidents for the four surveillance streams in OTF cattle herds in 2021 are shown in Figure 3.3.1 and Table 3.3.1. 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 tests (Trade and other surveillance stream).

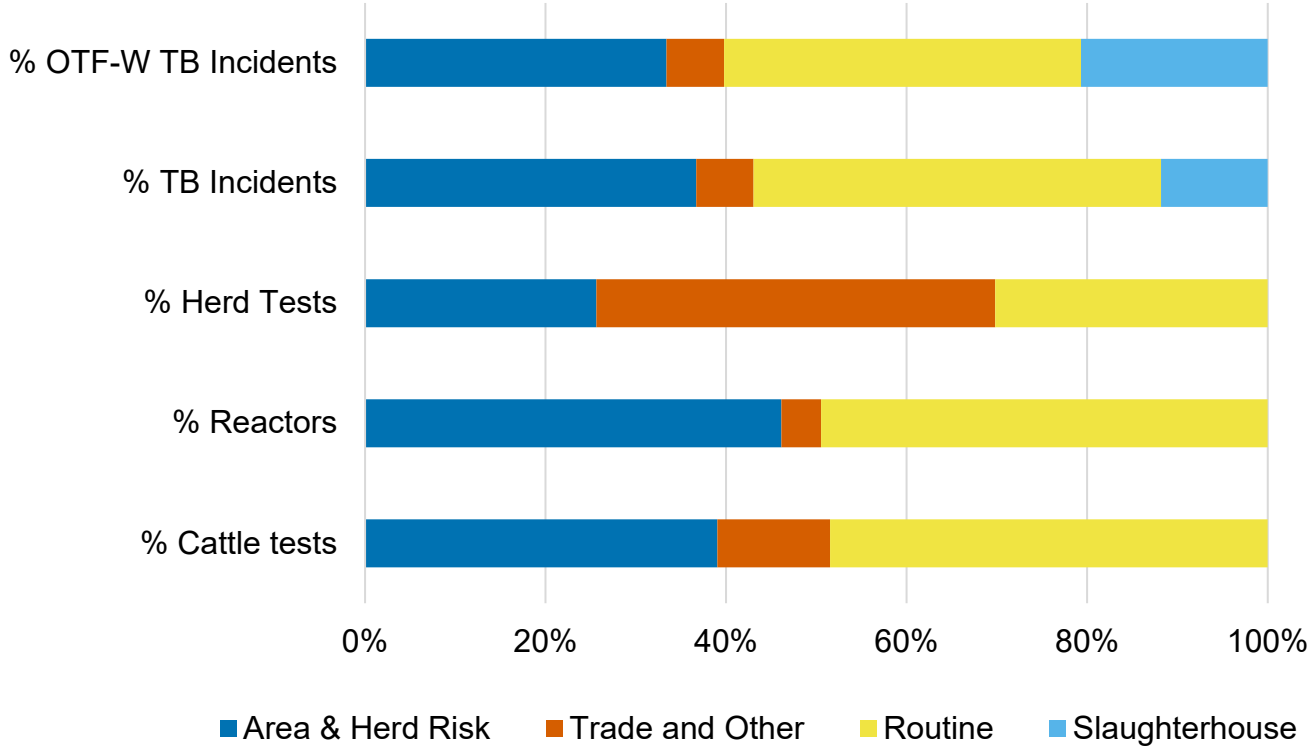


Figure 3.3.1. Proportion of herd and cattle tests, TB incidents in herds and individual reactors in England detected through each TB surveillance stream in 2021

In addition to the tests in Table 3.3.1, a further 2,517 cattle herds under TB restrictions underwent short-interval skin testing, supplemented in some instances by blood tests (primarily interferon gamma [IFN-γ] tests). These skin and blood tests are excluded from Tables 3.3.1-3.3.4 as they are not routinely used to detect new infection in OTF herds, but to regain OTF herd status. These include short interval (SI) tests used to eradicate infection from a TB incident herd, inconclusive reactor (IR) re-tests, IFN-γ blood tests, and tests occasionally used on an approved segregated group (ASG) of a herd, often during a TB incident. A total of 22 new TB incidents were disclosed by these test types, mostly

through the testing of cattle at epidemiologically-linked premises during IFN-γ testing (n=9).

Table 3.3.1 shows all tests and herd tests, whether they are:

- herd-level and conducted on all or the majority of animals in a herd, such as whole herd test (WHT) or routine herd tests (RHT), conducted as part of Routine Surveillance
- animal-level, e.g. tracing tests conducted as part of Area and Herd Risk Surveillance
- pre-movement tests conducted as part of Trade and Other Surveillance
- *post-mortem* meat inspection of all cattle slaughtered for human consumption (Slaughterhouse Surveillance).

Routine surveillance in England contributed to a slightly higher proportion of overall cattle tests than Area and Herd Risk surveillance in 2021 (Figure 3.3.1 a-c). Routine surveillance testing also detected the most reactors, TB incidents and OTF-W incidents in 2021, but was followed closely by Area and Herd Risk surveillance testing. The fact that the proportions of the two surveillance types are similar highlights the value of targeting higher risk herds through specific tests such as tracing tests (Table 3.3.1 a-c).

In the HRA, almost half (43%) of all incidents were detected by Routine (annual) surveillance, but this was followed closely by Area and Herd Risk surveillance (38%, (Figure 3.3.1a). The increase in the detection of incidents from Routine surveillance is likely to be due to the change in policy implemented in September 2020, where herds in Staffordshire and Shropshire moved from annual to six-monthly testing.
In 2021 there was an 19% increase in Whole-Herd tests compared to 2020, this was due to a 70% increase in Shropshire, and an 85% increase in Staffordshire.

Similarly in the Edge Area, most (56%) TB incidents were detected by Routine (six-monthly or annual) surveillance (Figure 3.3.1b).

In the LRA, 47% TB incidents and OTF-W TB incidents were detected by Area and Herd Risk surveillance (Figure 3.3.1c). One in three TB incidents were detected by Routine surveillance (37%), which reflects a higher proportion compared to the number of tests of this type conducted in this risk area (24%). Routine testing is conducted every four years in the majority of LRA herds because of the lower force of infection compared to elsewhere in England.

In previous years, the proportion of incidents detected through Trade and other surveillance was higher in the LRA compared to the other TB risk areas, which highlighted the importance of pre- and post-movement testing of cattle moving into the LRA from higher TB risk areas of GB. However, in 2021 the proportion of TB incidents and OTF-W incidents detected was much lower (5.7% and 7.9% respectively), without a similar reduction seen in the number of herds tested. This is in line with observations made in the Tuberculosis (TB) in Cattle: Pre-movement and Post-movement Cattle Testing Statistics in

Great Britain, which highlights that further analysis of the emerging trend will be carried out when more data points are available. The proportion of TB incidents disclosed by Slaughterhouse surveillance in the LRA was just under 10%, a slight increase compared to 2020. However, this type of surveillance is more important in the LRA than in the other risk areas, because of the lower frequency of routine skin testing (Table 3.3.1).

Table 3.3.1.a Total number of tests, reactors, and TB incidents by risk area and surveillance stream in 2021 in the High Risk Area of England.

Surveillance Stream	Herd tests N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Routine	12,806 (29.2)	918 (42.6)	473 (37.5)	7.2	2.3
Area and Herd Risk	11,477 (26.1)	807 (37.5)	441 (34.9)	7.0	2.7
Slaughterhouse	0 (0.0)	277 (12.9)	267 (21.2)	0.0	0.0
Trade and other	19,648 (44.7)	151 (7.0)	81 (6.4)	0.8	0.8
HRA Total	**43,931 (58.9)**	**2,155 (75.6)**	**1,265 (80.4)**	**3.7**	**1.5**
England Total	**74,537**	**2,851**	**1,573**	**1.1**	**1.6**

Table 3.3.1.b Total number of tests, reactors, and TB incidents by risk area and surveillance stream in 2021 in the Edge Area of England.

Surveillance Stream	Herd tests N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Routine	6,730 (37.0)	322 (56.2)	143 (53.0)	4.8	1.0
Area and Herd Risk	4,133 (22.7)	180 (31.4)	64 (23.7)	4.4	1.4
Slaughterhouse	0 (0.0)	48 (8.4)	47 (17.4)	0.0	0.0
Trade and other	7,322 (40.3)	23 (4.0)	16 (5.9)	0.3	1.0
Edge Total	**18,185 (24.4)**	**573 (20.1)**	**270 (17.2)**	**2.4**	**0.8**
England Total	**74,537**	**2,849**	**1,570**	**1.1**	**1.6**

Table 3.3.1.c Total number of tests, reactors, and TB incidents by risk area and surveillance stream in 2021 in the Low Risk Area of England.

Surveillance Stream	Herd tests N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Routine	2,969 (23.9)	46 (37.4)	6 (15.8)	1.5	0.2
Area and Herd Risk	3,486 (28.1)	58 (47.2)	18 (47.4)	1.7	0.3
Slaughterhouse	0 (0.0)	12 (9.8)	11 (28.9)	0.0	0.0
Trade and other	5,966 (48.0)	7 (5.7)	3 (7.9)	0.1	0.1
LRA total	**12,421 (16.7)**	**123 (4.3)**	**38 (2.4)**	**0.8**	**0.1**
England total	**74,537**	**2,849**	**1,570**	**1.1**	**1.6**

Over the past five years, the relative proportion of new TB incidents disclosed by surveillance stream has varied more in the LRA compared to the HRA and Edge Area. This is due in part, to the low number of TB incidents in the LRA. In 2021 in the HRA, recent surveillance policy changes are likely to be a contributing factor in the fluctuation in the proportion of TB incidents detected by different surveillance streams.

The proportion of new incidents detected by Routine surveillance in the Edge Area fell slightly between 2017 and 2018 (Figure 3.3.2) but has stabilized around 56%. This is following the introduction of six-monthly testing in parts of the Edge Area, which started in 2018. Similarly, in the HRA in 2021 there was an increase in the proportion of new incidents detected by Routine surveillance in the HRA due to the introduction of six-monthly testing in Staffordshire and Shropshire.

In the LRA, the proportion of new TB incidents detected through Slaughterhouse surveillance increased in 2021 to 9.8% compared to 2020 (5.9%), ending the downward trend observed since 2015. In England, the proportion of TB incidents detected by Slaughterhouse surveillance fell by a quarter over the past six years (15.7% in 2015 vs 11.8% in 2021). This could be explained by enhanced on-farm surveillance and control regimes adopted since 2013/14, detecting infected cattle at earlier stages of infection on farm.

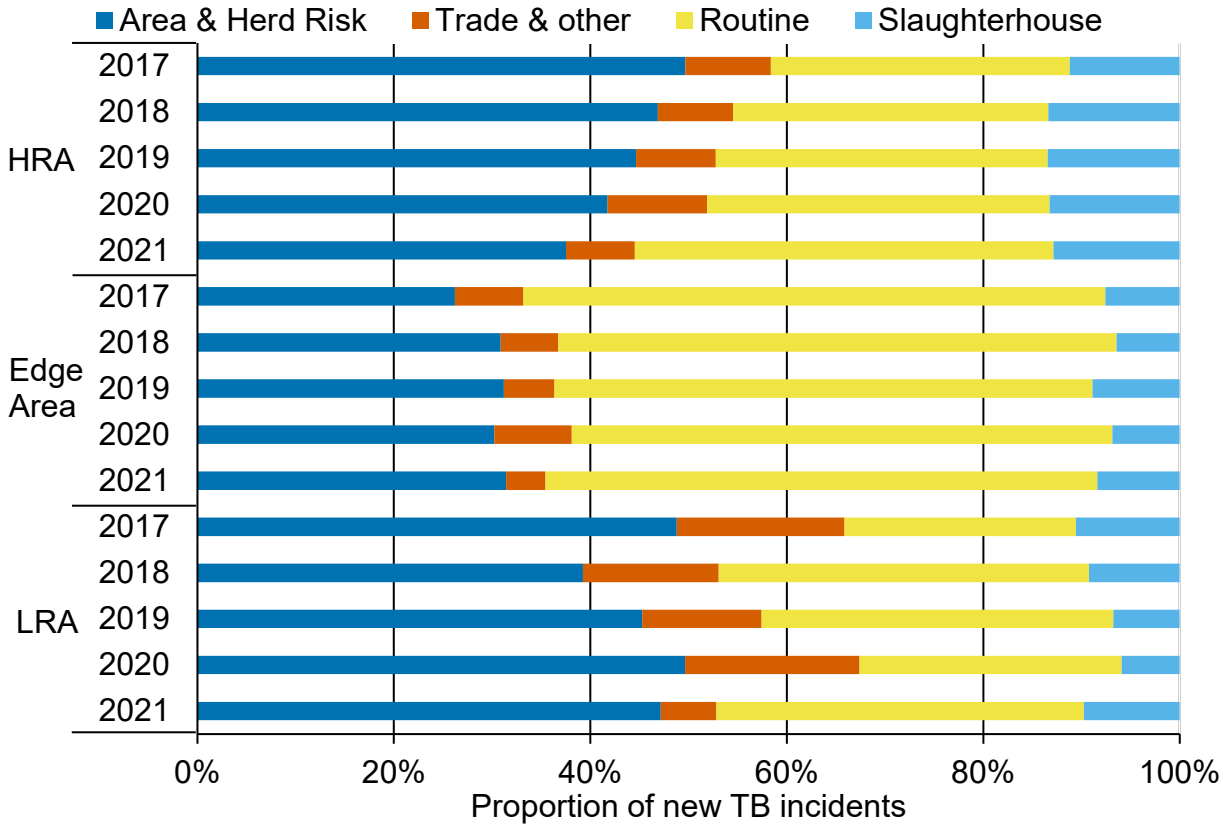


Figure 3.3.2 Annual proportions of new TB incidents detected by different surveillance streams within each risk area from 2017 to 2021

Routine surveillance stream

The Routine surveillance stream includes WHTs and RHTs conducted in OTF herds and tests conducted in new herds (NH). These are performed at scheduled intervals of six months or one year (WHTs) and four years (RHTs). WHTs are conducted in all cattle over six weeks old in the HRA and Edge Area; and in high risk herds in the LRA. RHTs in the LRA are conducted mainly in breeding stock and younger replacements for the breeding stock.

Proportionally more TB incidents were disclosed per herd test in the HRA than in the Edge Area, by both WHT and NH tests. This is likely to be due to a higher background force of infection in the HRA (Tables 3.3.1 and 3.3.2 a and b).

In the LRA, most herds receive RHTs at four-yearly intervals; with only 1% of herds receiving WHTs in 2021. New Herd tests disclosed 8.7% of incidents in this risk area, but none were OTF-W TB incidents. Marginally fewer TB incidents per 100 herd tests were detected by WHTs (1.4) compared to RHTs (1.7), despite herds receiving WHTs in the LRA being higher risk (Table 3.3.2c).

Table 3.3.2.a Performance of main test types within the Routine surveillance stream in the HRA in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 herd test events	Reactors per 1000 cattle tested
New Herd Tests	608 (4.7)	21 (2.3)	8 (1.7)	124 (4.7)	3.5	6.0
Whole Herd Tests	12,197 (95.3)	897 (97.7)	465 (98.3)	2,520 (95.3)	7.4	2.3
HRA Routine Total	**12,805**	**918**	**473**	**2,644**	**5.5**	**4.2**

Table 3.3.2.b Performance of main test types within the Routine surveillance stream in the Edge Area in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 herd test events	Reactors per 1000 cattle tested
New Herd Tests	258 (3.8)	5 (1.6)	2 (1.4)	6 (0.9)	1.9	0.8
Whole Herd Tests	6,472 (96.2)	317 (98.4)	141 (98.6)	670 (99.1)	4.9	1.0
Edge Routine Total	**6,730**	**322**	**143**	**676**	**3.4**	**0.9**

Table 3.3.2.c Performance of main test types within the Routine surveillance stream in the LRA in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 herd test events	Reactors per 1000 cattle tested
New Herd Tests	449 (15.1)	4 (8.7)	0 (0.0)	4 (10.0)	0.9	0.3
Whole Herd Tests	207 (7.0)	3 (6.5)	1 (16.7)	4 (10.0)	1.4	0.2
Routine Herd Tests	2,313 (77.9)	39 (84.8)	5 (83.3)	32 (80.0)	1.7	0.2
LRA Routine Total	**2,969**	**46**	**6**	**40**	**1.3**	**0.2**

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

Area and Herd Risk Surveillance Stream

The Area and Herd Risk surveillance stream comprises tests carried out in higher risk situations. This surveillance stream includes tests in OTF herds defined as higher risk, such as herds subject to post-incident check testing and in permanently restricted herds

(Approved Finishing Units (AFUs)); as well as tests for assessing potential source and spread following the detection of a TB incident, for example tracing, contiguous herds, hotspot, and radial tests. Short interval herd tests conducted during a TB incident to regain OTF status are excluded from the tables in this section.

In the HRA, most Area and Herd Risk TB incidents and OTF-W TB incidents were detected by post-incident tests, followed by contiguous herd tests (Table 3.3.3a), as in 2019 and 2020. Few source tracing tests were carried out in the HRA (less than one per cent of the Area and Herd risk surveillance stream). However, they detected the highest amount of incidents per 100 herd tests (20.3) and the highest detection rate for reactors, with 6.7 positive reactors disclosed for every 1,000 cattle tested (Table 3.3.3a).

In the Edge Area, over half of TB incidents and OTF-W TB incidents were detected by post-incident tests in this surveillance stream, similar to in 2019 and 2020 (Figure 3.3.3b). Similar to the HRA, source tracing tests detected the highest number of TB incidents per 100 test events (16.7) despite representing less than 1% of all test events.

In the LRA, just over half of the Area and Herd Risk herd tests carried out were radial tests, and they disclosed a higher proportion of OTF-W incidents (78%) compared to TB incidents (69%) (not necessarily confirmed as the same *M. bovis* genotype as the index case). Radial tests enable the early detection of any local lateral spread of infection from the index OTF-W incident herd. They also provide evidence for the presence or absence of endemic disease around incidents in the LRA. In the HRA and LRA, source tracing tests detected the highest proportion of TB incidents per 100 test events (15.4) despite representing less than 1% of total test events.

Post-incident, radial, contiguous herd and tracing tests are recorded as such if conducted at the same time as another scheduled herd test (e.g. a WHT) and so will be underreported as test types.

Potential TB Hotspot tests are conducted in the LRA in response to an OTF-W incident (or cluster of incidents) of obscure or uncertain origin. These apply to herds identified in an area determined by APHA, comprising at least a 3 km radius around the farm boundary of the index OTF-W herd. A total of 352 herd hotspot tests were carried out in the LRA in 2021 (55,953 individual cattle tests) with nine reactors disclosed from seven TB incidents, one of which was OTF-W. In 2021, there were 52 herd hotspot tests in Leicestershire and Nottinghamshire in the Edge Area. Four reactors were disclosed from three TB incidents, one of which was OTF-W.

Table 3.3.3.a Percentage of main test types within the Area and Herd Risk surveillance stream in the HRA in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 test events	Reactors per 1000 cattle tested
Contiguous tests	844 (8.7)	91 (11.5)	55 (12.7)	278 (11.0)	10.8	2.6
Spread tracing tests	4,880 (50.2)	25 (3.2)	17 (3.9)	66 (2.6)	0.5	2.8
Source tracing tests	64 (0.7)	13 (1.6)	11 (2.5)	62 (2.5)	20.3	6.7
Post-incident tests	3,819 (39.3)	652 (82.4)	347 (80.1)	2,099 (83.3)	17.1	2.7
Check tests	103 (1.1)	9 (1.1)	3 (0.7)	15 (0.6)	8.7	0.8
AFU tests	8 (0.1)	1 (0.1)	0 (0.0)	1 (<0.05)	12.5	1.4
HRA Area and Herd Risk Total	**9,718**	**791**	**433**	**2,521**	**11.7**	**2.8**

Table 3.3.3.b Percentage of main test types within the Area and Herd Risk surveillance stream in the Edge Area in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 test events	Reactors per 1000 cattle tested
Contiguous tests	21 (0.6)	1 (0.6)	0 (0.0)	1 (0.2)	4.8	2.6
Radial tests	1,377 (38.6)	63 (36.2)	22 (34.4)	106 (25.2)	4.6	0.7
Hotspot tests	52 (1.5)	3 (1.7)	1 (1.6)	4 (1.0)	5.8	0.9
Spread tracing tests	1,354 (37.9)	7 (4.0)	2 (3.1)	14 (3.3)	0.5	2.4
Source tracing tests	18 (0.5)	3 (1.7)	2 (3.1)	19 (4.5)	16.7	5.0
Post-incident tests	719 (20.1)	94 (54.0)	36 (56.3)	272 (64.8)	13.1	1.9
Check tests	28 (0.8)	3 (1.7)	1 (1.6)	4 (1.0)	10.7	1.1
Edge Area and Herd Risk Total	**3,569**	**174**	**64**	**420**	**8.0**	**2.1**

Table 3.3.3.c Percentage of main test types within the Area and Herd Risk surveillance stream in the LRA in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 test events	Reactors per 1000 cattle tested
Radial tests	1,721 (52.3)	40 (69.0)	14 (77.8)	48 (58.5)	2.3	0.2
Hotspot tests	352 (10.7)	7 (12.1)	1 (5.6)	9 (11.0)	2.0	0.2
Spread tracing tests	1,018 (30.9)	2 (3.4)	1 (5.6)	2 (2.4)	0.2	0.4
Source tracing tests	13 (0.4)	2 (3.4)	1 (5.6)	2 (2.4)	15.4	0.7
Post-incident tests	150 (4.6)	7 (12.1)	1 (5.6)	21 (25.6)	4.7	0.8
Check tests	38 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
LRA Area and Herd Risk Total	**3,292**	**58**	**18**	**82**	**4.1**	**0.4**

Note: Table 3.3.3. test types include: Contiguous tests (VE-CON, VE-CON12), Radial tests (VE-RAD, VE-RAD6, VE-RAD12), Hotspot tests (VE-HS1, VE-HS2), Spread Tracing tests (VE-TR), Source tracing tests (VE-CT(EM)), Post-incident tests (VE-6M, VE-12M), Check tests (VE-CT(I-I)), AFU tests (VE-TBU).

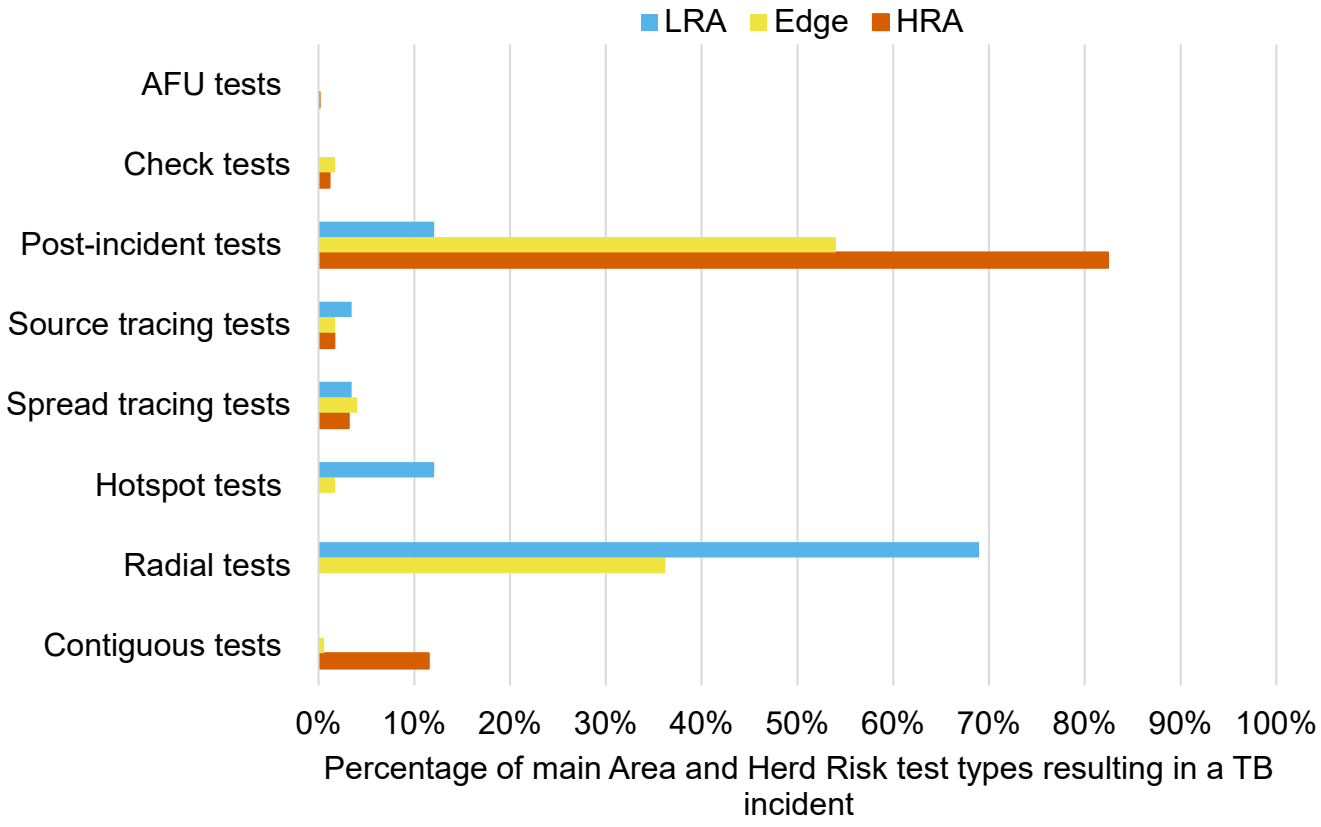


Figure 3.3.3 Percentage of TB incidents by main test types within the Area and Herd Risk surveillance stream by surveillance risk area in 2021

Slaughterhouse Surveillance Stream

Slaughterhouse surveillance is provided by compulsory *post-mortem* meat inspection (visual inspection of carcases with palpation and incision of suspect lymph nodes) of all cattle slaughtered for human consumption. laboratory confirmation of *M. bovis* is performed (if possible) from the suspect tissue. It is an ongoing, supplementary surveillance stream that may detect infected cattle missed by active surveillance.

Detection of TB incidents disclosed by slaughterhouse surveillance depends on the background force of infection and frequency and efficacy of active surveillance testing in cattle herds. Further analysis of the efficacy of Slaughterhouse surveillance and monitoring performance may be found in the Slaughterhouse surveillance report (2016-2019). Herds are skin tested four times more frequently in the Edge Area and HRA than in the LRA. Therefore, a higher proportion (but lower number) of TB incidents is expected at routine slaughter of cattle in the LRA. However, in 2021the proportion of TB incidents disclosed by slaughterhouse surveillance was highest in the HRA (13%), followed by the LRA (10%) and Edge Area (8.4%). This may reflect the high background force of infection in the HRA. As expected, however, the proportion of OTF-W incidents disclosed by Slaughterhouse surveillance, was highest in the LRA (29%) compared to the HRA and Edge Area (21% and 17%, respectively).

Slaughterhouse surveillance predominantly detects OTF-W incidents, because, by definition, the identification of visible lesions of TB at routine slaughter has to be confirmed by positive culture results. Unconfirmed slaughterhouse cases in OTF herds do not trigger a new TB incident. Every year, a small number of OTF-S incidents are also reported, that were initially triggered at the slaughterhouse. These are cases where visible lesions detected in the slaughterhouse were unconfirmed by laboratory testing, but a skin check test in the source herd identified reactors, which did not have visible lesions.

Since 2011, the proportion of OTF-W TB incidents disclosed through slaughterhouse surveillance in the HRA has remained fairly stable. In the Edge Area and LRA, by contrast, there has been greater variation (Figure 3.3.4).

The proportion of OTF-W TB incidents disclosed by slaughterhouse surveillance in the Edge Area increased from 12% in 2020 to 17% in 2021 remains below the HRA and LRA. However, the proportion disclosed is over half that observed in 2011 (29%) for the first time since 2016. This reduction in Edge Area slaughterhouse cases since 2011 is most likely due to the increased frequency of routine surveillance in this area.

In the LRA, the proportion of OTF-W incidents increased from 16.3% in 2020 to 28.9% in 2021, similar to that observed in 2018, reversing the trend observed since 2016.The LRA once more disclosed the highest proportion of OTF-W incidents by Slaughterhouse surveillance.

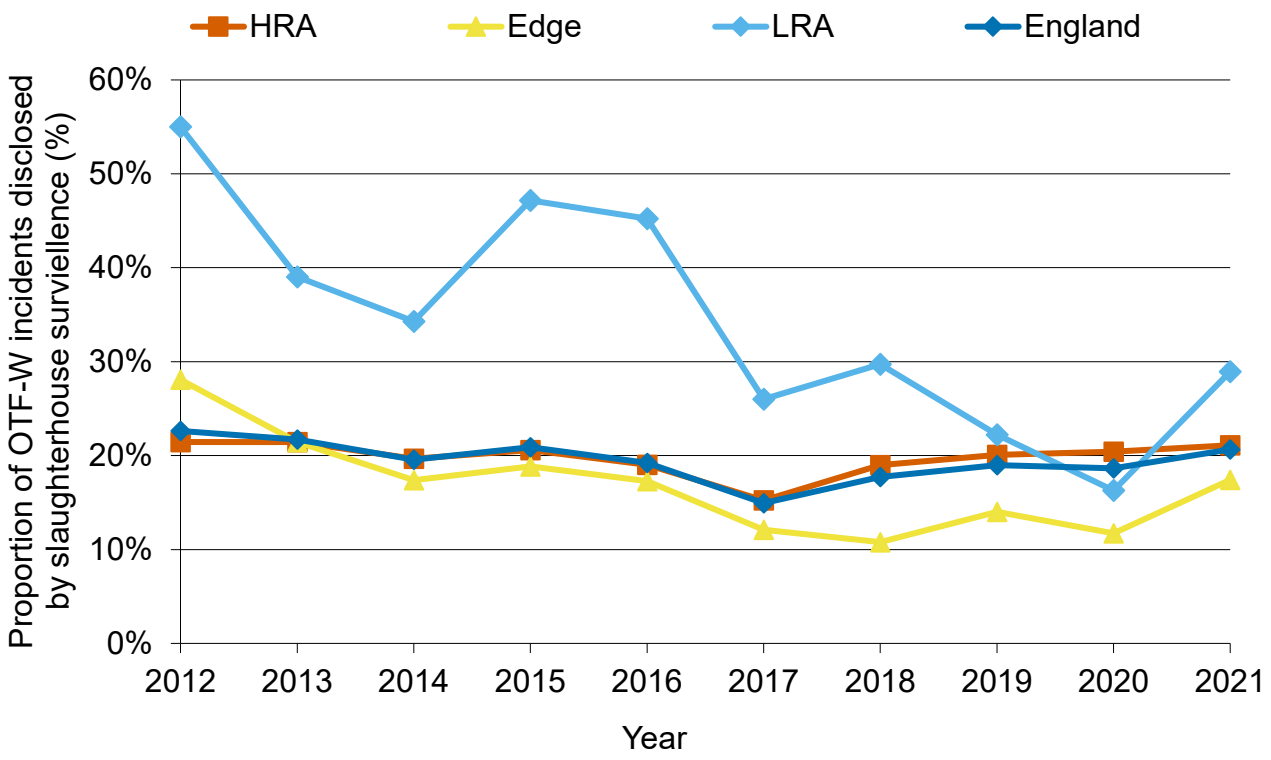


Figure 3.3.4 Annual proportion of new OTF-W TB incidents that were disclosed by Slaughterhouse surveillance from 2012 to 2021, by risk area

Trade and other surveillance stream

Trade surveillance includes international trade tests, private tests, tests at artificial insemination centres and statutory pre- and post-movement TB testing of cattle. Typically, only single animals or a batch of animals are tested and so these are referred to as 'animal' tests rather than herd tests.

Large numbers of cattle movements take place across the country, but not all require pre-movement testing (PrMT). Animals subject to an official herd test within the required timeframe qualifies as pre-movement tested and a further PrMT is not required. Therefore, the number of PrMT's cannot be counted within surveillance data. Trade and other tests detect the lowest proportion of TB incidents of all the surveillance streams (6.4%). However, they disclose a relatively high rate of reactors detected per 1,000 tests (0.8 in the HRA, where most tests in this stream are conducted, and 1.0 in the Edge Area). This rate decreased in the HRA in 2021 (0.8) compared to 2020 (1.4). This could be due to the large amount of interferon gamma testing in the HRA overall, which could have reduced infection at the animal level. The primary purpose of Trade and other tests is to reduce the risk of TB spread via movements of undetected infected cattle between herds, for example into the LRA. A fortuitous consequence is the additional detection of TB-infected herds missed by routine surveillance.

As expected, the majority of Trade and other surveillance tests were conducted in the HRA (60%) compared to the Edge Area (22%) and LRA (18%) (Table 3.3.1). In the HRA and Edge Area, virtually all Trade and other surveillance stream tests in 2021 were PrMTs (Table 3.3.4); whereas in the LRA, post-movement tests and PrMTs were the majority of Trade and other surveillance stream tests. In April 2016, it became compulsory for cattle farmers in the LRA to post-movement test animals entering their herds from higher risk areas of GB.

Private tests represented less than 1% of cattle tests within this surveillance stream in 2021 (as in 2020) and disclosed no TB incidents. International trade tests (pre-export and post-import tests) and voluntary pre-sale check tests resulted in the disclosure of no OTF-W incidents in 2021 (Table 3.3.4).

Table 3.3.4.a Performance of main test types within the Trade and other surveillance stream in the HRA in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Pre-export	2 (<0.05)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Post-import	34 (0.2)	0 (0.0)	0 (0.0)	1 (0.4)	0	1.3
Post-movement	69 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Pre-movement	19,519 (99.3)	151 (100.0)	81 (100.0)	238 (99.6)	0.8	0.8
Private	24 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
HRA Trade Total	**19,648**	**151**	**81**	**239**	**0.2**	**0.4**

Table 3.3.4.b Performance of main test types within the Trade and other surveillance stream in the Edge Area in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Pre-export	4 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Post-import	23 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Post-movement	53 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Pre-movement	7,207 (98.4)	23 (100.0)	16 (100.0)	54 (100.0)	0.3	0.5
Private	35 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Edge Trade Total	**7,322**	**23**	**16**	**54**	**0.1**	**0.1**

Table 3.3.4c Performance of main test types within the Trade and other surveillance stream in the LRA in 2021

Test type	Test events N (%)	TB incidents N (%)	OTF-W TB incidents N (%)	Reactors N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Pre-export	53 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Post-import	49 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Post-movement	2,624 (44.0)	5 (71.4)	3 (100.0)	4 (57.1)	0.2	0.1
Pre-movement	3,051 (51.1)	2 (28.6)	0 (0.0)	3 (42.9)	0.1	0.1
Private	189 (3.2)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
LRA Trade Total	**5,966**	**7**	**3**	**7**	**0.1**	**<0.05**

Note: Test types include: Pre-export (VE-EX), Post-import (VE-PII, VE-PIO), Post-movement (VE-POSTMT, POSTMOVNC, VE-POSTMOVOV), Pre-movement (VE-PRMT, VE-AI), Private (VE-PRI). In 2021, no cattle were tested under the Pre-sale check LRA (VE-CT-LRA-SA) test type in the LRA, thus this data was excluded from the table.

Pre-movement testing (PrMT)

There were over 2.8 million cattle movements within GB in 2021, excluding direct and indirect movements to slaughter (e.g. via slaughter markets and AFU's). This was an increase of 21,967 movements compared to 2020. Farms in all risk areas move more cattle within their area than without. Further, there is more cattle movement between areas most similar in terms of TB risk (Table 3.3.5). In the HRA and LRA around 80% or more of cattle moved within their area compared to 60% of Edge Area cattle.

Table 3.3.5 Summary of number of cattle movements between risk areas and countries, 2021

Cattle movements in 2021	To HRA	To Edge	To LRA	To Scotland	To Wales	Total
From HRA	675,876	94,666	39,500	1,383	39,697	851,122
From Edge	68,601	206,791	46,708	855	23,719	346,674
From LRA	16,409	44,433	645,223	27,320	8,512	741,897
From Scotland	1,215	4,990	51,528	445,910	1,250	504,893
From Wales	87,564	42,170	34,065	921	277,268	441,988
Total	**849,665**	**393,050**	**817,024**	**476,389**	**350,446**	**2,886,574**

Over 1.1 million cattle movements in 2021 originated in the HRA or Edge Areas, similar to 2020, 2019 and 2018.

The proportion of TB incidents disclosed by PrMTs in the HRA was fairly stable between 2011 and 2019 (around 8%). However, in 2020 it increased to 10%, before decreasing to 7% in 2021 (Figure 3.3.5). There has been more variability in the Edge Area and LRA over this time period. There was a notable increase in the proportion of TB incidents detected by PrMTs in the Edge Area in 2013. This was due to the introduction of annual testing, increasing the number of eligible herds. I PrMT disclosure was 5% in 2019, 8% in 2020, but has decreased to 4% in 2021.

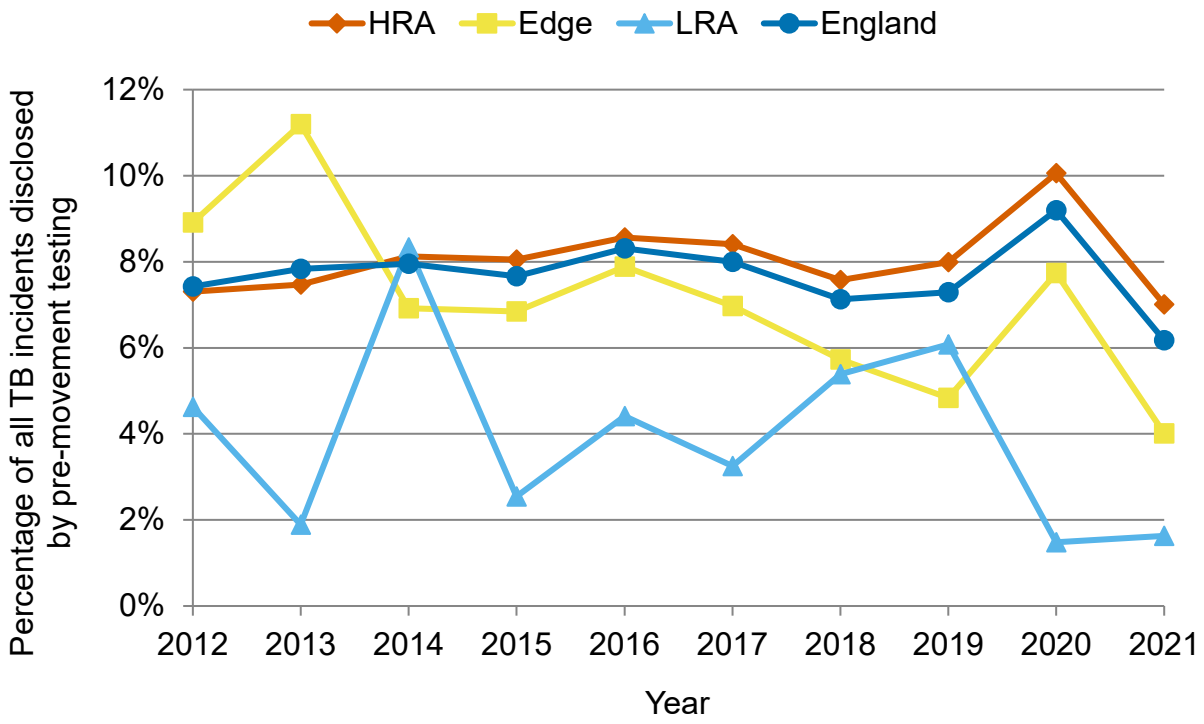


Figure 3.3.5 Annual proportion of total TB incidents disclosed by pre-movement testing between 2012 and 2021, by risk area. Presented data refer to tests categorised as (bespoke) PrMT, but does not include other (government-funded) tests that can qualify as a PrMT.

Inconclusive reactors (IRs)

Inconclusive reactors (IRs) are cattle that have a differential bovine-avian reaction to the SICCT test that is not strong enough to classify them as reactors. These animals remain isolated from their herd while awaiting the results of a retest at 60 days. IRs that do not give a negative result at the retest are deemed to be test reactors and removed, triggering a new incident if their herd was OTF.

As expected, most IR-only herds (herds that had only IRs at the initial test, with no concurrent reactors) are detected in the HRA (66%). Similarly, most IRs are identified in the HRA (69%). Between 2020 and 2021, there was a decrease in the number of IR-only herds and IRs disclosed in the LRA but remained the same or increased in both the Edge Area and HRA, as seen in previous years (Table 3.3.6). More details on inconclusive reactors can be found in Chapter 3.4.

Table 3.3.6 Summary of number of IR-only herds and IRs disclosed [in such herds], their percentages and percentage change between 2020 and 2021 by surveillance risk area.

Region	IR-only herds (% of all IR-only herds) (% change 2020-21)	IRs disclosed (% of all IRs disclosed) in IR only herds (% change 2020-21)
HRA	1,535 (66.3%) (1%)	3,411 (69.4%) (5%)
Edge Area	552 (23.8%) (0%)	1,096 (22.3%) (8%)
LRA	228 (9.8%) (-21%)	406 (8.3%) (-22%)
England total	**2,315 (-2%)**	**4,913 (3%)**

In 2021, 40% of IR-only herds in the HRA went on to have a TB incident within the following 15 months. In the Edge Area the percentage was 36% and 25% in the LRA (Figure 3.3.6).

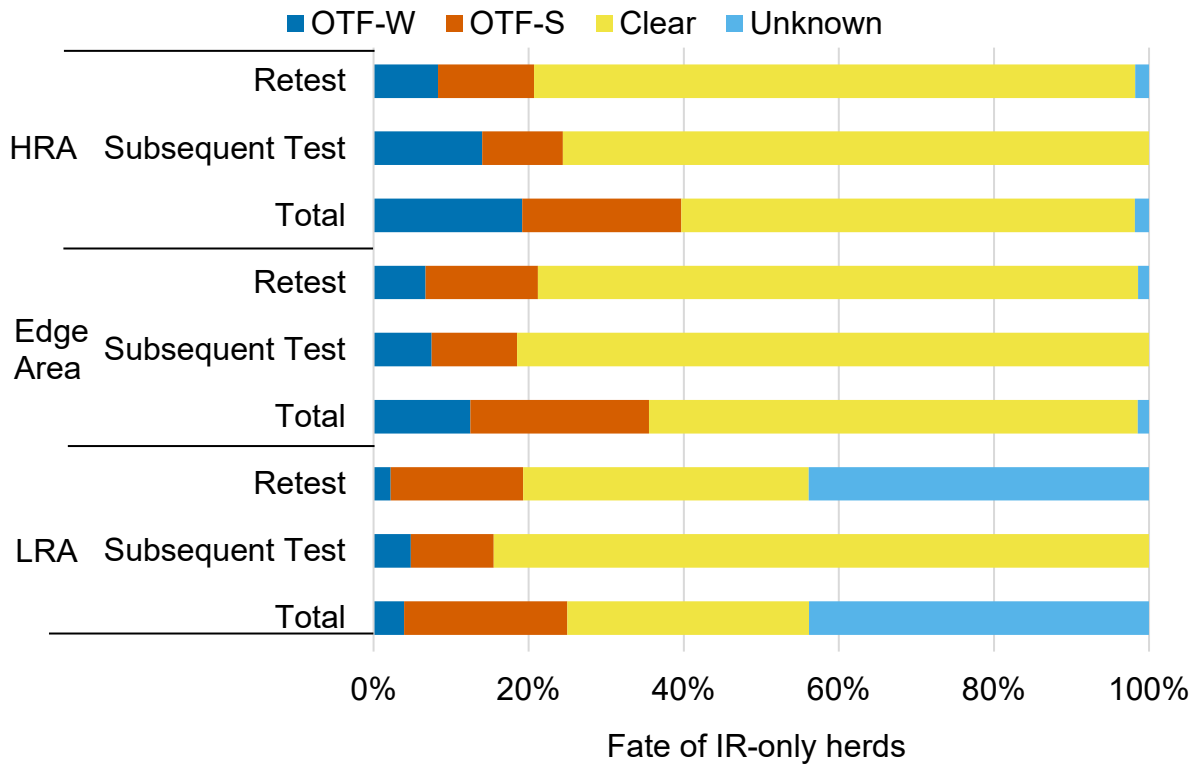


Figure 3.3.6 Fate of IR-only herds, following disclosure in 2021, by risk area. The fate of some herds is recorded as unknown due to reasons such as ceasing trading and not having a retest.

In 2021, in the Edge Area and LRA, the majority of IR-only tests occurred in herds without a recent history of an OTF-W incident (79% and 94% respectively). The HRA had the lowest proportion of these herds at 63%. Around half of the IRs in IR-only herds that went on develop TB (OTF-S or OTF-W) were detected by the IR-only herd retests in the HRA (52%) as opposed to the subsequent tests. In the LRA and Edge Area most IRs that developed TB were detected at a retest (77% and 60%, respectively).

Figure 3.3.7 suggests that IR-only herds in the HRA and Edge Area have an increased risk of a TB incident at a retest or subsequent test if they have a history of TB, compared to the LRA where the increased risk was from a retest in a herd that had no history of TB. A recent multivariable analysis (Brunton et al. (2018)) showed that the risk posed by IRs in the HRA and Edge Area was substantially reduced if those animals become reactors or 2xIRs at the 60 day retest and are removed from herds. However, IRs that pass the retest can pose a TB risk for around 2.5 years from first disclosure. This indicates that IRs are an important predictor of the presence of infection. Although retesting after 60 days mitigates much of the risk posed by IRs, the policy to permanently restrict all resolved IRs in the HRA, Edge Area and incident herds in the LRA to the herd in which they are disclosed reduces the risk further.

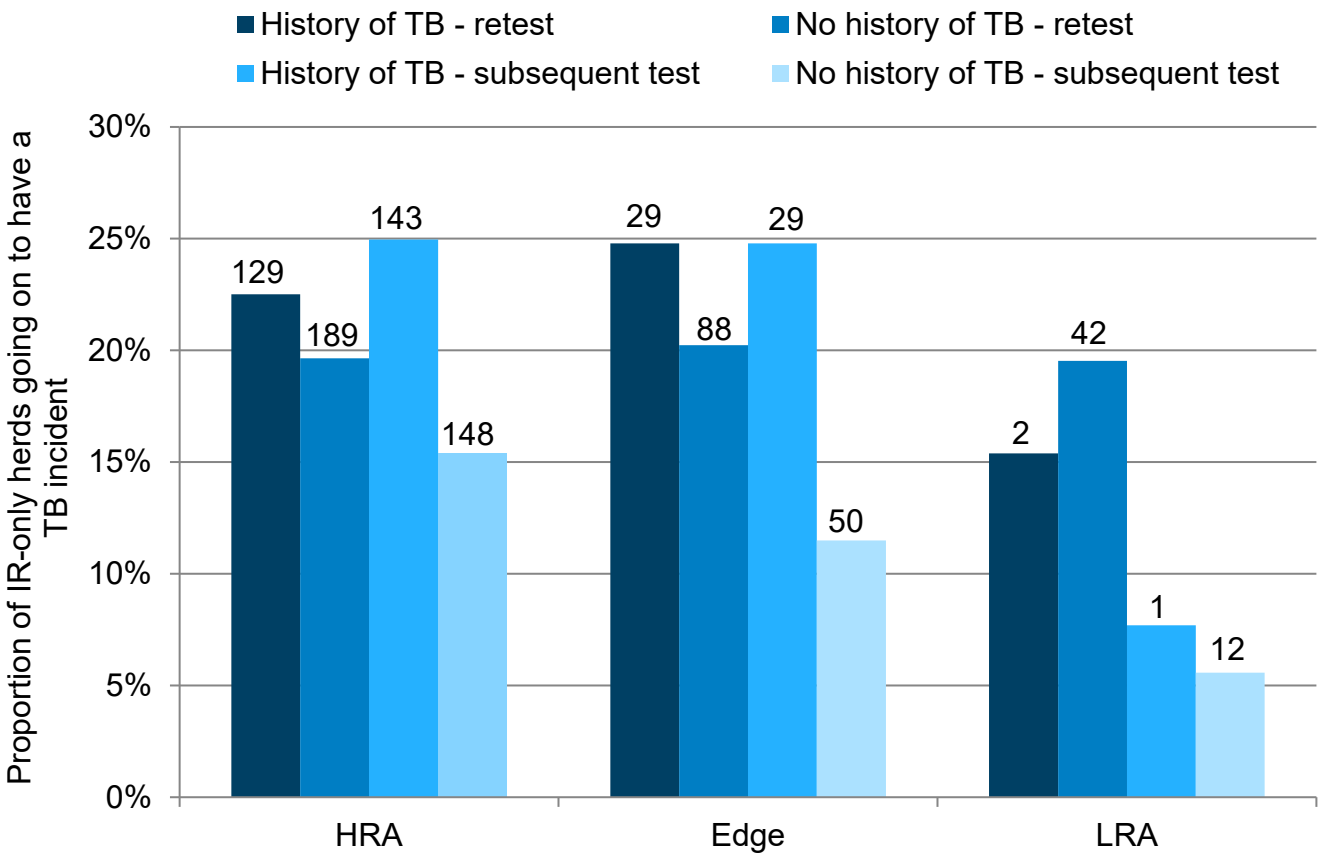


Figure 3.3.7 Proportion of IR-only herds which disclosed a TB incident in 2021 at either the IR retest or a subsequent test (within 15 months after IR test), by surveillance risk area and TB history. Totals above each column represent the number of herds with a TB incident.

Interferon gamma tests for detection of additional infected cattle within TB incident herds

The interferon gamma (IFN-γ) blood test is generally used in England as a parallel test (in conjunction with the skin test) to boost the sensitivity of testing in selected TB incident herds with *post-mortem* evidence of *M. bovis* infection.

From the 1st of January 2021 to the 11th of July 2021, all herds experiencing laboratory confirmed (OTF-W) TB incidents in the LRA and Edge Area, as well as ins areas of the HRA undergoing badger control programme (BCP) which had completed at least two culling seasons; were subjected to supplementary IFN-γ blood testing, to maximise the detection of infected cattle. Mandatory IFN-γ tests were also used in persistent herds (restriction for more than 18 months), herds with explosive incidents and those being considered for whole or partial slaughter.

After the 12th of July 2021, the IFN-γ policy was refined for the HRA and the six-monthly surveillance testing part of the Edge Area. Any new OTF-W incidents that occurred within 18 months of the herd regaining OTF status following a previous OTFW breakdown were subjected to a mandatory IFN-γ test. The policy was unchanged in the LRA and the annual surveillance testing of the Edge Area, where all new OTF-W incidents continued to be subjected to mandatory IFN-γ testing. Any chronic and persistent OTF-W incidents across the HRA and Edge Area were also subjected to an IFN-γ test. Outside these scenarios, the deployment of the IFN-γ blood test in 2021 was at APHA case vets' discretion.

Table 3.3.7 Animals (herds) receiving an IFN-γ test in 2021, by risk area and testing reason

Risk Area	Total	Miscellaneous	New OTF-W in BCP areas	OTF-W outside HRA	Persistent OTF-W	Persistent OTF-W in BCP areas	Recurrent Testing
HRA	144,621 (1,289)	7,440 (106)	92,717 (853)	0 (0)	19,121 (128)	5,178 (47)	20,165 (155)
Edge Area	60,573 (583)	7 (3)	8,926 (55)	47,933 (502)	476 (3)	1,251 (6)	1,980 (14)
LRA	7,979 (98)	3 (1)	260 (1)	7,716 (96)	0 (0)	0 (0)	0 (0)
England	**213,173 (1,970)**	**7,450 (110)**	**101,903 (909)**	**55,649 (598)**	**19,597 (131)**	**6,429 (53)**	**22,145 (169)**

Note: Test types included Chronic breakdown management (VE-IFN_SLHERD), Miscellaneous (VE-IFN, VE-IFN_ANOM, VE-IFN_BOV_OTH, VE-IFN_FLEX, VE-IFN_NSR, VE-IFN_OTH_SP, VE-IFN_PRI), New OTF-W in BCP Areas (VE-IFN_NBCP), OTF-W outside HRA (VE-IFN_LOW_IN), Persistent OTF-W (VE-IFN_PERSI), Persistent OTF-W in BCP Areas (VE-IFN_PBCP), and Recurrent testing (VE-IFN_RECUR). Herds tested are in parentheses. Of note, several herds were assigned to test code "VE-IFN_LOW_IN" but located within the HRA, most likely due to veterinary discretion prior to policy changes for gamma testing in July 2021; these were added to the totals for Miscellaneous testing for clarity. In 2021, no cattle were tested under the Chronic Breakdown Management Policy in England, thus this data was excluded from the table.

A total of 213,173 cattle were IFN-γ tested in England in 2021 and 5.3% (11,355) were positive. A total of 1,970 herds were tested and 1,330 (68%) disclosed at least one IFN-γ test positive (68%). Both the number of individual animals, and the number of herds receiving IFN-γ tests in 2021 was an increase on 2020 (209,718 animals and 1,847 herds in 2020).

During the COVID-19 pandemic, some supplementary IFN-γ tests were not performed, particularly where use was discretionary. For example, repeat IFN-γ testing was not applied to some herds which would have received two or more rounds; while in some herds only specific epidemiological groups were tested, rather than the whole herd over six months of age.

Since 2012, the overall IFN-γ test positive rate in animals has varied between 4% and 6%. Historically there have been differences between risk areas, with higher rates in HRA

herds (19% in 2015, 8% in 2016 and 11% in 2017). However, in 2021, the rate in the HRA fell to 6%, and 4% in the Edge Area and LRA (Figure 3.3.8). This is likely to be due to the sharp increase in mandatory IFN-γ testing in BCP areas, as well as the change in policy (introducing recurrent herds), which particularly affects the HRA. This trend is likely to continue, as previously, many IFN-γ tests were applied to 'explosive breakdown' herds where a higher positive rate is expected.

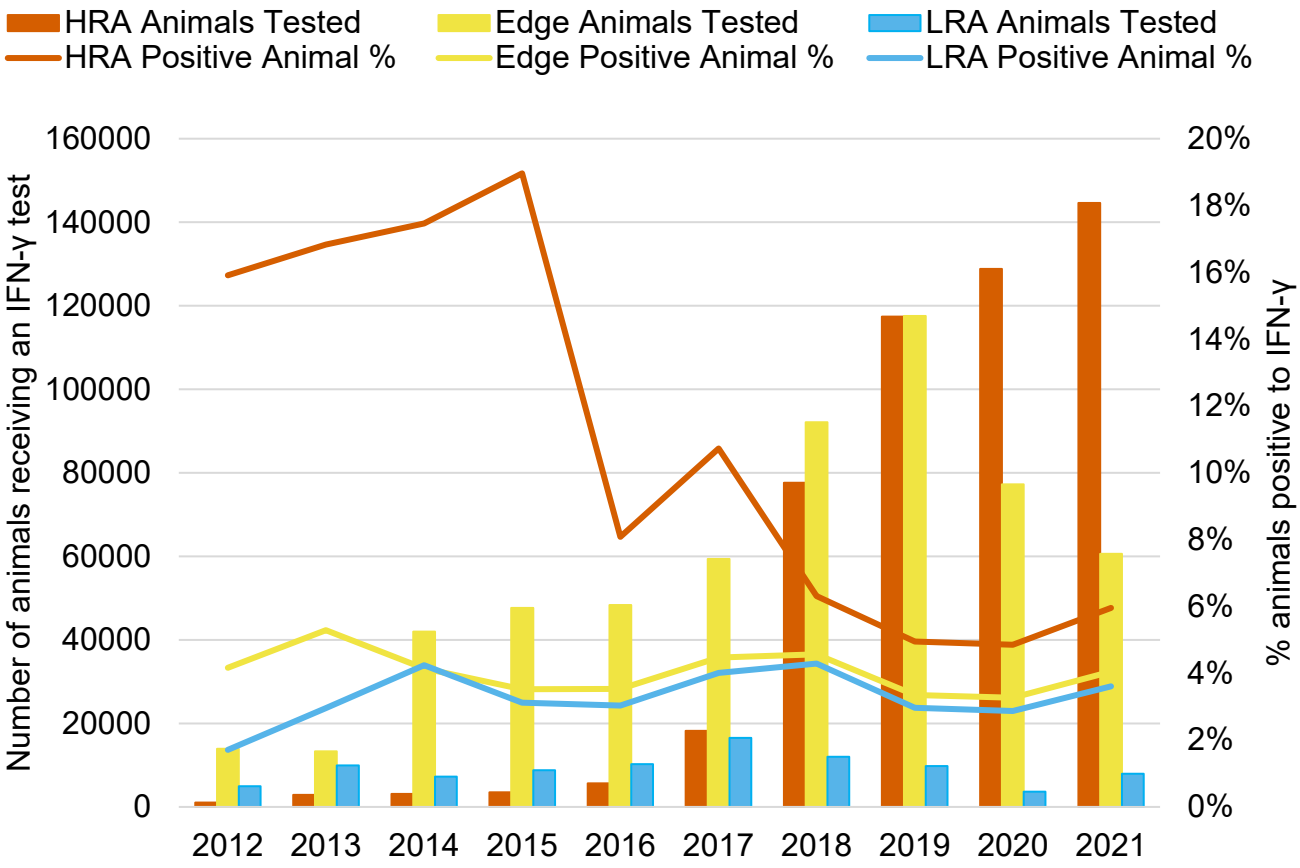


Figure 3.3.8. Number of animals tested and proportions of animals IFN-γ test positive by risk area, 2012 to 2021.

In the Edge Area, the proportion of herds which received a IFN-γ test with reactors disclosed remains consistent at 60-80%. There has been wider variation in the HRA and LRA, possibly due to the overall increase in IFN-γ testing (Figure 3.3.9).

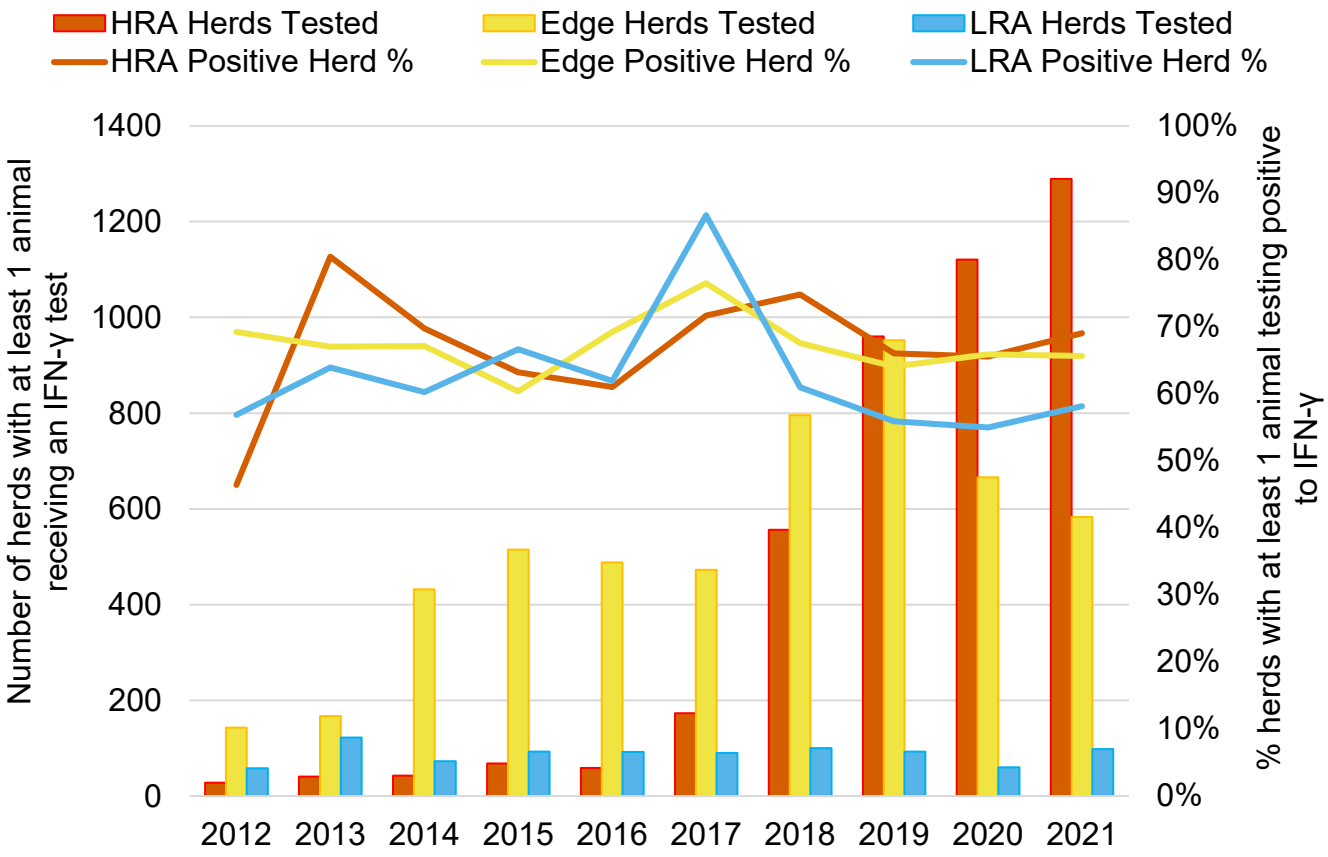


Figure 3.3.9. Number of herds tested and proportions of herds which had a IFN-γ test with at least one positive animal by risk area, 2012 to 2021.

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

- During 2021, at any point in time, an average of 2,293 herds (almost 5% of the cattle herds in England) were under movement restrictions due to a TB incident, similar to previous years. In other words, about 95% of all the cattle herds in England were Officially TB Free (OTF). This national prevalence level is similar to previous years. The end-of-year point prevalence for England was 4.4%, with 2,067 (of 46,793) herds under restrictions on 31st December 2021.
- Most herds under restrictions were in the HRA. In 2021, the monthly average herd level prevalence in the HRA was 8.9%, a decrease on 2020 (9.3%). Herd prevalence in the HRA in 2021 was at the lowest level since 2011.
- Prevalence in the Edge Area has continued to increase since 2003, with a particular rise from 2013 following the introduction of a stricter regulations for regaining OTF status. The end of the year prevalence in 2021 was highest in the counties of Oxfordshire (11%) and Berkshire (8%).
- Prevalence in the LRA remained very low and stable in 2021, at 0.8%.
- TB infected herds remained under restriction for a median of under seven months in the HRA and Edge Area, and four-and-a-half months in the LRA. Herds remained under movement restriction for longer periods in larger herds (>200 animals), and in TB incidents with more than one reactor disclosed.
- In the HRA, the number of TB incidents classed as ‘persistent’ (i.e. under restriction for over 18 months) and ongoing incidents decreased in 2021 (129), compared to compared to compared to 2020 (134), continuing a trend from 2015. The percentage of persistent TB however, increased slightly in 2021 (9%) compared to 2020 (8%). This is a factor of the reducing number of HRA TB incidents since 2017. The Edge Area was stable in 2021 with 23 persistent incidents (20 in 2020). There was only one persistent incident was ongoing in the LRA (in Lincolnshire) at the end of 2021.
- Overall, 153 persistent TB incidents were resolved in England during 2021, 84% of which were in the HRA.
- In 2021, 27,855 cattle were slaughtered for TB control reasons, with a median of three test reactors removed per TB incident. The mean number of reactors removed has fluctuated over time and between risk areas. In 2021, an average of ten reactors were removed per TB incident in the HRA, eight reactors in the Edge Area, and almost three in the LRA. The wide range in the number of reactors per incident means the financial impact of TB controls is much greater for some farmers than others.
- Seven new Badger Control Programme (BCP) areas were licensed in 2021; four in the HRA and three in the Edge Area. Licences were issued to vaccinate badgers in 425.6 km^2 across England, with 1,575 badgers vaccinated in 2021.

Herd prevalence

Herd prevalence shows the proportion of herds classified as infected with TB at a given point in time. In Figure 3.4.1 below it is measured by counting herds under restriction due to a TB incident at the mid-point of each month, divided by the number of active herds in a geographical area. However, the map in Figure 3.4.2 gives the percentages of herds under TB restrictions at the end of the year for each county (i.e. the point prevalence). The magnitude of the herd prevalence of TB depends on both

- how many herds are newly infected with TB (incidence), and
- how long restrictions are maintained (incident duration).

Stricter controls, in particular the number and types of tests with negative results needed for a TB incident herd to regain its OTF status, can increase the duration of restrictions. Less stringent controls may lead to a swifter resolution of the TB incident, but risks leaving undetected infection in the herd if controls are removed too soon.

Prevalence provides an indication of the impact the epidemic is having on the cattle farming sector.

During 2021, an average of almost 5% of all cattle herds in England were restricted at any one time due to a TB incident, equating to around 2,293 herds. However, this overall figure masks substantial differences between risk areas and counties within those areas, as shown in Figures 3.4.1 and 3.4.2, respectively. Figure 3.4.1 also shows a seasonal cycle, likely related to the time of year when most TB surveillance testing is undertaken in OTF herds. TB testing is planned to fit with the farming calendar when possible. Herd prevalence in the HRA remained fairly stable in 2021 compared to 2020, after the decreasing trend that started in 2018. In the Edge Area, while herd prevalence has increased steadily since 2007 with a marked upward trend since 2013 (when all herds in the area were placed on routine annual testing), it slightly decreased in 2020 and remained stable in 2021. The overall increase in prevalence since 2013 reflects both the earlier detection achieved and the more stringent controls deployed. In the LRA, prevalence has remained consistently low for the past ten years.

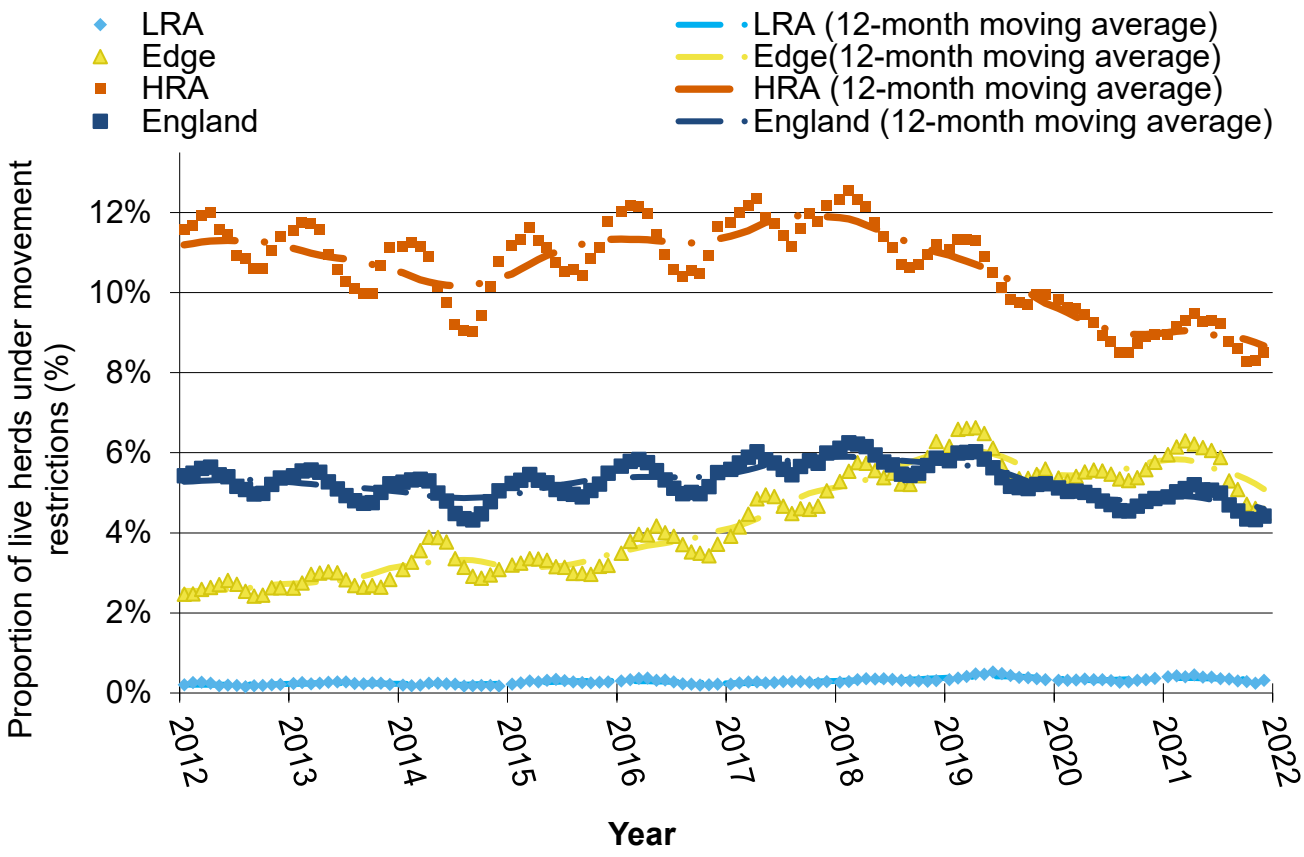


Figure 3.4.1 Proportion of live English herds under TB movement restrictions (prevalence) as a result of any TB incident, by month, between January 2011 and December 2021

- Prevalence in the HRA has generally plateaued since 2011, with a tendency to decrease since 2018.
- In the Edge Area, prevalence has risen over time peaking in 2019 and slightly decreased in 2020 and 2021.
- Prevalence has remained consistently low in the LRA.

In 2021, as in previous years, there was wide variation in the herd prevalence of TB between counties (Figure 3.4.2). The highest prevalence was seen in Avon (13%) (HRA), followed by Oxfordshire (11%) (Edge Area), Herefordshire (11%) and Shropshire (10%) (HRA) and the lowest prevalence was in the LRA counties. Further details about prevalence at county level are presented in Section 4. Prevalence levels and trends in individual counties of the Edge Area and LRA are also presented in the Year End Descriptive Epidemiology Reports.

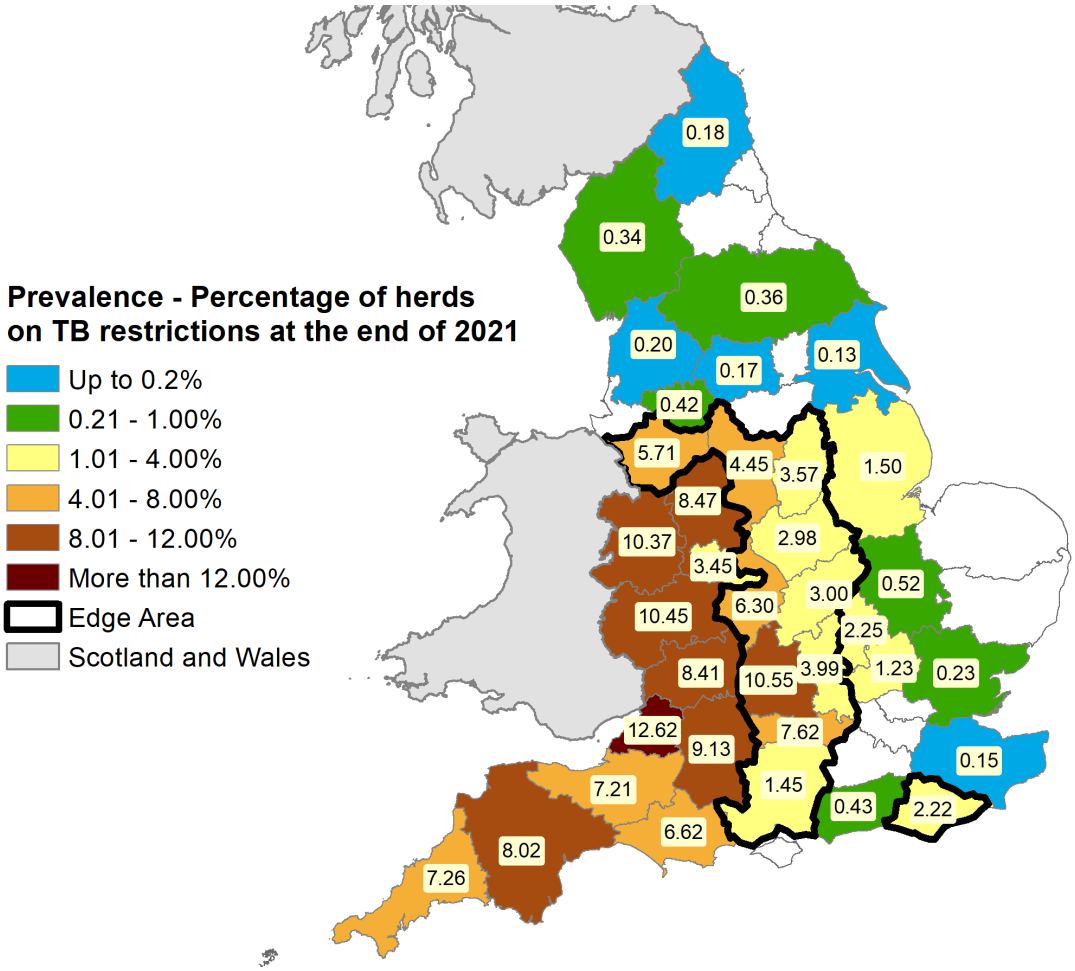


Figure 3.4.2 County prevalence: percentage of herds in each county that were under restrictions due to a TB incident at the end of 2021 (31st December)

- Prevalence is generally greatest in the HRA counties (highest in Avon). However, as in previous years, high levels of prevalence were also found in Oxfordshire.

Duration of TB incidents

Herds infected with TB lose their OTF status, and are thus prevented from moving cattle while incident control measures are in place to limit the risk of spreading TB. Limited exceptions, including direct movements to slaughter, slaughter markets or finishing units approved by APHA (AFUs), are permitted under licence.

TB incident duration has an effect on the costs of TB to both farmers and taxpayers because restrictions constrain the management of the herd. Longer incidents are generally associated with more herd tests and more animals removed, 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 undetected infection in the herd (and further spread of disease) if restrictions are removed too early.

A total of 3,175 incident herds in England regained OTF status (i.e. had movement restrictions lifted) in 2021. Of those, 10 were non-grazing AFUs (five in the HRA, three in the Edge Area and two in the LRA). Due to differences in the management of TB in AFUs, they have been excluded from the following duration figures.

Herds with a TB incident were under restriction for longer in the HRA and Edge Area, compared to the LRA, with a median duration of a little less than seven months (Figure 3.4.3). The median and interquartile range (IQR) for herds in the HRA and Edge Area indicates that the herds were under restriction for 202 and 200 days (HRA IQR 167-291 days, Edge area IQR 165-273 days). In the LRA, the median duration of TB incidents was 138 days (IQR 98-199 days). This reflects the higher proportion of herds with OTF-S cases in the LRA, most of which require only a single short interval test (SIT) with negative results to regain OTF status.

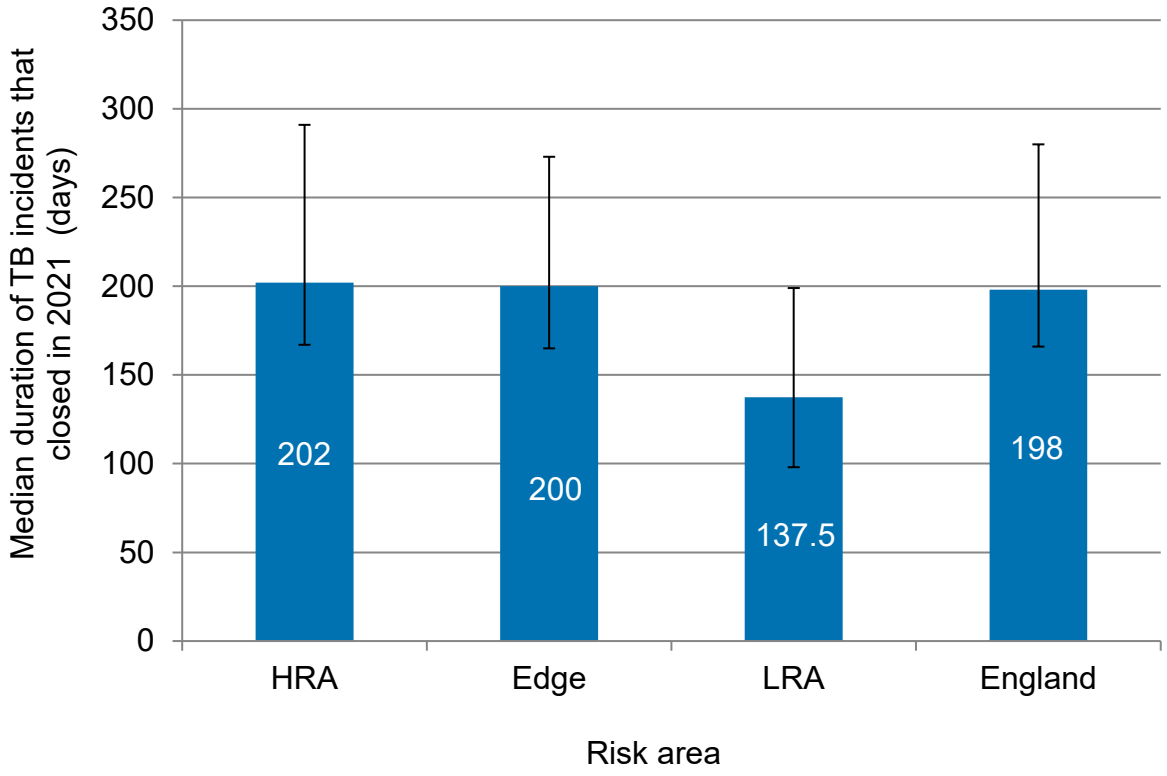


Figure 3.4.3 Median duration and interquartile range of all TB incidents that closed in 2021, by risk area

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

Factors significantly associated with long incident durations include large herd size and the number of reactors found. The latter can stem from case management processes, such as supplementary IFN-γ blood testing.

The duration of herd movement restrictions was associated with herd size in all risk areas (Figure 3.4.4). In 2021, it took longer for restrictions to be lifted in large herds (more than 200 animals) than in smaller herds. This can be seen by the increasing proportion of such herds (green shading) in the longer duration categories. A greater proportion of medium (between 51 and 200 animals) and small herds (between 1 and 20 animals) are restricted for shorter periods in the HRA, Edge Area and LRA (Figure 3.4.4)

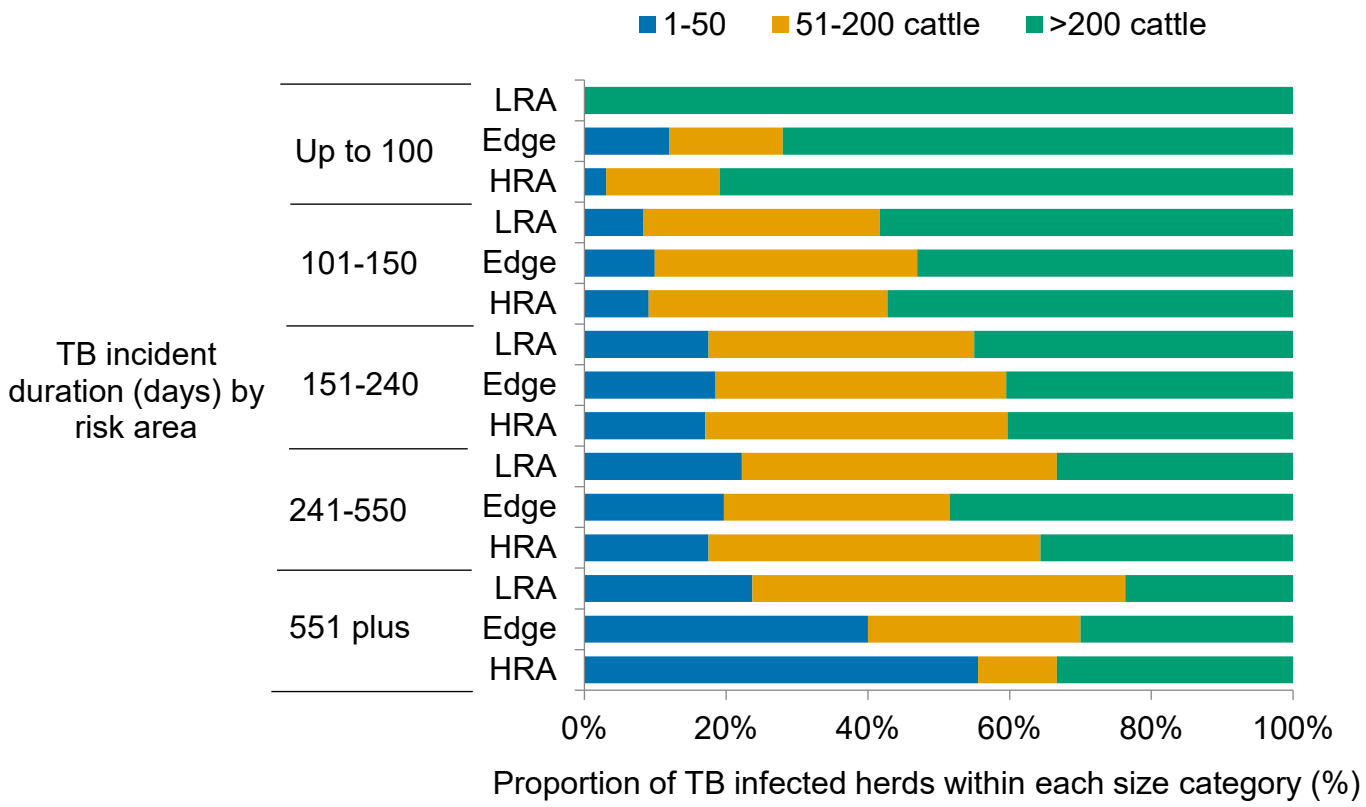


Figure 3.4.4 Comparative duration of TB incidents that closed in 2021, by risk area and herd size

- 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.

A long duration of movement restrictions is the result of challenges in removing infection, or in demonstrating freedom of infection. They may occur due to several factors that can interfere with efforts to remove infection, such as:

- The limitations of the existing diagnostics in finding all infected animals after one round of testing (imperfect sensitivity of the skin and interferon-gamma tests) leading to maintained infection within the herd and multiple rounds of herd testing.
- Intense cattle-to-cattle transmission (high within-herd infection prevalence).
- Re-introduction from continued or new exposure to a local infection source (e.g. from local wildlife reservoirs of TB, or infected contiguous cattle herds).
- New infection from with purchased animals (under licence).
- Uninfected animals showing non-specific reactions to tests (less common).

Figure 3.4.5 shows the number of SITs required to resolve a TB incident, comparing risk area and herd size.

In all risk areas, most TB incidents required two SITs to restore OTF herd status. Herds in the HRA tended to have longer TB incidents, with 12% of herds receiving more than five SITs in 2021. In the Edge Area, 8% of herds received more than five SITs, and in the LRA just two per cent (three herds).

In the HRA, 65% of small herds (1-50 cattle) required two SITs to clear a TB incident, while 32% required three or more. Fewer medium size herds (51-200 cattle) cleared a TB incident with two SITS (53%) and under half required three or more SITs (46%). Most large herds (>200 cattle) required three or more SITs (59%).

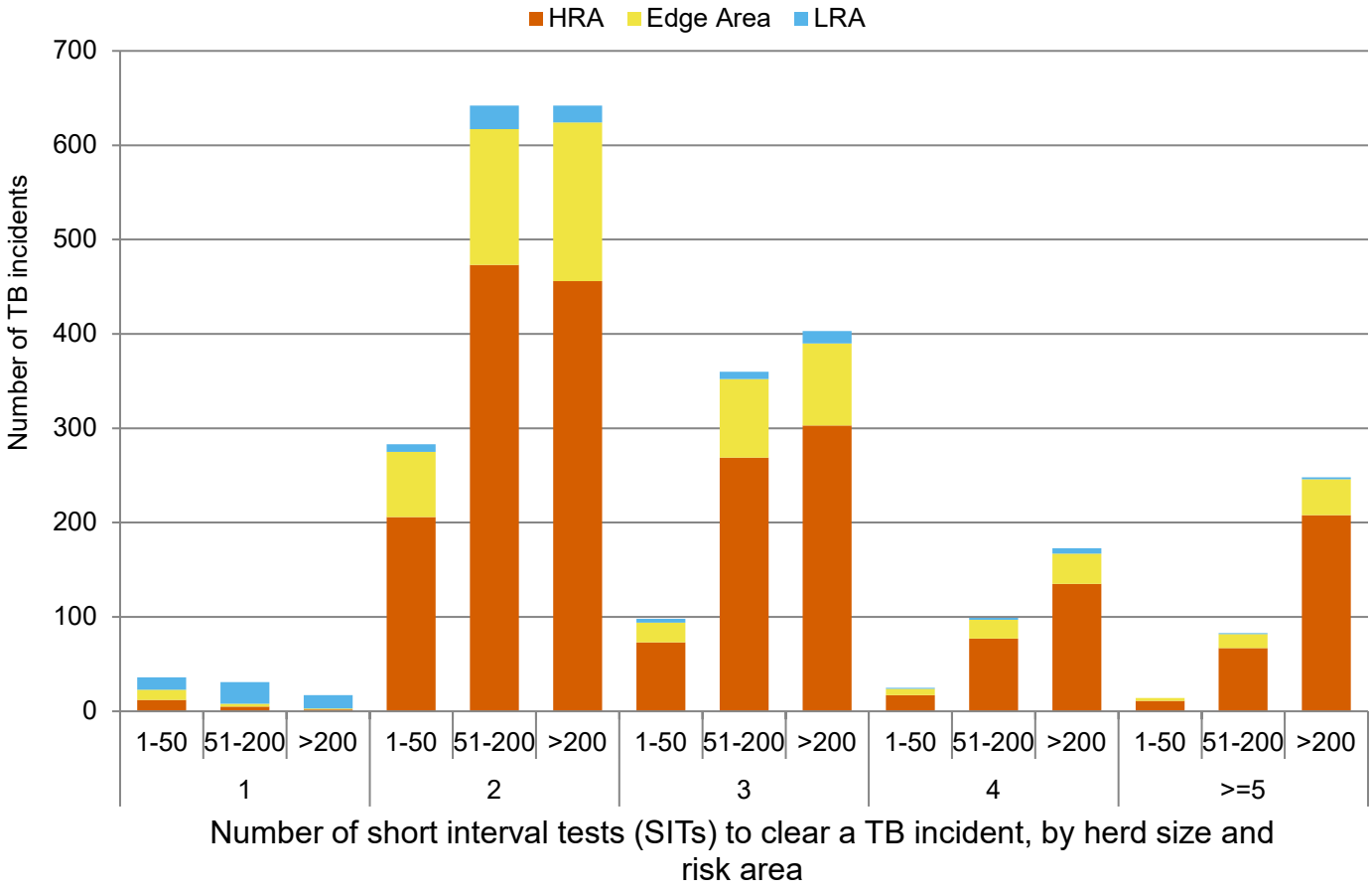


Figure 3.4.5 Number of short interval tests (SITs) to clear a TB incident, by risk area and herd size (for TB incidents ending in 2021)

- In all three risk areas, most herds required two SITs to clear a TB incident.
- In the HRA, large herds (more than 200 cattle) more often required three or more SITs to clear a TB incident compared to the Edge Area and the LRA.

Changes in incident duration over time

Since 2012, TB incidents with more than one reactor have consistently been under restriction for longer than those with only one reactor, across all risk areas (Figure 3.4.6). Historically, TB incidents with more than one reactor have generally had a longer duration of movement restrictions in the HRA, compared to herds in the Edge Area and LRA. In 2021, herds with any number of incidents in the Edge Area had a median duration similar to the HRA. In 2021, the Edge Area had the highest median duration in herds with more than one reactor since 2018. The duration of TB incidents with 0-1 reactors in the HRA and Edge Area have been similar to each other since 2014. The duration of TB incidents with up to one reactor is largely driven by the required minimum number of SITs. In the LRA, this is often only one as the majority of incidents only have reactors with no visible lesions and a negative culture result (OTF herd status suspended or OTF-S), rather than

lesion and/or culture positive animals (OTF herd status withdrawn or OTF-W), hence the lower incident duration in the LRA than in the HRA and Edge Area.

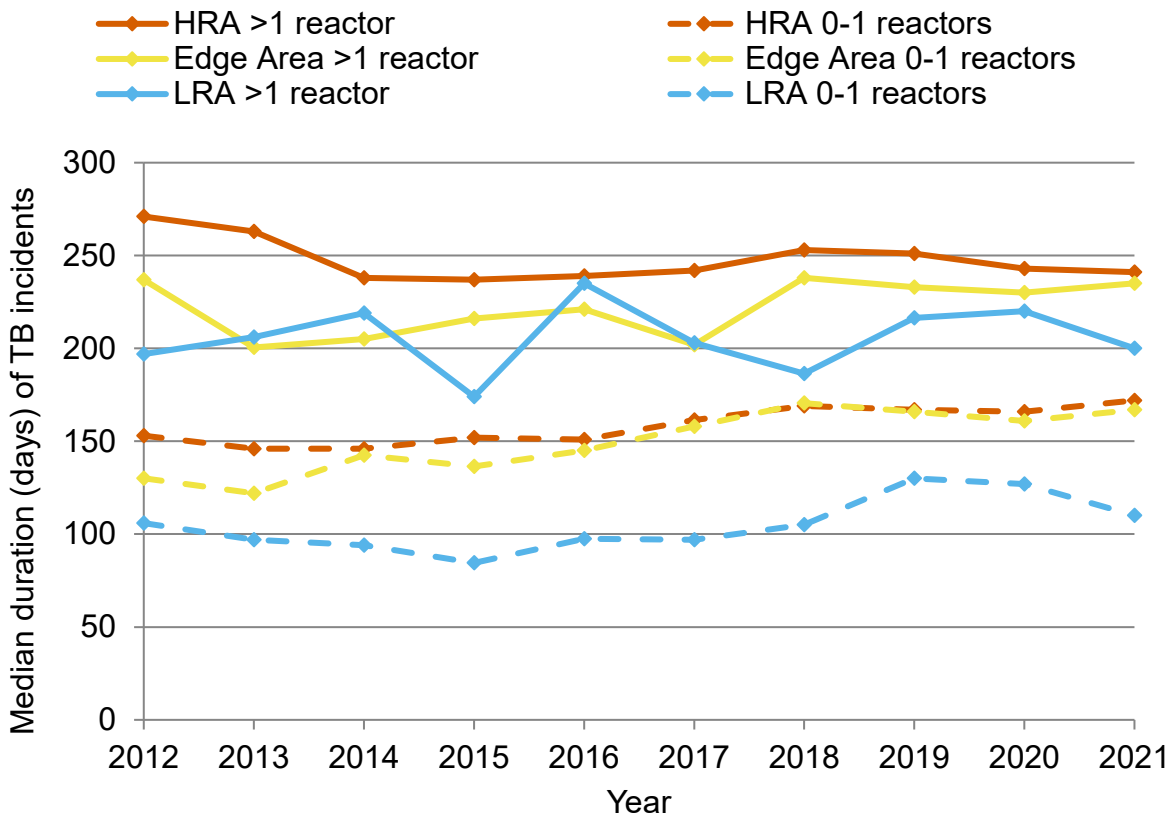


Figure 3.4.6 Median duration of TB incidents that closed in each year, between 2012 and 2021

- In 2021, TB incidents in the HRA and Edge Area with more than one reactor were under restriction for a similar duration.
- 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.
- Incidents in LRA were under restriction for a shorter time compared to the HRA and Edge Area, regardless of the number of reactors.

Persistent TB incidents

If a TB infected herd is under movement restrictions for over 550 days (about 18 months), APHA considers the incident to be ‘persistent’. The affected herds are eligible for enhanced management procedures, based on a series of prioritisation criteria. The causes of persistent TB incidents are listed under the paragraph “Duration of TB incidents”.

Figure 3.4.7 shows the number of persistent TB incidents that remained open at the end of each year, since 2012, by risk area. The vast majority (84%) were in the HRA.

The number of persistent incidents still open at the end of 2021 (n=153) was the lowest in the past 10 years, and consistent with what was observed in 2020 (n=155). In the Edge Area, the number of persistent incidents has remained stable at 23 (20 in 2020), after a progressive increase from 12 in 2016 to 29 in 2019. In the HRA the number of persistent TB incidents increased from 205 in 2015 to 242 in 2018. Later, the persistent incident number fell to 192 in 2019 to further decrease to 134 in 2020 and then to 129 in 2021. Only one persistent incident remained open in the LRA (Lincolnshire) at the end of 2021 (Figure 3.4.7).

The decrease in the number of persistent incidents still open at the end of each year in the HRA is positive. However, the number of all TB incidents open at the end of each year has also been decreasing annually in the HRA since 2017. As a result, the percentage of TB incidents still open at the end of the year that were persistent increased in 2021, to 9%, from 8% in 2020.

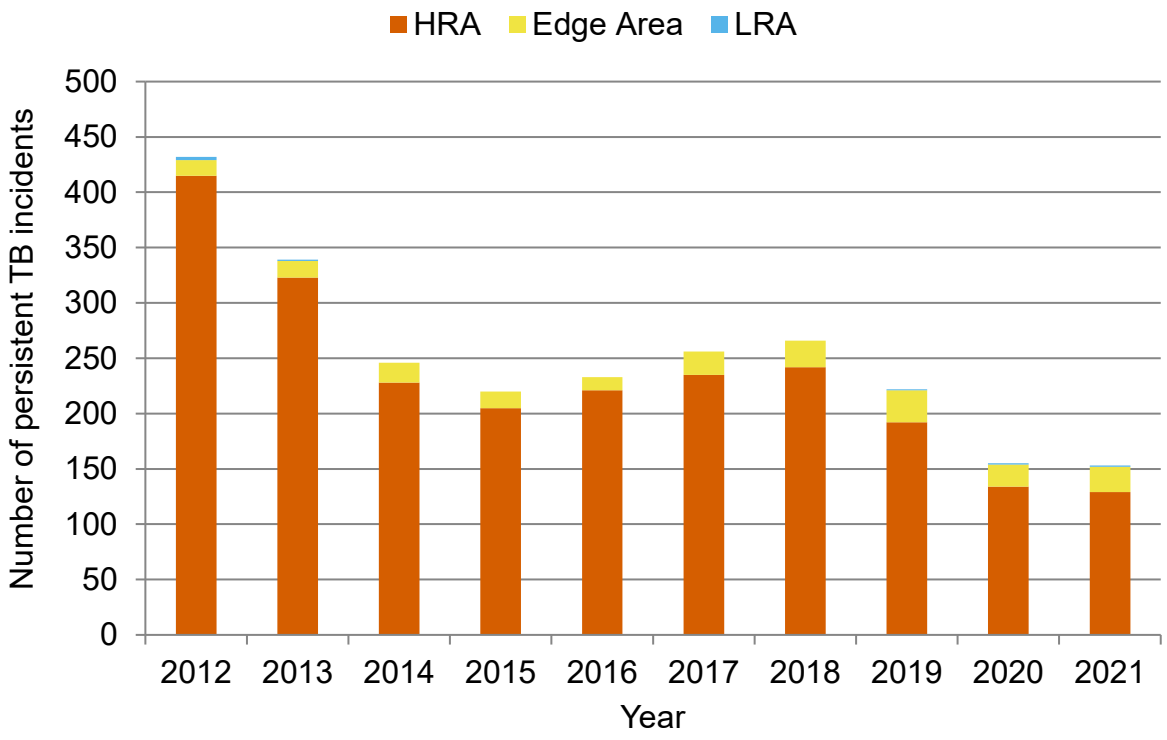


Figure 3.4.7 Number of TB incidents ongoing at the end of each year that had lasted more than 550 days ('persistent' TB incidents).

- During 2021, there were 153 persistent TB incidents in England overall (129 in the HRA, 23 in the Edge Area and one in the LRA).

There was variation in the burden of persistent incidents between counties (Figure 3.4.8). Within each county, the highest proportion of persistent TB incidents open in the HRA at the end of 2021 were located in Wiltshire (13%), Avon (13%), Gloucester (11%) and Cornwall (11%). In the Edge Area, Berkshire had the highest proportion of persistent

incidents (27%), followed by Oxfordshire (16%). Figure 3.4.8 shows that, as in 2020, the burden of persistent incidents disproportionately affected counties in the south and mid of the HRA and central western Edge Area.

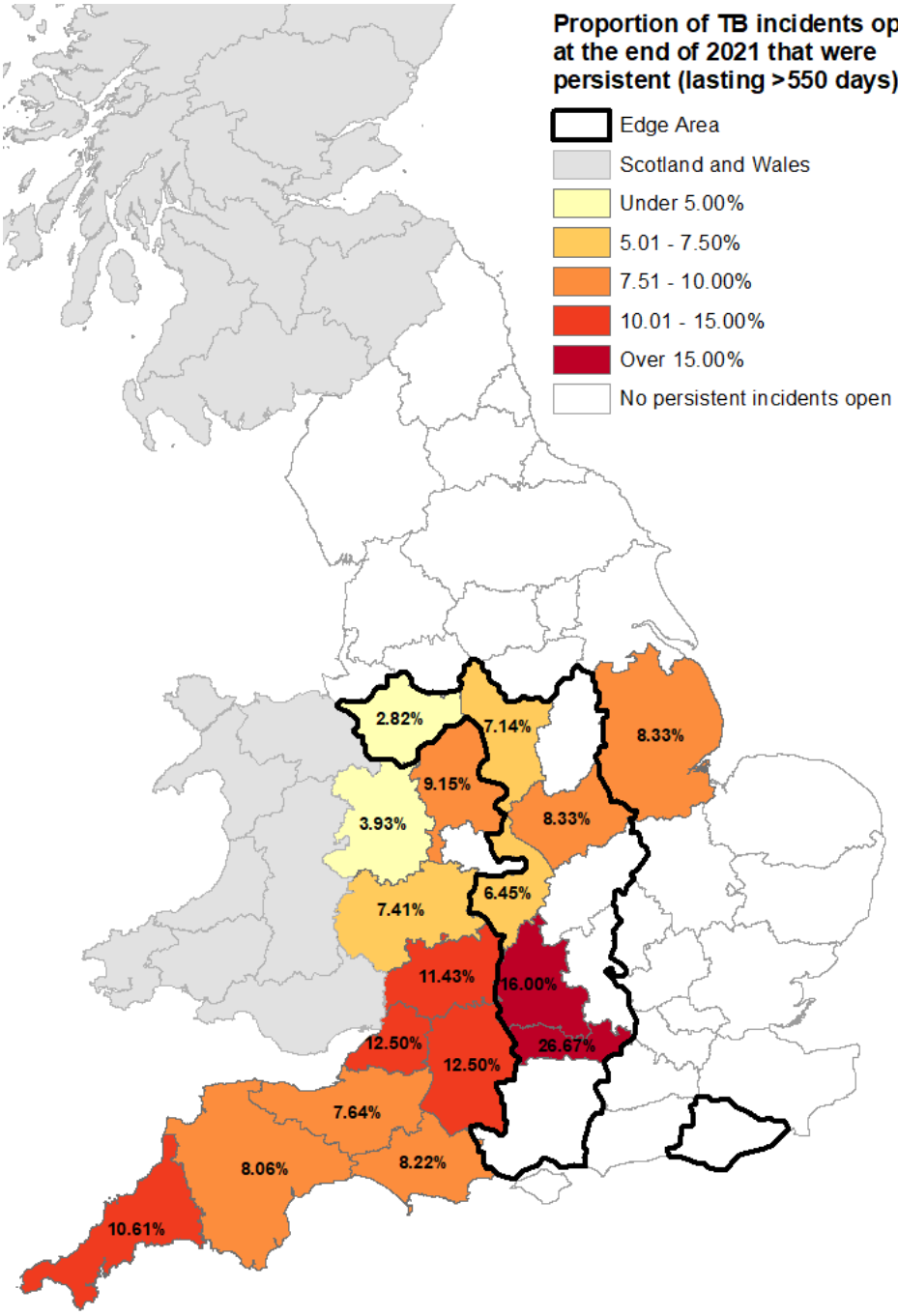


Figure 3.4.8 Proportion of all TB incidents in each county, open at the end of 2021, that had lasted more than 550 days (persistent incidents)

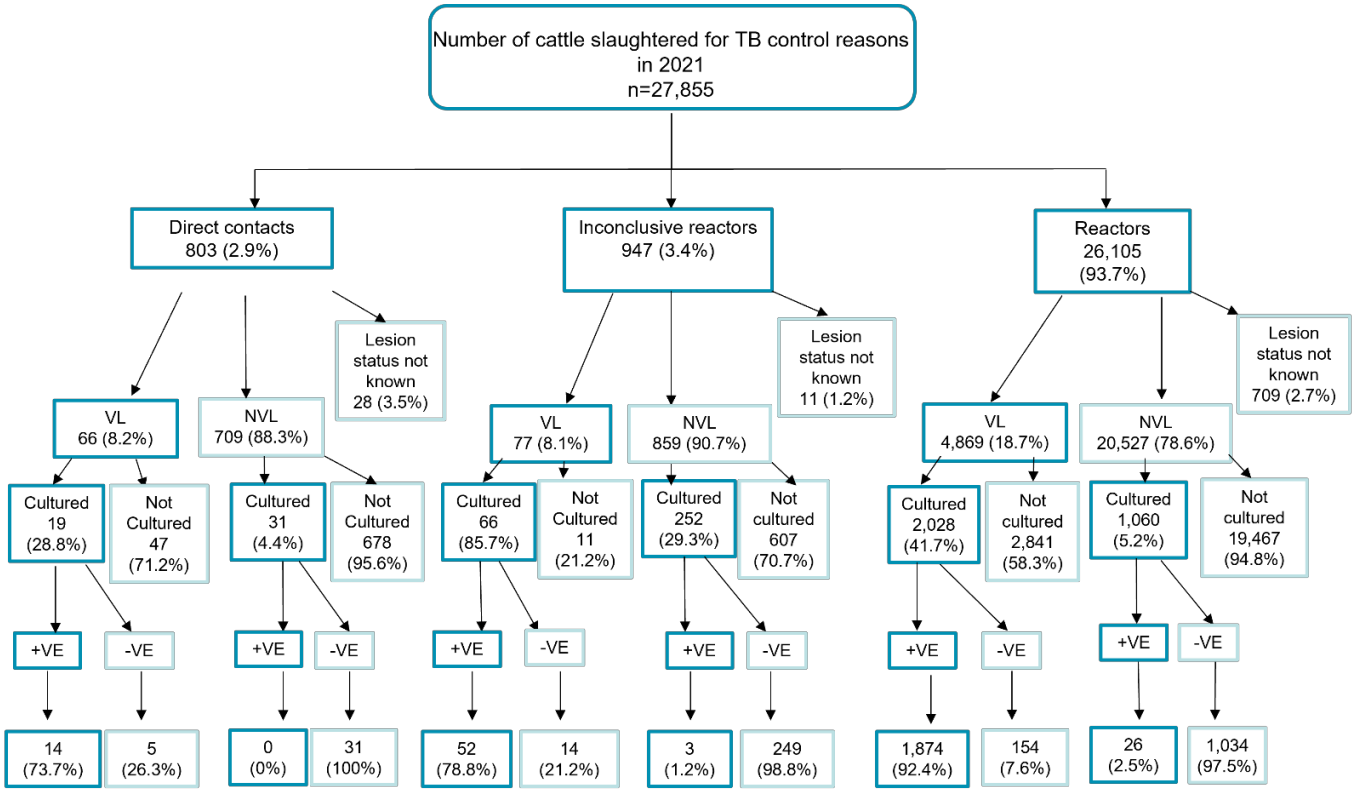
- The highest proportion of persistent TB incidents open the end of 2021 was in the HRA, mainly located in Wiltshire (13%), Avon (13%), Gloucester (11%) and Cornwall (11%).

Number of animals removed from TB incident herds

Cattle that test positive for TB must be isolated from the herd and are rapidly removed. In 2021, a total of 27,855 cattle were slaughtered for TB disease control purposes in England, with the vast majority of them being skin or interferon-gamma test reactors, or both (94%). The remaining 6% were removed as inconclusive reactors (IRs) before re-testing, either voluntarily by the keeper, or by APHA as direct contacts (Figure 3.4.9a).

Almost all cattle slaughtered for TB control purposes are subjected to *post-mortem* meat inspection(PMMI) in the slaughterhouse, but not every TB-affected animal is sampled for laboratory culture and isolation of *M. bovis*. Confirmation of TB infection means the detection of typical lesions at PMMI (visibly-lesioned or VL sample) in a slaughtered test reactor, or identification of *M. bovis* in culture.

In line with previous years, 92% of VL cattle carcases (reactors, IRs and DCs) that were sampled for culture yielded a positive result for *M. bovis*, compared to only a little over 2% of animals with non-visible lesions (NVL) (Figure 3.4.9a).



KEY: VL = visible lesions; NVL = non-visible lesions; +VE = *M. bovis* positive; -VE = *M. bovis* negative

Figure 3.4.9a Diagram showing the number of cattle that were slaughtered for TB control reasons in 2021 and the number in which infection with *M. bovis* was confirmed

The results of the SICCT skin test can be read at standard (ST) or severe (SEV) interpretation, depending on the circumstances in which the test is being performed. Severe interpretation is used for most short interval tests carried out in TB incident herds. It is designed to identify more positive animals, thus reducing the risk of leaving undisclosed infection in the herd.

In England, most test reactors in 2021 (43%) were removed under a IFN-γ test positive result (11,185 animals), followed by the standard-interpretation of the skin test (10,853 animals, 42%), while 15% (4,027 animals) were severe-interpretation reactors. Before 2021, IFN-γ tests were compulsory in OTF-W incidents in the Edge Area and the LRA, and in parts of the HRA where badger control had been in operation for at least two years. In 12th July 2021, a new policy was introduced in the HRA and in the annual testing zones of the Edge Area whereby herds with OTFW incidents occurring within 18 months of regaining officially TB free (OTF) status following a previous OTFW incident require a mandatory gamma test (See Preface section in this report for further details on new policies for 2021).

Over a third of all cattle slaughtered for TB control reasons in the HRA were IFN-γ test positive animals (41%). In the Edge Area and LRA, IFN-γ test positive animals accounted for 50% and 62% of all the cattle slaughtered, respectively.

Of all the cattle that were slaughtered for TB control reasons and had visible lesions of TB at PMMI or were *M. bovis* positive on culture, 74% were removed as standard-interpretation reactors.

In England, 33% of standard-interpretation reactors had visible lesions of TB, *M. bovis* positive culture results, or both. For severe-interpretation reactors and IFN-γ test positive animals, the equivalent proportion was 8%. The proportion for IFN-γ test positive animals decreased compared to 2020 (13%). As expected, these percentages varied by TB risk area (highest in the HRA and lowest in the LRA). In the HRA the IFN-γ test confirmed cases dropped from 16% in 2020 to 8% in 2021. standard-interpretation reactors only dropped from 41% to 34% while severe-interpretation reactors remained stable from 13% to 12% (Figure 3.4.9b).

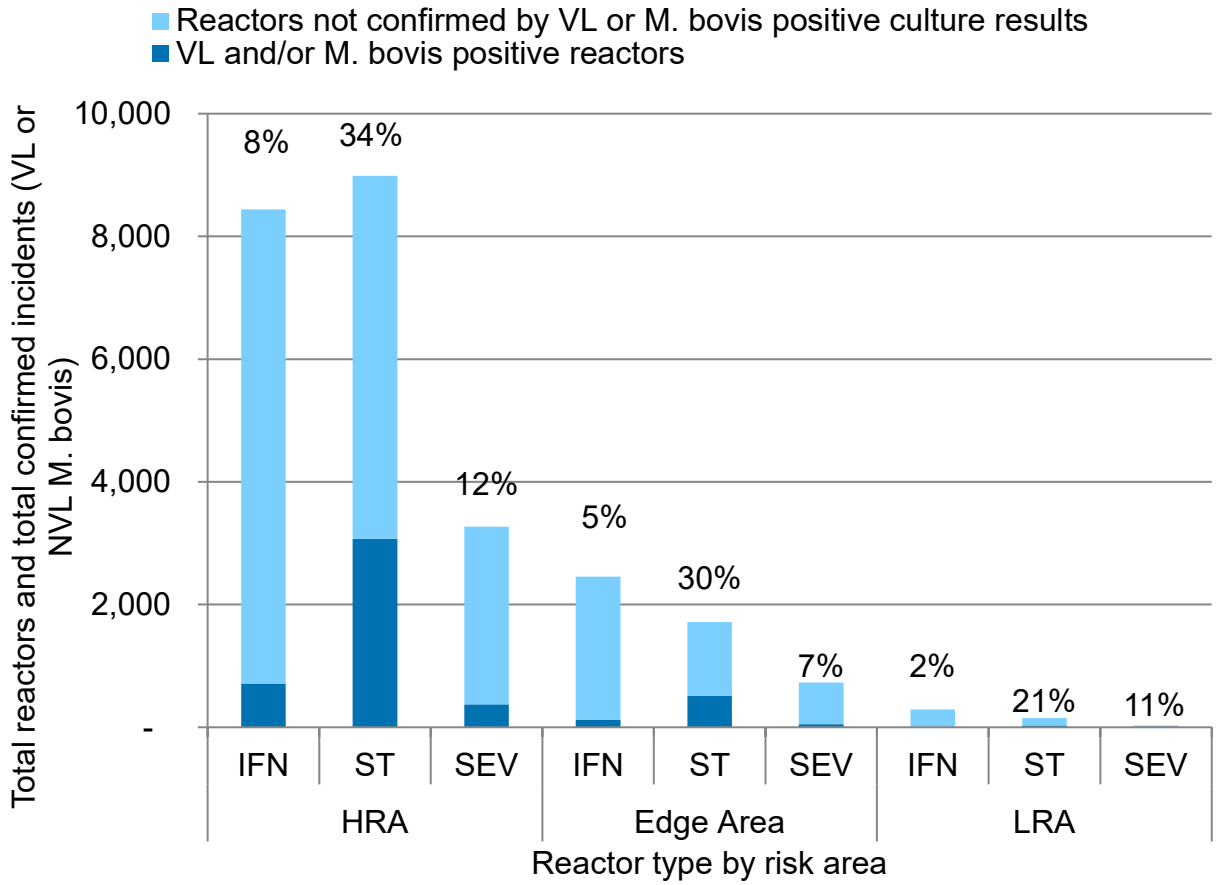


Figure 3.4.9b Number of reactors and total animals removed in 2021 with *post-mortem* evidence of *M. bovis* infection (VL reactors and/or culture-positive animals), by reactor type (IFN-γ test positives, standard and severe interpretation reactors to the skin test) and risk area. Stacked bars labelled with the percentage of reactors that had visible lesions of TB (VL) and/or positive culture results.

In 2021, there was just over a 1% decrease in the number of cattle removed from herds across England compared to 2020. The majority of the 27,855 cattle removed from herds were reactors taken from the HRA (n=20,735, 79%), which has been the pattern over the last ten years (Figure 3.4.10). However, substantial numbers were also taken as 1xIRs or DCs (802 in the HRA) and 2xIR or 3xIRs (500 in the HRA).

After a steep increase in the number of reactors removed from herds in the Edge Area, jumping from 2,609 in 2013 to 7,029 in 2019, the number of reactors decreased by 25% in 2020, to 5,242, and then a further 7% in 2021 (n=4,906). Increases seen since 2013 were due to more stringent controls in the Edge Area.

Two consecutive skin herd tests with negative results at severe interpretation are required before restrictions can be lifted from any incident herd in the HRA (since April 2016) and the Edge Area (since 2013). This means that some IRs disclosed at standard interpretation may be removed as reactors when severe reinterpretation is applied. This

increases the number of reactors, reducing the risk of leaving residual infection in the herd. Furthermore, compulsory IFN-γ testing in all herds with OTF-W incidents in the Edge Area was rolled out from 2014.

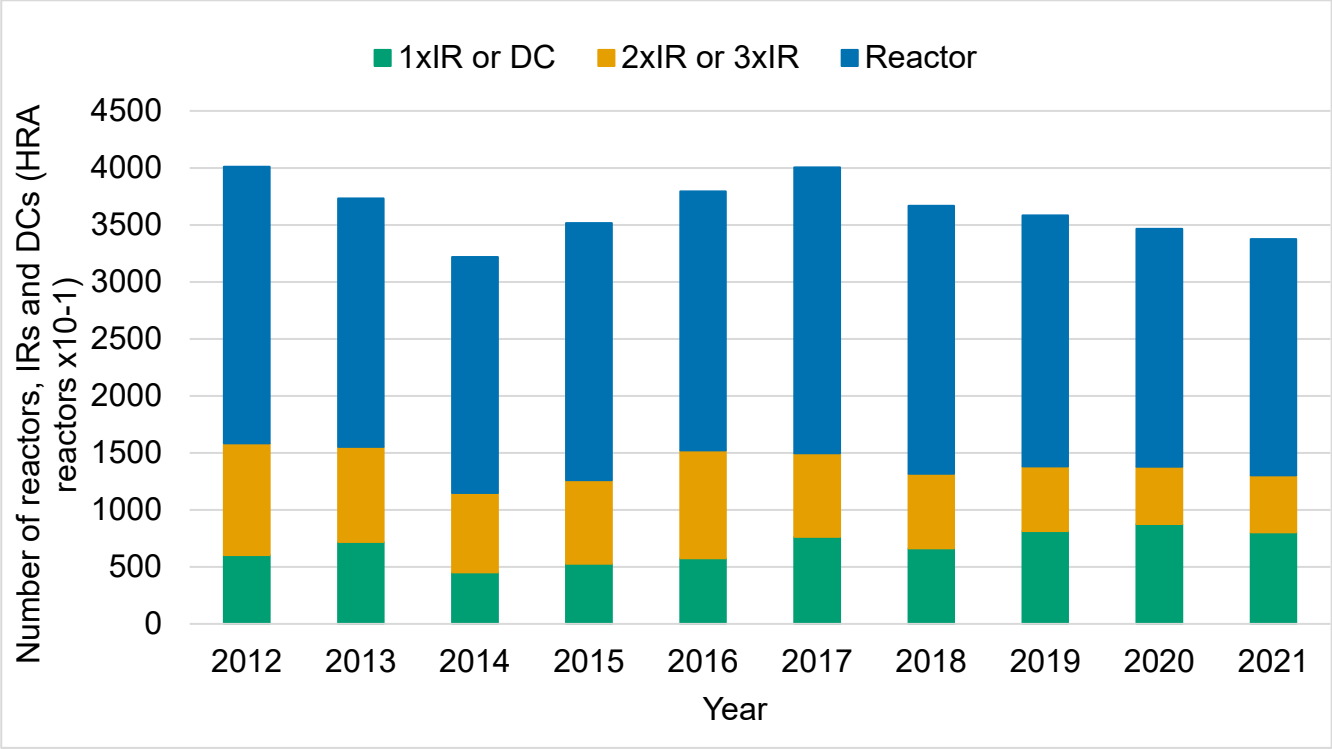


Figure 3.4.10a Number of reactors, inconclusive reactors and direct contacts removed from herds between 2012 and 2021, in the HRA risk area. Note - HRA reactors presented as a tenth of their true value.

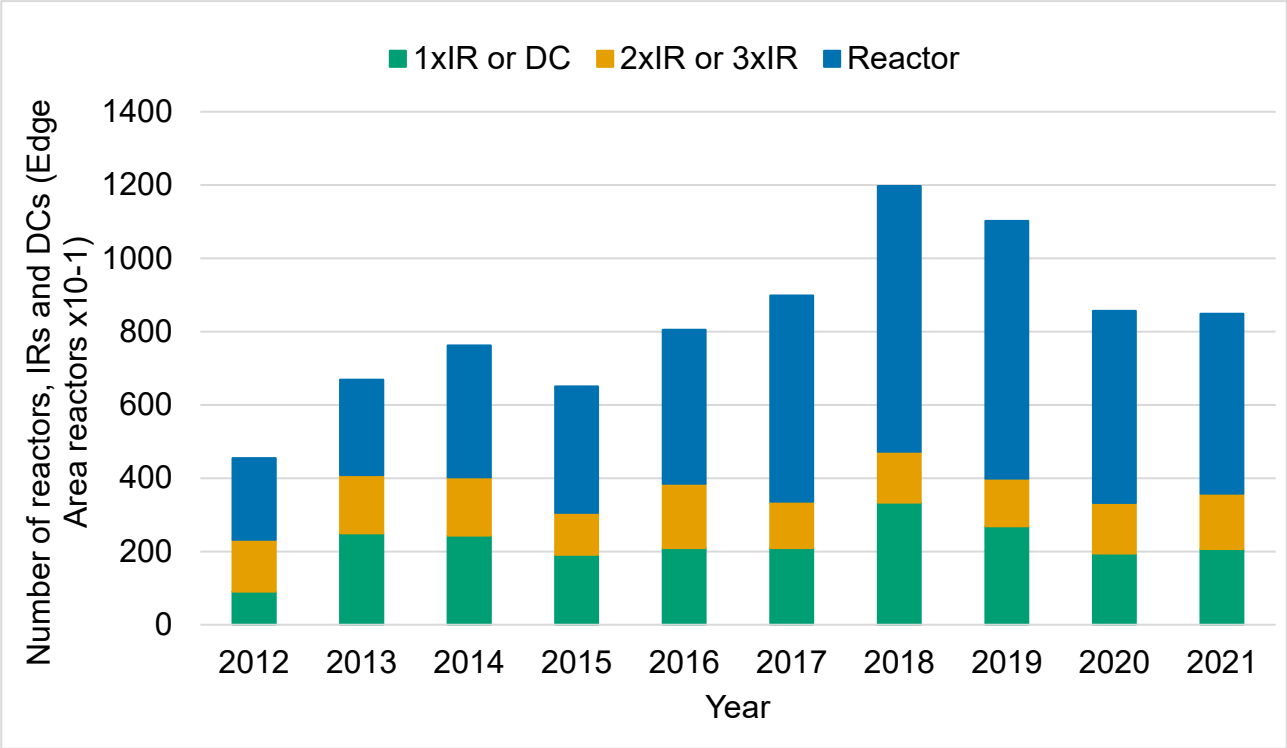


Figure 3.4.10b Number of reactors, inconclusive reactors and direct contacts removed from herds between 2012 and 2021, in the Edge Area. Note - HRA reactors presented as a tenth of their true value.

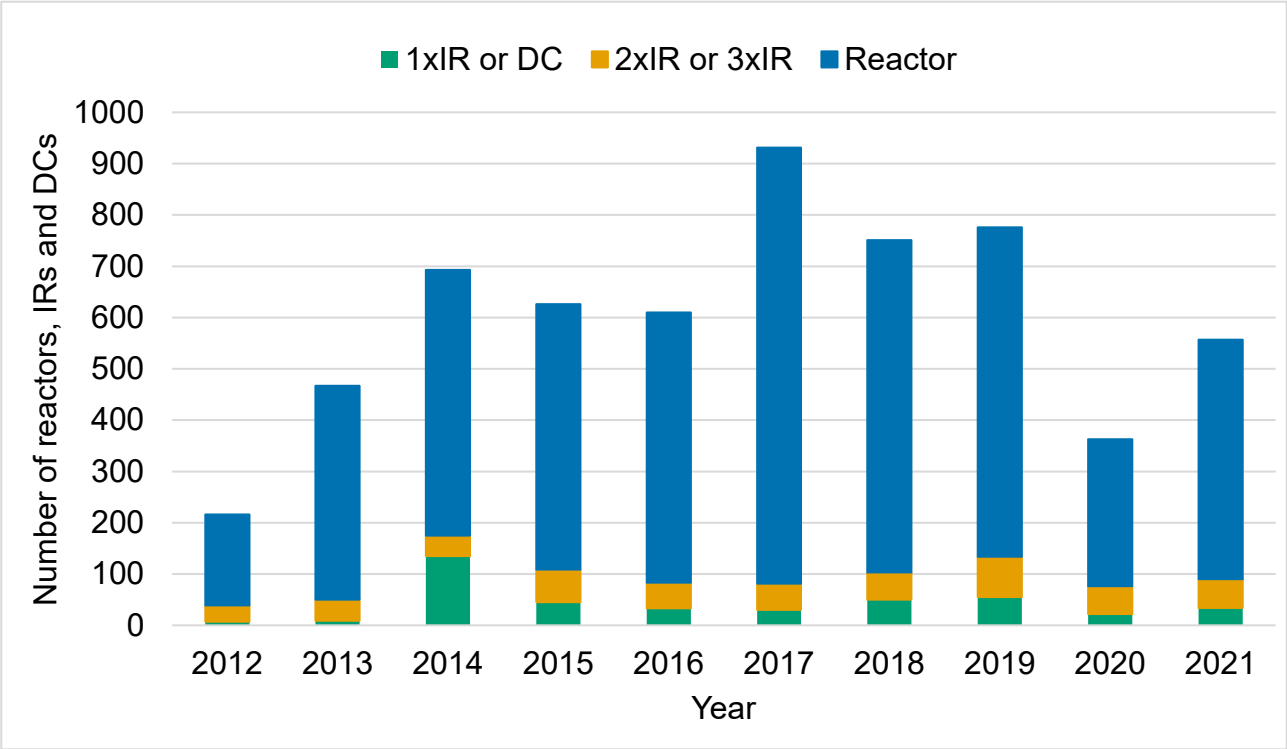


Figure 3.4.10c Number of reactors, inconclusive reactors and direct contacts removed from herds between 2012 and 2021, in the HRA risk area. Note - HRA reactors presented as a tenth of their true value to facilitate comparisons with the other risk areas

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

In 2021, the *median* number of reactors removed per incident was three, consistent with previous years. The *mean* number of test reactors removed (including IFN-γ test positive animals) in the HRA per TB incident was around six from 2009 to 2014. It since increased to almost 10, by the end of 2020, and remained stable in 2021. Figure 3.4.11a shows the moving average (mean) number of reactors removed in each risk area. There has been greater fluctuation in the Edge Area, which showed a peak in 2015 and has risen to over 10 since 2018, but decreased to a *mean* value of just above 8 in 2021. This was most likely due to the increased use of IFN-γ tests in recent years, with the total number of IFN-γ tests in England overall increasing by 12% (N=144,621) in 2021 from 2020 (N=128,858). The number of animals tested with the IFN-γ test decreased in 2020 due to the COVID-19 pandemic, but increased again in 2021 by 2% from 2020. In 2021, the further decrease of

the *mean* number of reactors in the Edge Area might be due fewer IFN-γ tests administered in the Edge Area (Chapter 3.3, Interferon gamma test for detection of additional infected cattle within TB incident herds). There are very few incidents in the LRA, so the equivalent mean shows greater variability.

Of the TB incidents that closed in 2021, 283 had no reactors (Figure 3.4.11b). These were either incidents initiated by a slaughterhouse case, or by two or more inconclusive reactors per TB incident, where subsequent testing in the herd revealed no further reactors. Sixty-seven percent of TB incidents in England had two or more reactors, largely driven by the Edge Area and the HRA (70% and 69% respectively). In the LRA, the proportion was 34% (Figure 3.4.11b).

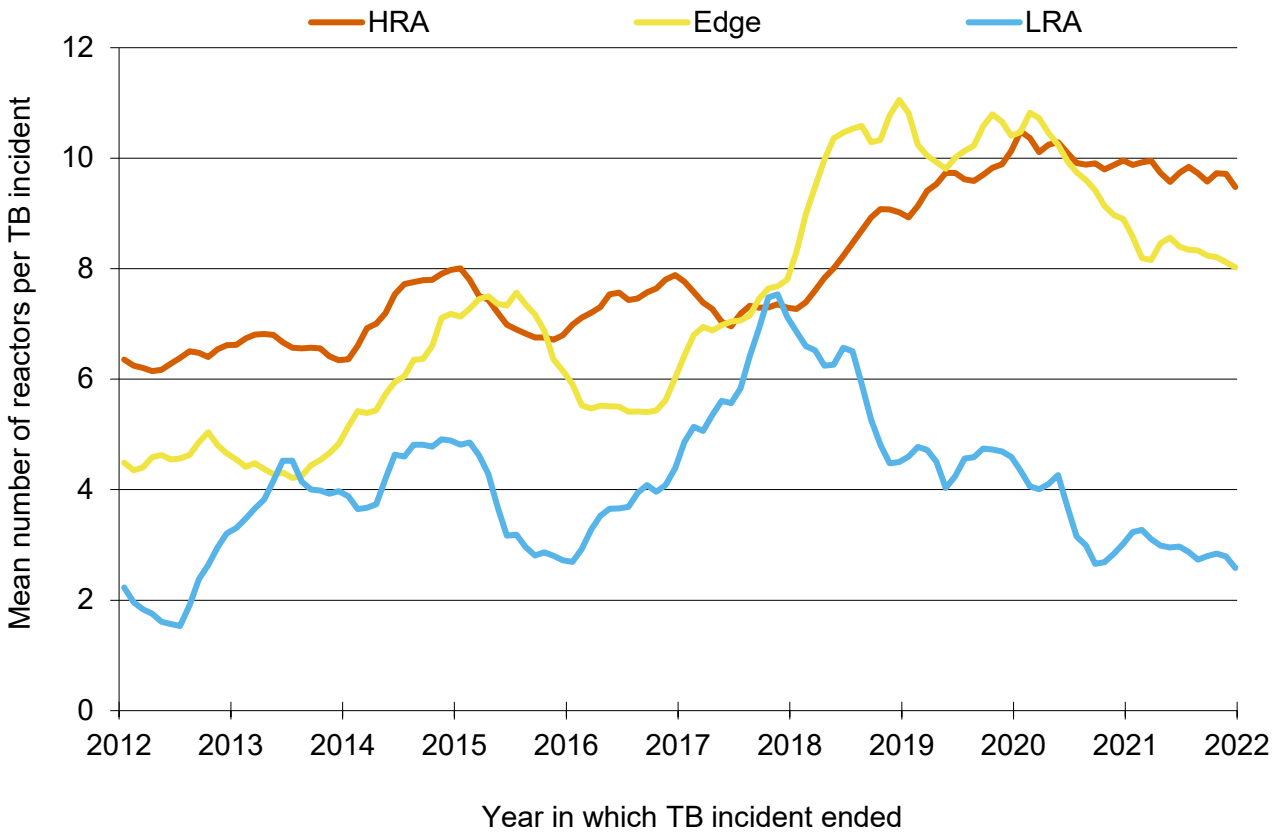


Figure 3.4.11a Monthly rolling <u>mean</u> total number of test reactors taken per TB incident that closed between January 2012 and December 2021, by risk area (12-month moving average)

- The mean total number of test reactors removed in the HRA per TB incident was around six from 2009 to 2014 and has since risen to close to 10 reactors in 2020 and in 2021.
- There has been greater fluctuation in the Edge Area, which showed a peak in 2015, before increasing to over 10 in 2018 and 2019, but falling below 10 by the end of 2020 and to just over 8 in 2021.

- There are few incidents in the LRA, so the mean shows greater variability.

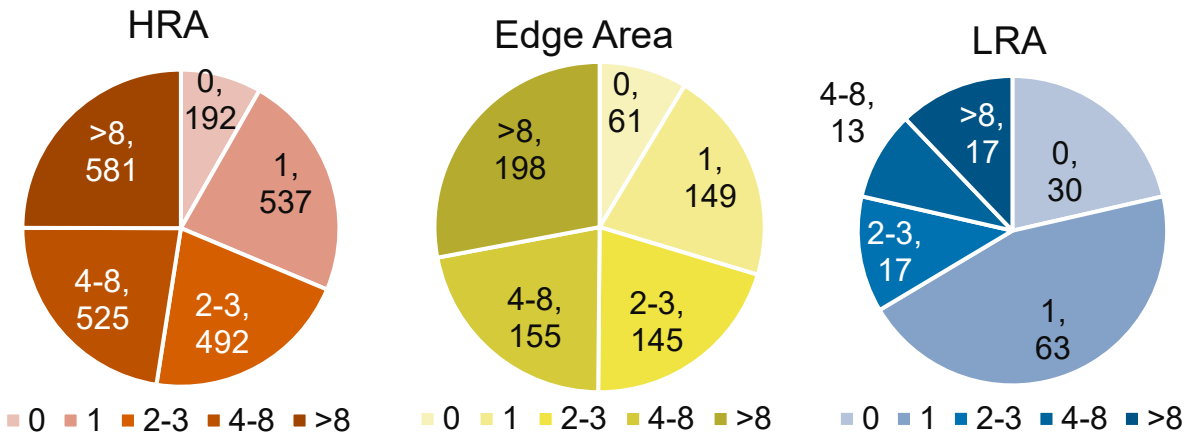


Figure 3.4.11b Number of reactors per TB incident that closed in 2021, by risk area. The frequency of TB incidents for each category of reactor numbers is specified in each pie

- In the HRA and Edge Area, incidents are spread fairly evenly between all reactor categories, with the exception of 0 reactors, which has fewer incidents.
- In the HRA and Edge Area, incidents with more than eight reactors were most common.
- In the LRA, incidents with just one reactor were most common.

TB control in wildlife

Although the bovine TB bacterium (*Mycobacterium bovis*) can potentially infect any mammal, the main wildlife reservoir in England is the European badger (*Meles meles*) (Clifton-Hadley, 1993). Badger culling for TB control purposes has been implemented in England since 2013, under licence from Natural England in badger control programme (BCP) areas. TB in badgers is also controlled through the licensed use of injectable BCG vaccine. Licensed badger culling and badger vaccination activities undertaken in 2021 are summarised below.

Licensed badger culling

In 2021, seven new intensive badger culling areas were licensed in England; four in the HRA and three in the Edge Area. In total, 40 intensive badger control areas were in operation during 2021, as well as 21 additional areas where Supplementary Badger

Control was undertaken (having already completed four annual seasons of intensive culling).

Badger removal results from 2021 indicate that all 40 BCP areas undergoing intensive culling achieved the spatial coverage and minimum number of badger removals required. Further information can be found in the Summary of badger control monitoring during 2021.

Licensed badger vaccination

In 2021, 1,575 badgers were vaccinated against bovine TB in England, an increase from 1,094 badgers in 2020. Licences to vaccinate badgers were in operation in almost every HRA and Edge Area county; excluding the West Midlands, Buckinghamshire and Northamptonshire. Licences were also issued in the LRA counties of Cumbria and Greater Manchester. Together, these licences covered a total of 425.6 km^2 across England. More details can be found in the Summary of badger vaccination in 2021.

4. The TB epidemic in England's risk areas

4.1 Epidemiology of TB in the High Risk Area

- In 2021, TB herd incidence in the HRA was 14.4 TB incidents per 100 herd years at risk (HYR), compared to 16.2 TB incidents per 100 HYR in 2020 (16.9 in 2019). This represented a statistically significant reduction of 11% ($p<0.001$) compared to 2020 and was the lowest annual herd incidence rate recorded in the HRA since 2007.
- The total number of TB incidents detected in the HRA in 2021 (n=2,155) fell significantly by 9% compared to 2020 (n=2,358) ($p<0.001$).
- In 2021, TB incidence per 100 HYR decreased for almost all HRA counties. The exception was in Hereford & Worcester, where a non-significant increase was observed during the period ($p=0.753$). The lowest incidence rates were observed in Cornwall, Somerset and the West Midlands.
- The overall average monthly herd prevalence for the HRA decreased from 9.1% in 2020 to 8.9% in 2021, however this decrease was not statistically significant ($p=0.815$). As with incidence, prevalence varied between counties. The highest end-of-year herd prevalence in 2021 were seen in Avon (13%), Hereford & Worcester (10%) and Shropshire (10%). The West Midlands had the lowest prevalence, though this represented an almost two thirds increase from 2020 (from 2% in 2020 to 3% in 2021). However, the West Midlands contains very few herds, so estimates of prevalence can vary widely due to sampling variability.
- Devon had both the highest population of herds and accounted for the highest proportion of all new TB incidents in the HRA in 2021 (23% for both). This was followed by Shropshire, which had 13% of new TB incidents, but only 10% of HRA herds.
- The median duration of TB herd incidents was just over 200 days for all HRA counties in 2021. Counties experiencing the longest TB incidents on average (for incidents ending in 2021) included Dorset (226.5 days), Gloucestershire (214 days), Wiltshire (212.5 days) and Avon (212.5).
- Overall, most counties in the HRA saw an increase in the proportion of persistent TB incidents ongoing at the end of 2021 compared to 2020. The exceptions were Devon and Dorset. Counties with the highest percentage of persistent incidents were Avon and Wiltshire (both 13%) and Gloucestershire (12%).
- The HRA accounted for 67% (n=144,621) of all IFN-γ tests carried out in England in 2021, a 12% increase from 2020 (n=128,858) and an almost 25% increase on 2019 (n=117,381). Of these IFN-γ tests, 32% (n=46,054) were carried out in Devon alone, similar to 2020.

Geographical coverage of the HRA

The HRA extends from the western areas of the Midlands to the south and west of England (excluding the Isles of Scilly) (Figure 4.1.1). In January 2018, the boundary of the HRA was redefined to exclude five counties that were previously divided between the HRA and Edge Area. All these counties (Cheshire, Derbyshire, East Sussex, Oxfordshire and Warwickshire) were moved fully into the Edge Area, reducing the size of the HRA. Data reported in this chapter are for the 12 counties that constituted the HRA from 2018 onwards, unless otherwise stated. TB trends over time compare TB incidents in the post-2018 HRA counties only, and do not include incidents in parts of counties that were formerly in the HRA but are now fully in the Edge Area.

Defra's overall objective for the HRA is to gradually reduce TB incidence following a period of stabilisation.

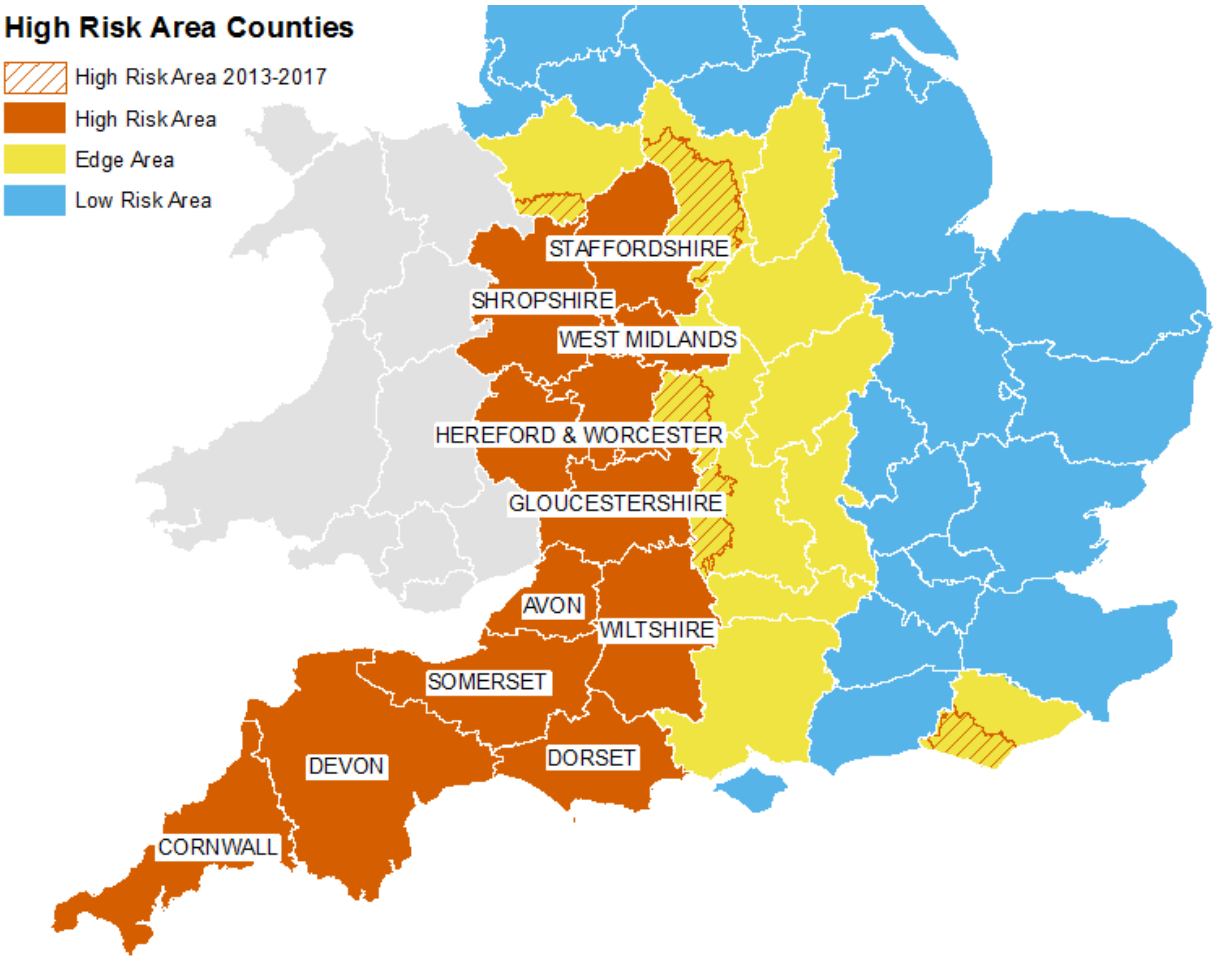


Figure 4.1.1 HRA county map in 2021, showing the former HRA sections of five counties with 'split' status between 2013 and 2017.

In this chapter, TB incidents are mostly reported with no distinction between their post-mortem status (lesion and/or culture confirmed (OTF-W), or strongly suspected (OTF-S)).

This is due to the high positive predictive value of the skin test in the HRA, which indicates that over 90% of all skin test reactors are truly infected (see Explanatory Supplement for further details).

The herd incidence rate in the HRA in 2021 was 14.4 TB incidents per 100 HYR. This was a statistically significant decrease of almost 9% compared to 2020 (16.2 incidents per 100 HYR) (p< 0.001) (Table 4.1.1).

Table 4.1.1 Table of headline TB epidemiological parameters for the High Risk Area of England in 2021

Year	Total number of new TB infected herds (TB incidents)	Incidence rate	Median duration of TB incident (days) (interquartile range)	Prevalence (average monthly)
2021	2,155	14.4	202 (167 to 291)	8.9
2020	2,358	16.2	196 (160 to 294)	9.1
Change (%)	-8.6	-11.1	3.1	-1.7
Statistical significance	(p<0.001)	(p<0.001)	(p=0.312)	(p=0.815)

Note: The change in total number of incidents was compared using a chi-squared test. The incidence rate is defined as new TB infected herds per 100 herd-years at risk (100 HYR). The difference between 100 HYR incidence in 2021 and 2020 was compared using the incidence rate ratio. The median duration of TB incidents (days) was compared using the K-sample equality-of-medians test. Average monthly prevalence between 2020 and 2021 was compared using a z-test.

Number of new TB infected herds

The annual number of new TB infected herds is important in terms of disease control resource planning and the number of farm businesses impacted. The number of new TB incidents decreased in nine of the eleven HRA counties in 2021 compared to 2020. Incidents increased in two HRA counties, Hereford & Worcester (242 incidents in 2021 vs 231 in 2020) and Avon (99 incidents in 2021 vs 96 in 2020).

When considering the trend in new TB incidents over a five-year period (2017 to 2021), a significant decreasing trend was observed for most counties in the HRA: Avon (p=0.036), Cornwall (p<0.001), Devon (p<0.001), Dorset (p=0.022), Gloucestershire (p<0.001), Staffordshire (p<0.001) and Wiltshire (p<0.001). For Shropshire, Somerset and the West Midlands, the five-year trend was not significant (Figure 4.1.2), although a drop in new incidents was seen between 2020 and 2021 for all three counties.

The greatest relative reduction in new TB incidents between 2017 and 2021 was seen in Gloucestershire and Cornwall (42% and 38% reduction, respectively). Almost a quarter

(23%) of all HRA TB incidents were detected in Devon in 2021, where incidents reduced by 36% between 2017 and 2021.

Figure 4.1.3 shows the proportion of new TB incidents that were OTF-W in each county. In 2021, the highest proportion of OTF-W incidents were disclosed in the West Midlands (67%), Avon (64%) and Shropshire (64%) (Figure 4.1.3). The proportion of OTF-W incidents increased slightly in Cornwall, from 57% in 2020 to 58% in 2021.
In Devon, Gloucestershire, Somerset and Avon, the proportion of OTF-W incidents fell for four or five consecutive years. Overall, despite fluctuations at individual county level, all counties have seen decreases in the number of new incidents in 2021 compared to five years ago (Figure 4.1.3).

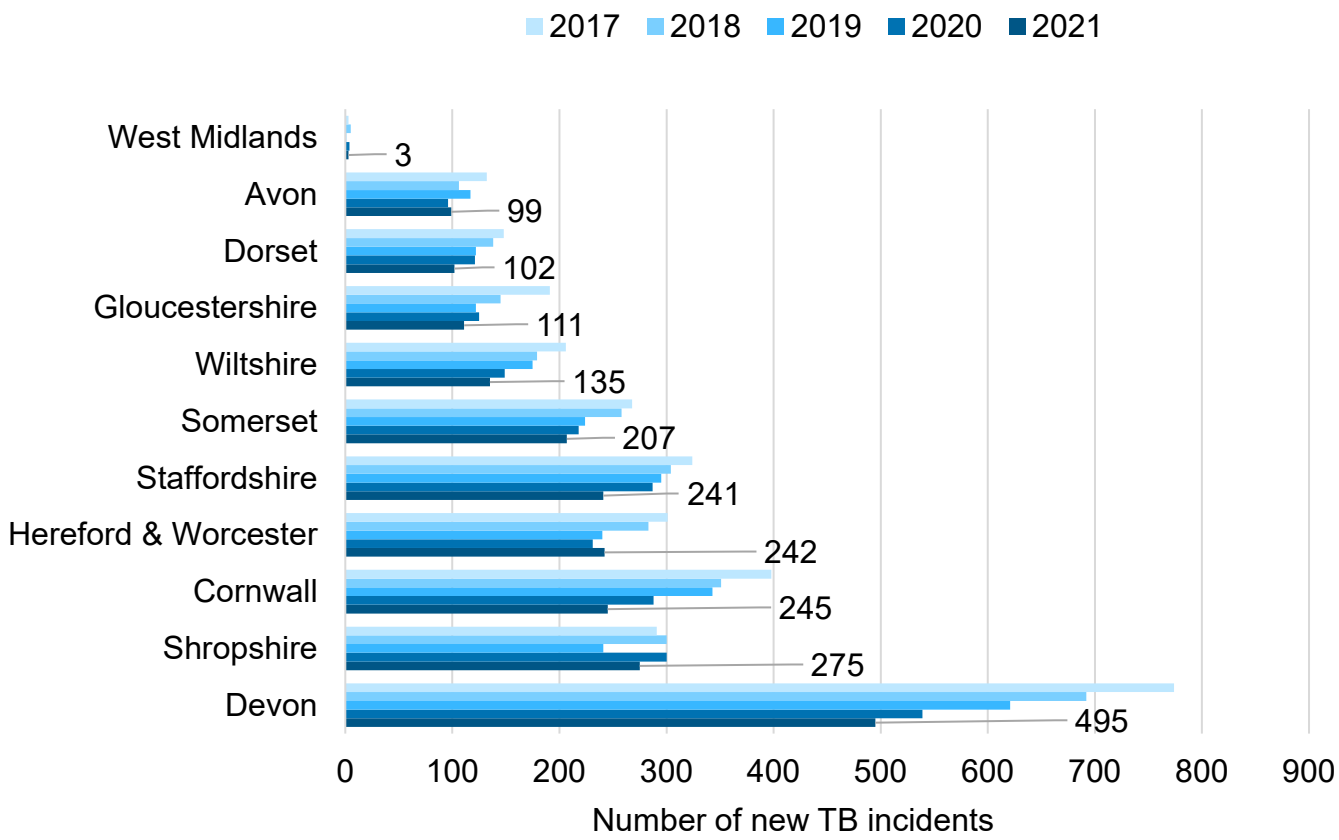


Figure 4.1.2 Annual total number of new TB incidents (OTF-W and OTF-S) by HRA county 2017 to 2021. Counties ranked by total TB incidents. Number of incidents in 2021 labelled on chart.

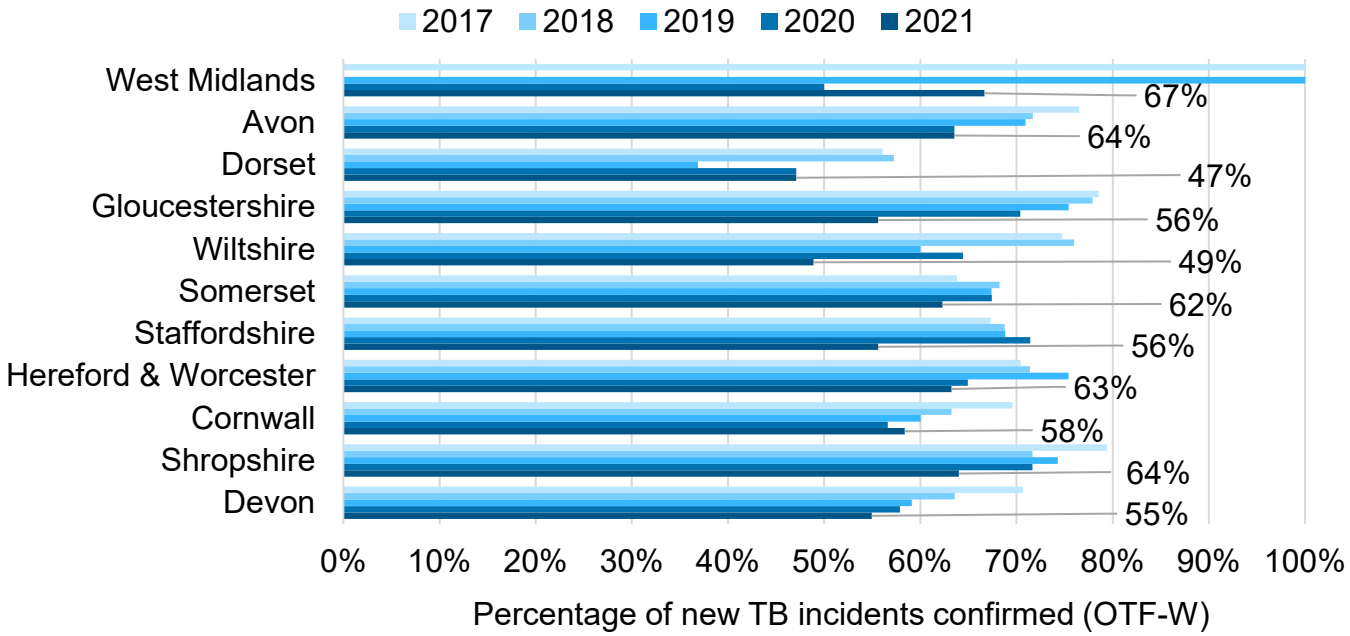


Figure 4.1.3 The percentage of new TB incidents confirmed (OTF-W) in HRA counties, 2017 to 2021. Counties ranked by total TB incidents in 2021. Percentage of OTF-W in 2021 labelled on chart.

County level TB incidence rate

The preferred measure of disease occurrence is incidents per 100 HYR, the rate at which new TB incidents are occurring in the population of herds at risk. Figure 4.1.4 ranks counties in the HRA by their incidence rate since 2017.

The TB incidence decreased from 2020 to 2021 in all but one of the HRA counties. A small non-significant increase in incidence was detected in Hereford and Worcester (p=0.062), as expected given the increase in the number of incidents in 2021.
The highest incidence rate in 2021 was observed in Avon, Shropshire and Hereford and Worcester (18.0, 17.9 and 17.8 TB incidents per 100 HYR, respectively). Notably, the highest incidence in 2021 (Avon, 18.0 TB incidents per 100 HYR) was lower than the highest incidence in 2020 (Shropshire, 20.9 TB incidents per 100 HYR).
Overall, the incidence rate in the HRA was the lowest it has been since at least 2013. (Figure 4.1.4).
Although incidence broadly decreased throughout the HRA, most county-level reductions in incidence were non-significant. Significant declines were seen in Staffordshire (25% reduction, p=0.001), Cornwall (17% reduction, p=0.03) and Devon (10% reduction, p<0.001). (Figure 4.1.4).

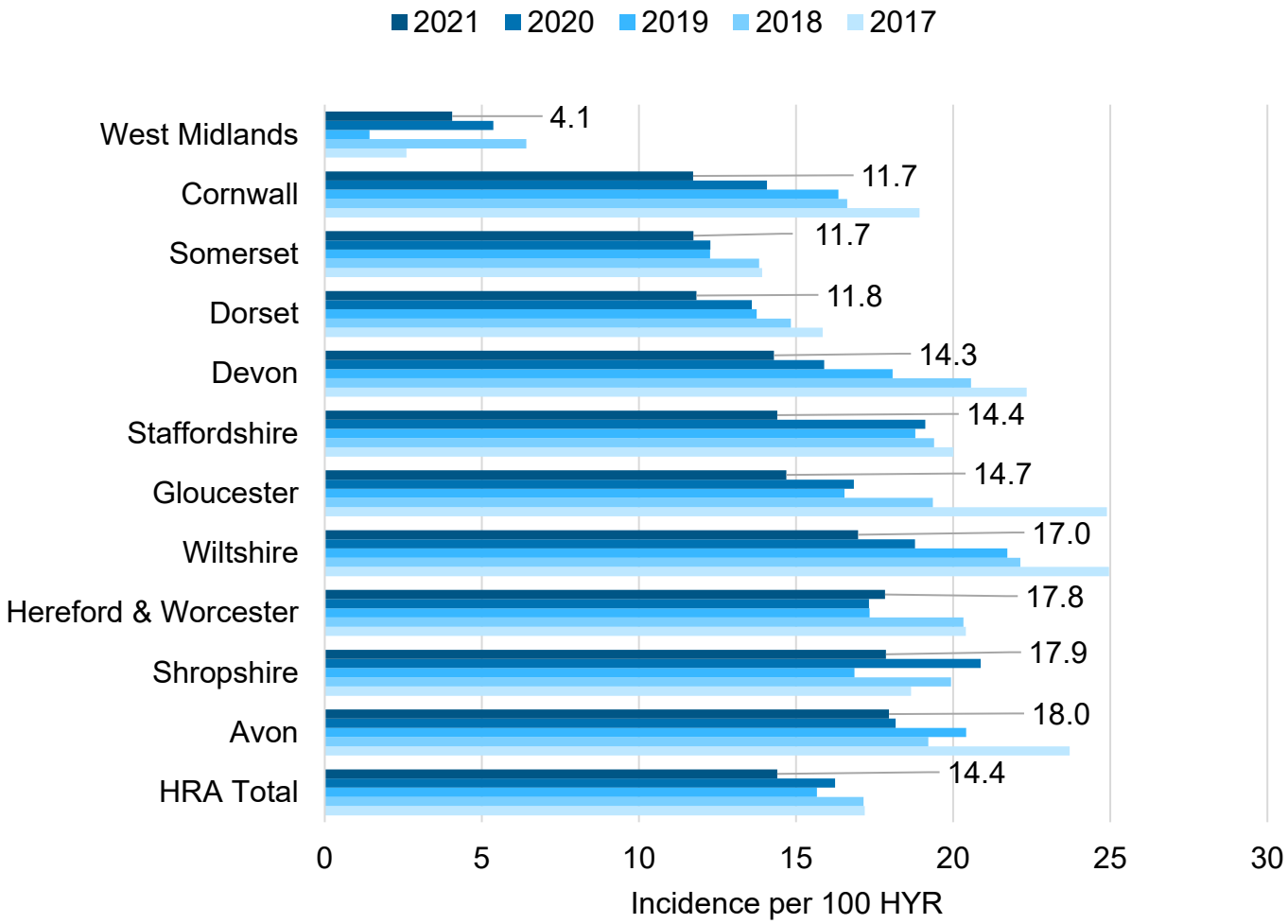


Figure 4.1.4 TB Incidence rate per 100 herd-years at risk from 2017-2 021, by HRA county. Counties ranked by incidence in 2021.

- The incidence rate fell broadly across the HRA in 2021 compared to 2020. The exception was in Hereford & Worcester, where a non-significant increase was observed during the period.
- Wiltshire, Devon, Cornwall, Somerset, and Avon have been showing a decreasing trend in incidence for the past three years or more.

County level end-of-year prevalence

End of year herd prevalence figures for 2021 are provided in Figure 4.1.5. Prevalence reflects the proportion of herds that are restricted due to TB at a given point in time, reported here at 31st December in each year. Prevalence values reflect variation in the incidence rate, the duration of TB incidents, and the timing of the start of the incident. Further notes on the methodology of incidence and prevalence measures are described in the Explanatory Supplement.

End of year herd prevalence dropped in the HRA overall (8.5% in 2021, 8.9% in 2020). An increase in prevalence relative to 2020 was seen in Avon (13%), Hereford & Worcester

(10%), Somerset (7%) and West Midlands (3%). However, most counties in the HRA experienced a decrease in prevalence between 2020 and 2021, which in some cases was sustained year-on-year since 2017(Fig 4.1.5).

As with incidence, Avon had the highest prevalence in 2020 (12.6%). The lowest prevalence in 2020 was seen in Dorset (7%) and the West Midlands (3%) (Figure 4.1.5).

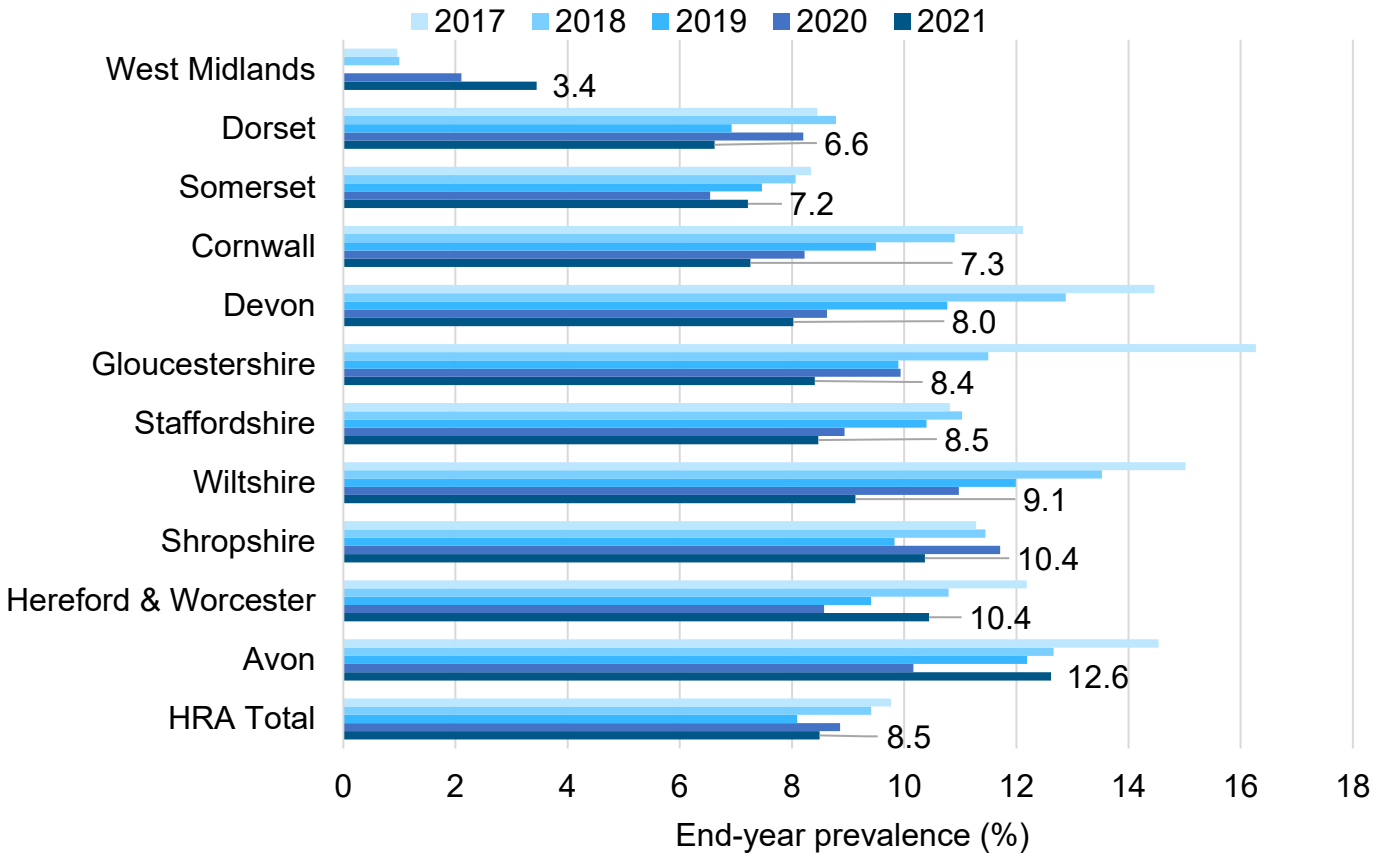


Figure 4.1.5 End of year prevalence from 2017-2021, by HRA county. Counties ranked by decreasing order of prevalence in 2021

Demographics and influence on TB

The risk of TB infection 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., 2016). The total number of cattle is a crude demographic measure, as the cattle distribution and management within herds can influence the risk of disease. Generally, the number of TB incidents increased with the number of cattle and number of cattle herds in a county, but there were exceptions (Figure 4.1.6, also see 3.2.1a and b, Chapter 3.2 Characteristics of herds found infected with TB).

Devon had 23% of all HRA TB incidents in 2021, as well as 23% of herds and 25% of all HRA cattle. Shropshire was the county with the second highest proportion, with 13% of all HRA TB incidents, but only 10% of herds and 10% of cattle (Figure 4.1.6).

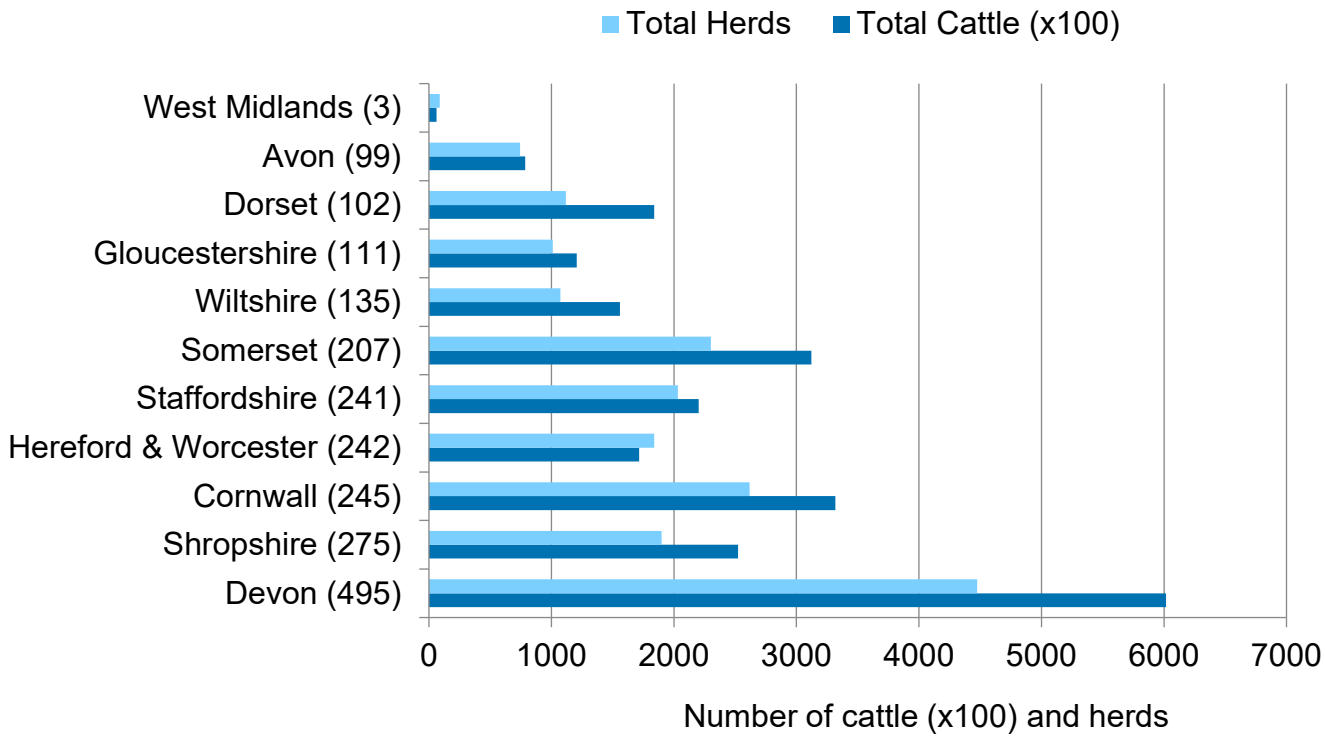


Figure 4.1.6 Total Number of cattle (x100) and herds in HRA counties in 2021. Counties ranked by new TB incident totals (in parenthesis next to county name).

- As expected, counties with larger numbers of cattle and herds, tended to have a greater number of TB incidents.
- Shropshire had more TB incidents than would be expected when considering the number of herds and cattle in the county. Cornwall and Somerset appear to have had fewer TB incidents than may have been expected.

Figure 4.1.7 shows the relative numbers of herds, and proportions of large herds in the different counties of the HRA in 2021, ranked by the proportion of large herds (>300 cattle). The proportion of large herds in 2021 is very similar to 2020. Although analyses confirm that larger herds are at higher risk of becoming infected, the presence of more large herds alone cannot explain the higher incidence rate in the HRA. Some HRA counties with a high proportion of large herds had a relatively low incidence rate; for

example, Dorset, had the highest proportion of large and very large herds, but was ranked 9th for incidence per 100 HYR in the HRA).

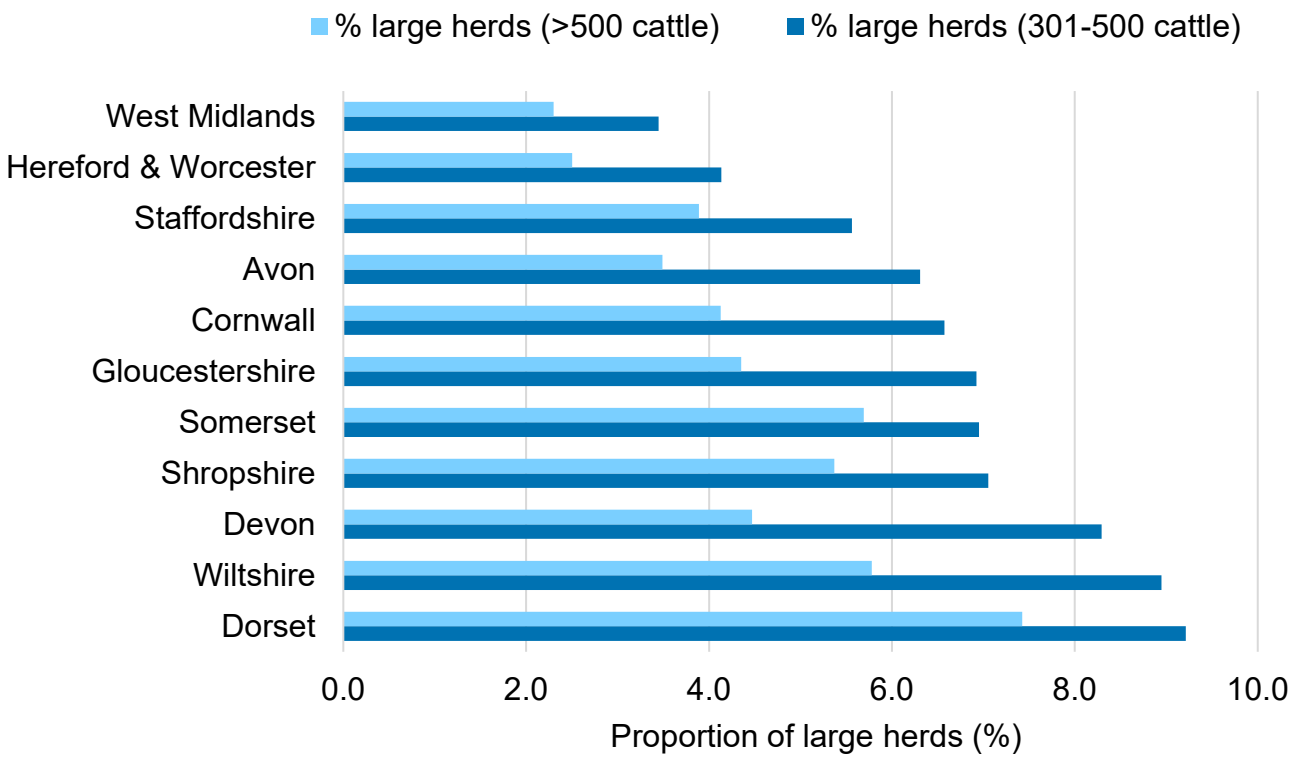


Figure 4.1.7 Percentage of large herds, by HRA county, in 2021. Counties ranked by herds with 301-500 animals

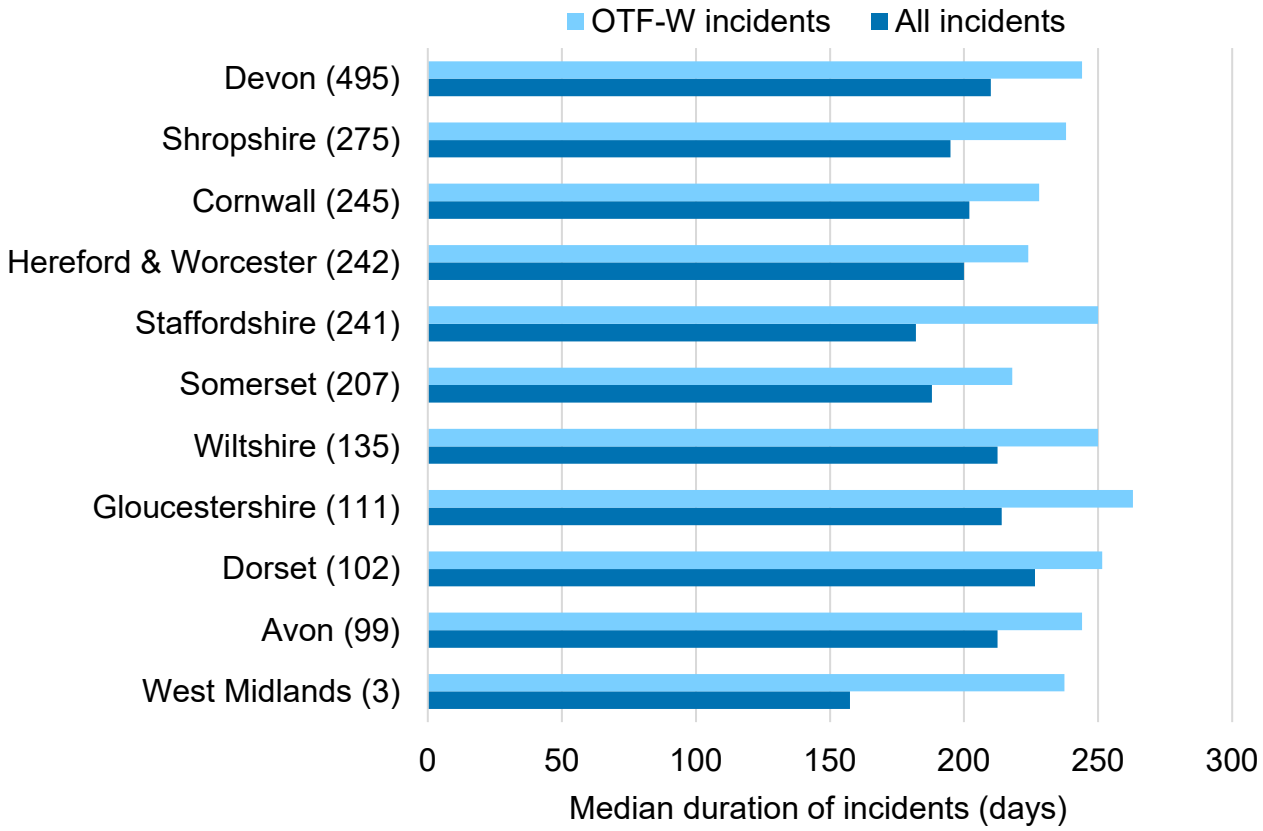
- Dorset had the highest proportion of herds with greater than 300 cattle (17%) followed by Wiltshire (15%).
- Hereford and Worcester (7%, 122 herds) and West Midlands (6%, 5 herds) had the lowest proportion of herds with over 300 animals.

TB incident duration and persistence

A total of 2,327 TB incidents ended in the HRA in 2021. Figure 4.1.8a shows the median duration of all those incidents, and OTF-W incidents only, by HRA county. Five of the 2,327 TB incidents involved finishing units (AFUs) and so were excluded from the median duration calculations presented in Figure 4.1.8a due to the unique testing regimes operating in AFUs. In 2021, the median incident duration was just over 200 days for all counties in the HRA. The longest median duration for all TB incidents was Dorset (226.5 days), followed by Gloucestershire (214 days), Avon and Wiltshire (212.5 days each) (Figure 4.1.8a).

The median duration of confirmed (OTF-W) incidents was longer than the median for all TB incidents, across all HRA counties (Figure 4.1.8a). One possible factor contributing to

this was the compulsory interferon-gamma (IFN-γ) testing policy that was in force for OTF-W herds in badger control areas of the HRA during much of 2021 and may have delayed the return to OTF herd status following the detection of additional positive test animals.



- Figure 4.1.8a Median duration (days) of incidents that ended in 2021, for all incidents and OTF-W incidents, by HRA county. **Counties ranked by the duration of all TB incidents (number of incidents in parenthesis)**In all counties, duration of herds under movement restrictions was higher in lesion or culture-positive (OTF-W) TB incidents compared to total TB incidents.
- Median duration was highest in Dorset (226.5 days for all TB incidents)

Figure 4.1.8b shows the median duration of all TB incidents (including finishing units) that closed in each year from 2017 to 2021. For many counties, duration has varied around 200 days over the time period, as in 2020. The difference in median duration between counties was not significant in 2021 (p=0.312; K sample equality-of-medians test). Dorset was the only county to rank in the top three for median duration every year since 2016. This may be due to the high proportion of large and very large herds in the county (>300 animals) (Figure 4.1.7).

Overall, most counties saw an increase in median duration between 2020 and 2021. Gloucestershire, Avon, and Hereford & Worcester all had an increase in median duration of 15 days or more over the last three consecutive years.

Shropshire, Staffordshire, Somerset, and the West Midlands saw a fall in median duration over the same period. This was only two and four days respectively for Shropshire/Staffordshire, but represented a drop of 10 and 30.5 days for Somerset and the West Midlands. (Figure 4.1.8b).

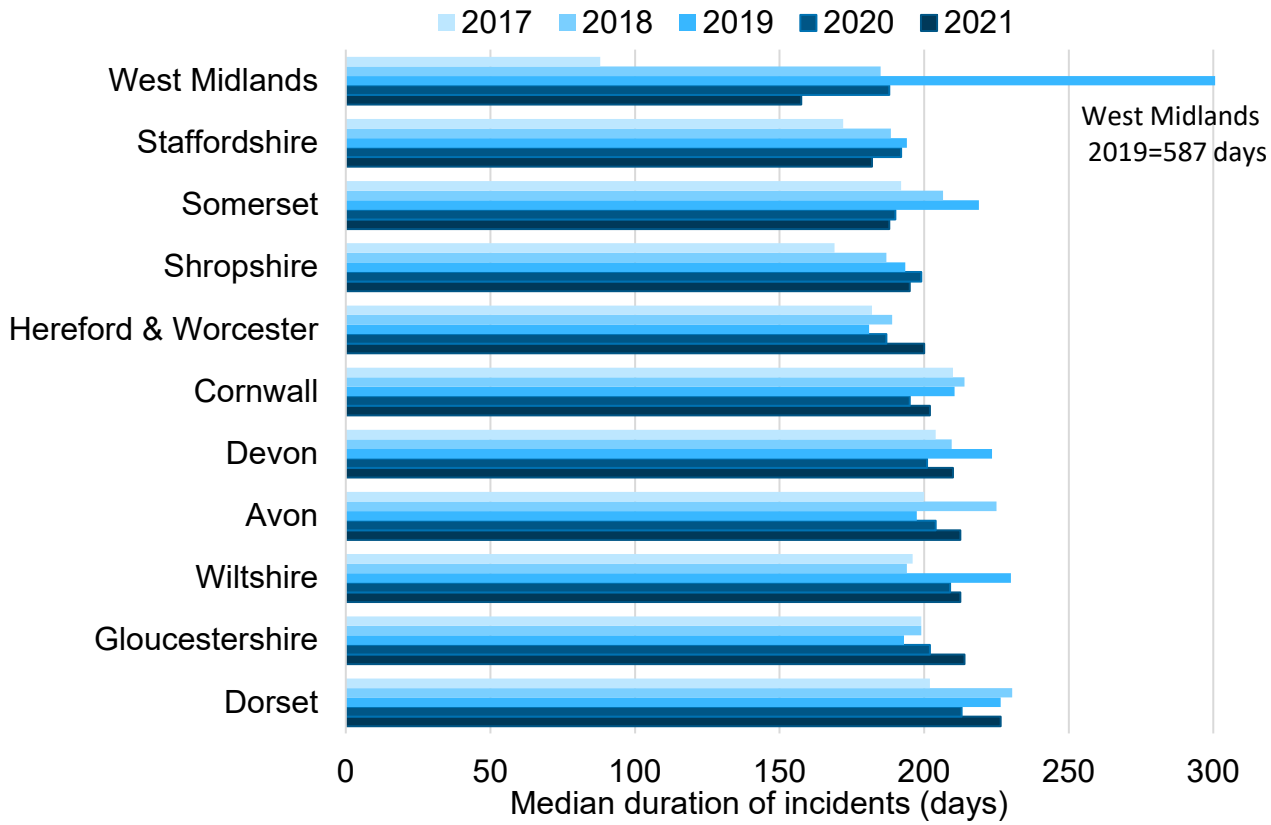


Figure 4.1.8b Median duration (days) of all incidents that ended in each year between 2017 and 2021, by HRA county. Counties ranked by 2021 duration.

- The high median duration in the West Midlands in 2019 was due to only two incidents in that year, one of which was persistent (>550 days).

Incidents lasting for more than 550 days are deemed to be persistent and affected herds are eligible for enhanced management procedures (Figure 4.1.9). During 2021, 128 persistent incidents were resolved in the HRA, however 129 were still ongoing at the end of the year.

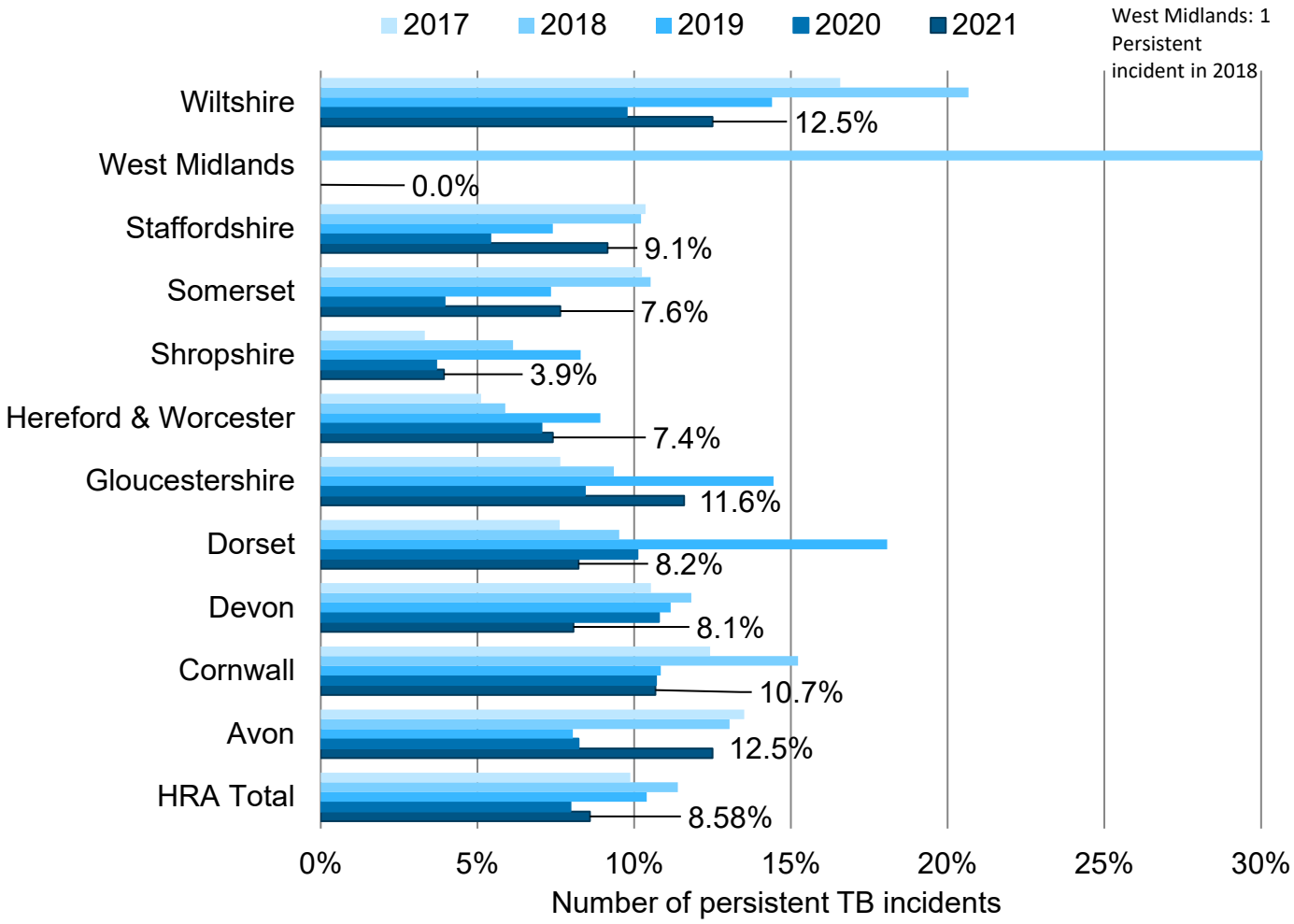


Figure 4.1.9 Percentage of persistent TB incidents (duration over 550 days) that were still ongoing at the end of 2021, from of all incidents in the HRA.

- The proportion of persistent incidents was highest in Avon, Wiltshire Gloucestershire and Cornwall.
- Overall, most counties saw an increase in the proportion of persistent incidents in 2021 compared to 2020. The exceptions were Devon and Dorset.

Recurrence of TB infection

In 2021, 56% of TB incidents in the HRA occurred in herds that had experienced at least one TB incident in the previous three years. This proportion was the lowest observed in the HRA since 2016 (59%) and followed a decreasing trend over the past six consecutive years, although it was still higher than in the Edge Area (44%) and LRA (10%). Within the HRA, recurrence was highest in Avon (66%), Devon (61%) and Staffordshire (60%), and lowest in West Midlands (33%, 1 of 3 incidents), Somerset and Dorset (47% each) (Figure 4.1.10).

Most (six out of eleven) counties in the HRA saw a decrease in the proportion of recurrent TB incidents in 2021 relative to 2020; the exceptions were Avon, Devon, Shropshire, Staffordshire, and the West Midlands, which experienced increases (Fig 4.1.10).

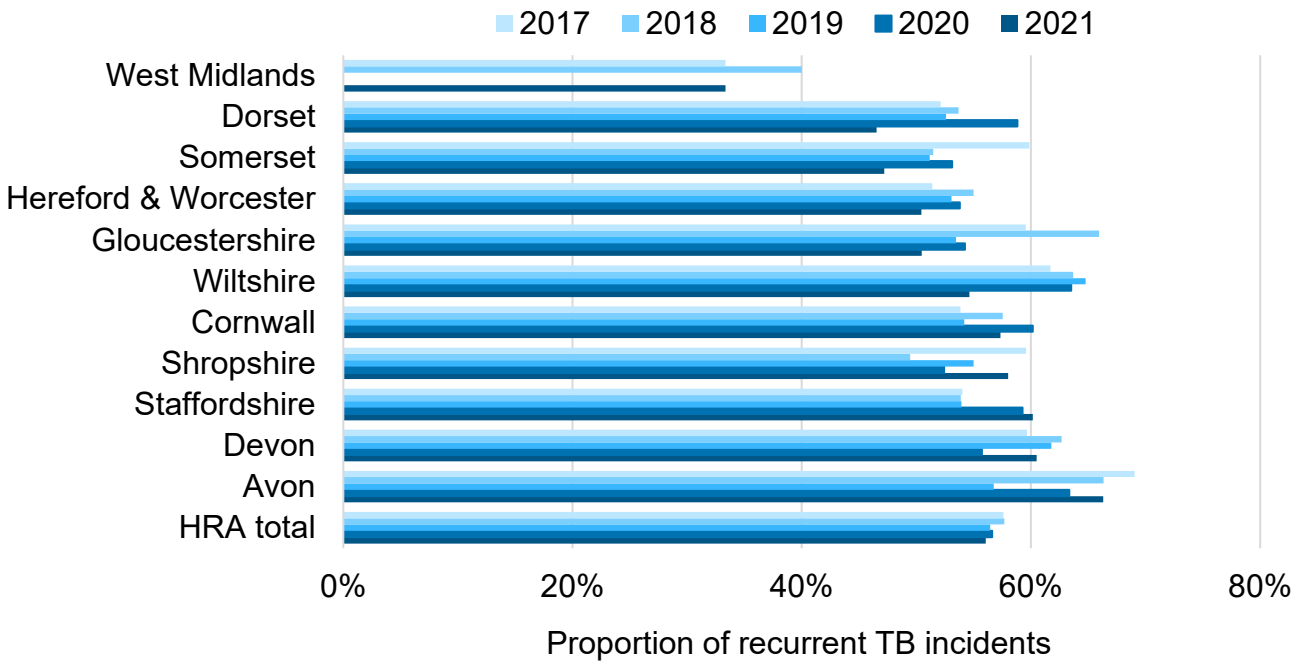


Figure 4.1.10 Annual proportion of TB incidents in herds that had experienced any TB incident in the previous three years, by HRA county (2017 to 2021). Counties ranked by decreasing recurrence in 2021.

The high positive predictive value of the skin test in the HRA, together with the need to intensify the efforts to tackle disease in this area and reduce recurrence, has led to additional cattle controls. These include the application of two successive short interval tests (SITs) at severe interpretation at the beginning of any new incident in the HRA irrespective of post-mortem results. This, along with the increased use of the IFN-γ blood test in the HRA since April 2017, should help reduce recurrence due to residual cattle infection and may also reduce the severity of incidents. Other measures implemented in the HRA that may have helped reduce incident recurrence include the provision of bespoke farm biosecurity advice and control of the reservoir of infection in badgers.

TB surveillance and incident detection

A detailed description of the test types included in each of the four TB surveillance streams explored in this chapter can be found in Chapter 3.3 (Finding Infected Herds). Figure 4.1.11 shows the proportion of TB infected herds disclosed by each surveillance stream and county. In the HRA overall, the highest proportion of TB incidents were disclosed by Routine tests (43%). This was the leading disclosing surveillance type in most counties, however in Avon, Cornwall, Devon, and Wiltshire more incidents were detected through Area and Herd Risk testing. In Shropshire and Staffordshire (where the routine testing

interval for most cattle herds was reduced from 12 to six months from January 2021), and in the West Midlands, routine tests disclosed over half of all incidents.

Overall, Area and Herd Risk surveillance tests disclosed the second highest proportion of TB incidents in the HRA (38%), with the highest proportion of incidents disclosed in Wiltshire (50%), followed by Devon (43%). Trade and other surveillance tests led to the fewest detections of TB in the HRA in 2021 (7%), with Hereford & Worcester finding the highest proportion of incidents (10%) (Figure 4.1.11).

Overall, source tracing herd tests were the most efficient tests at detecting incidents within the HRA in 2021 (20 incidents per 100 herd tests). This was second to post-incident tests, carried out at approximately six and 18 months after restoration of an OTF herd status, which disclosed 17 TB incidents per 100 herds tested in 2021 (Table 3.3.3.a, Chapter 3.3 Finding Infected herds).

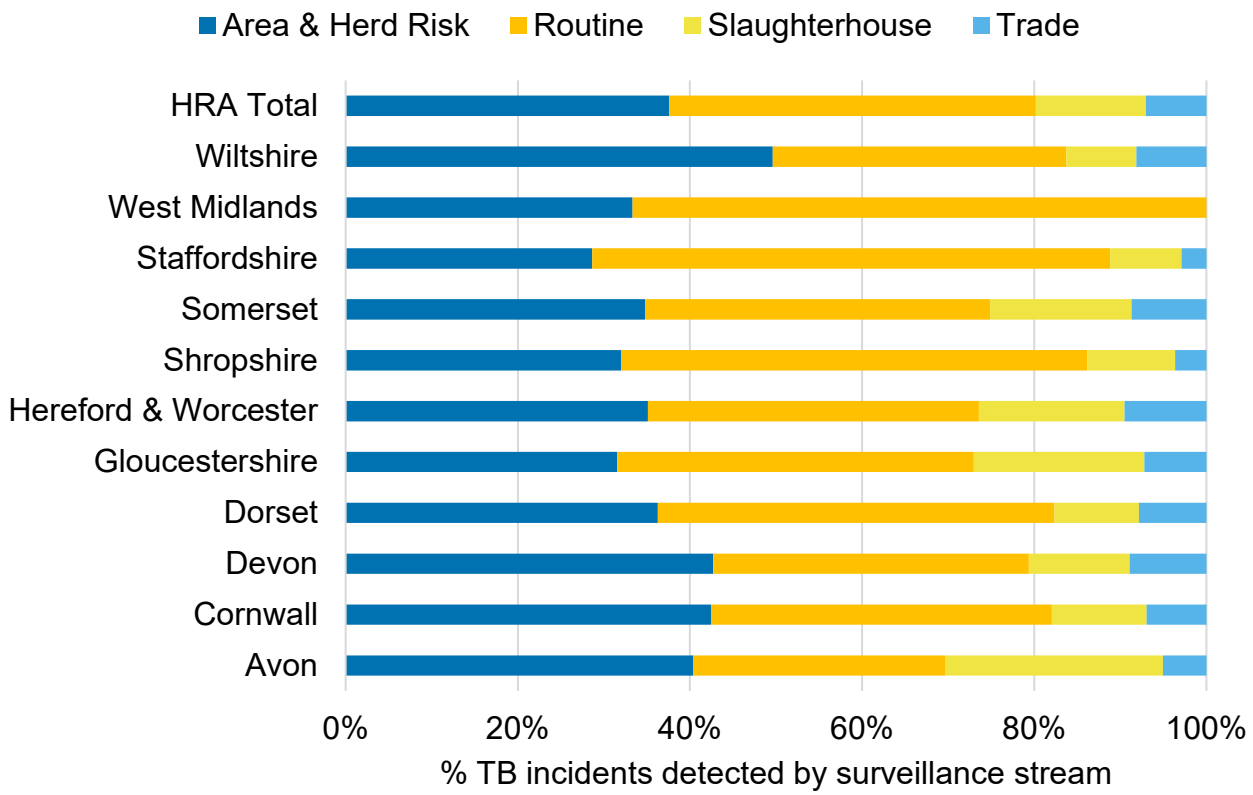


Figure 4.1.11 Percentage of TB infected herds in 2021 in each surveillance stream, by HRA county.

In the HRA overall, 13% of all TB incidents and 21% of OTF-W incidents were disclosed through routine post-mortem meat inspection of cattle in slaughterhouses in 2021, as was seen in 2020. Variation between counties can be seen in Figure 4.1.12. Avon (35%), Gloucestershire (29%), Hereford & Worcester (27%) and Somerset (26%) had the highest proportion of OTF-W incidents disclosed by SLH surveillance in 2021. The lowest rates of

OTF-W detection by SLH surveillance were reported in West Midlands (0% of 2 incidents) and Wiltshire (14%), which is expected given the low incidence in these regions.

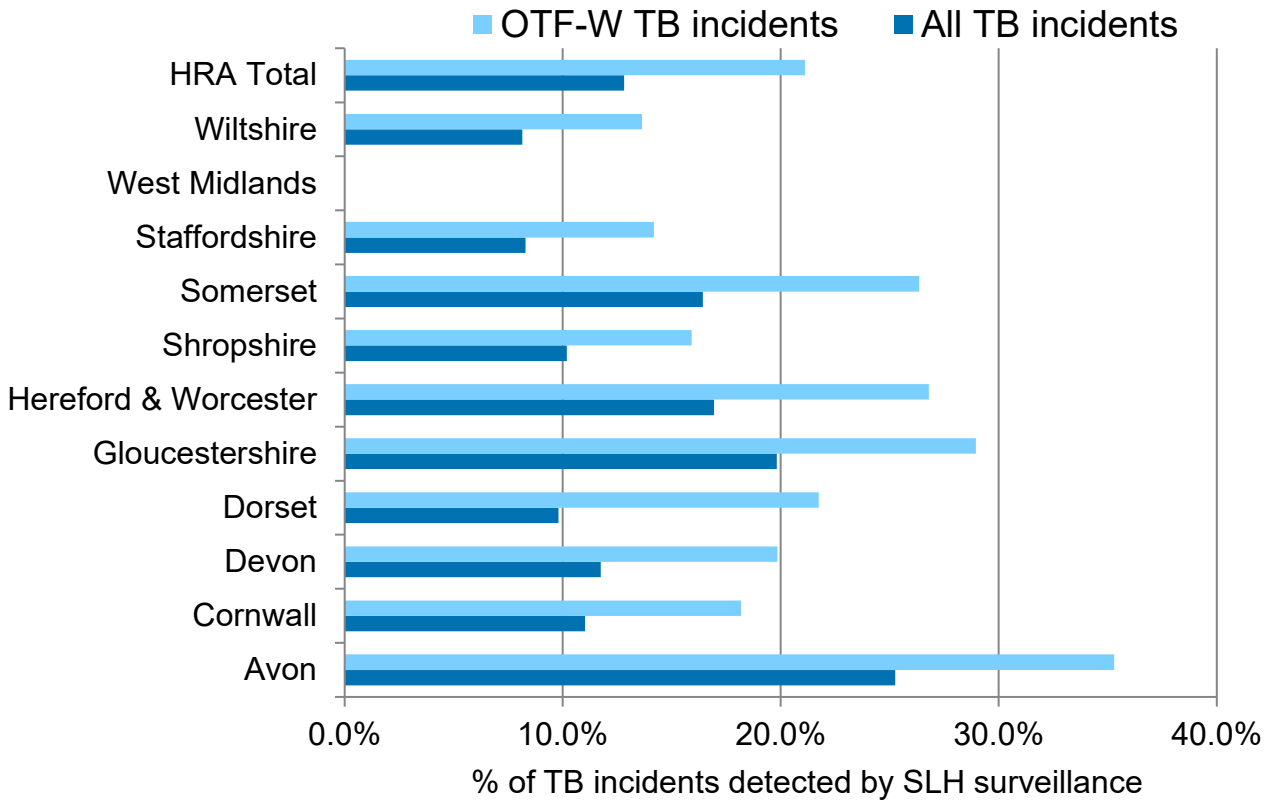


Figure 4.1.12 Percentage of TB incidents disclosed by slaughterhouse surveillance (post-mortem meat inspection) in 2021, for all TB incidents and OTF-W incidents, by HRA county.

Number of reactors removed

Overall, 20,735 cattle were slaughtered for TB control purposes in the HRA in 2021. These comprised 12,258 skin (SICCT) test reactors, 8,437 IFN-γ blood test positive animals and 40 antibody test positives. The total number of animals removed, and the proportion that were detected by IFN-γ testing, varied by county. Most cattle were removed from herds in Devon (5,506 animals), where 50% of reactors were detected by IFN-γ testing. The increase in the number of IFN-γ tests in the HRA can be explained by the increase in the number of badger control program areas in which IFN-γ was applied, prior to the introduction of new IFN-γ test eligibility criteria in July 2021.

In 2021, Somerset had the highest proportion of reactors detected by IFN-γ testing (56%),

followed by Gloucestershire (52%), and Devon (50%) (Figure 4.1.13).
No IFN-γ test positives were detected in the West Midlands in 2021.

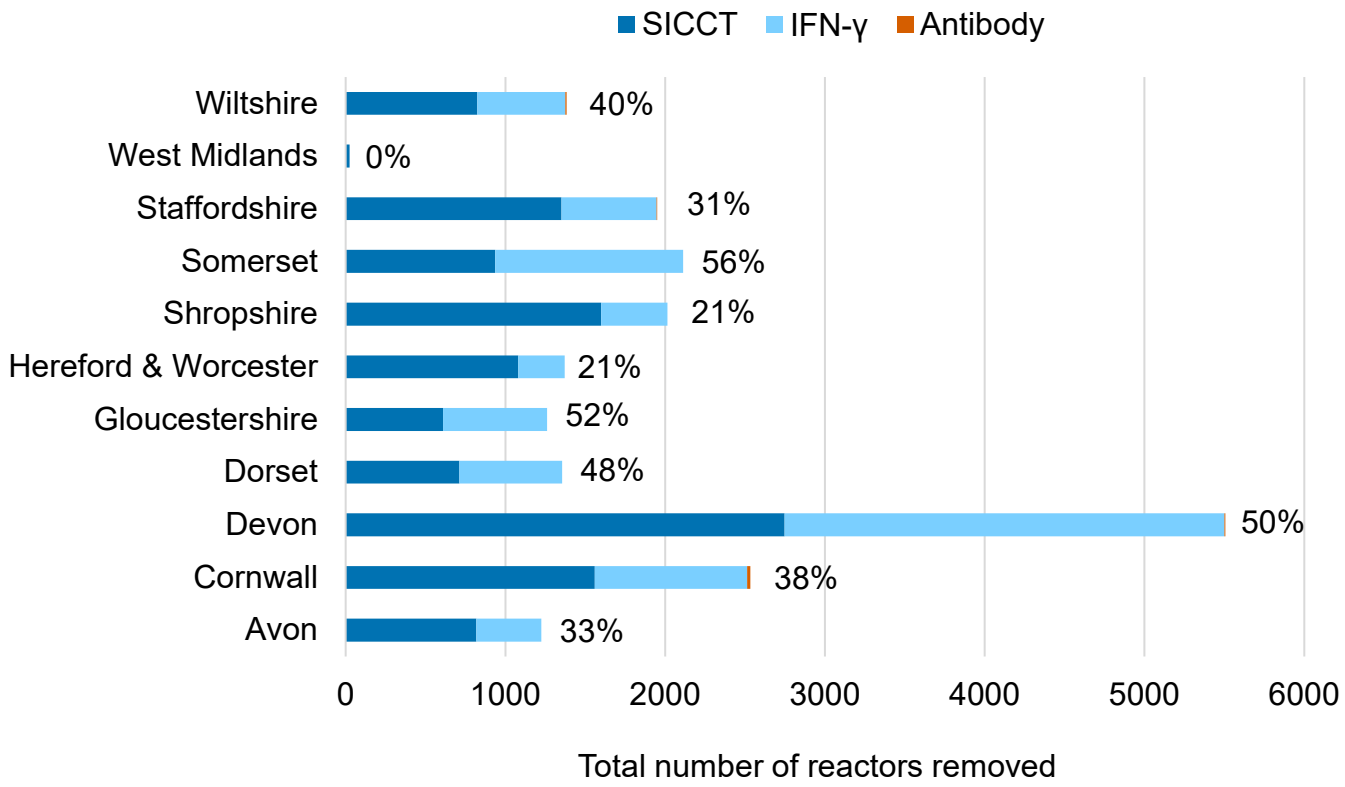


Figure 4.1.13 Number of reactors removed in 2021 due to SICCT, IFN-γ and antibody testing, by HRA county. Proportion of reactors removed due to IFN-γ testing above bars.

Use of the IFN-γ test in the HRA

As of July 2021, IFN-γ testing policy in the HRA was changed to be applied to any new breakdowns (incidents) with lesion and/or culture positive animals which meet the following criteria:

(1) *The breakdown occurred within 18 months of the herd regaining OTF status following a previous breakdown with OTF-W animals, or*
(2) *Are a c*hronic or persistent breakdowns with lesion and/or culture positive animals.

As previously, additional deployment of the IFN-γ blood test took place at APHA's discretion. This included the application of a flexible extended version of IFN-γ in cases, where co-infection with *Mycobacterium avium* subspecies *paratuberculosis* (Johne's disease) infection was suspected to interfere with the detection of *M. bovis*-infected animals.

The total number of IFN-γ tests carried out in the HRA has increased rapidly in recent years. In 2016 just under 6,000 tests were performed. In 2017 this rose to 19,000 IFN-γ

tests, increasing fourfold to 80,000 in 2018. In 2021, 144,621 animals received an IFN-γ test in the HRA, with 6% identified as positive. Although this is a 12% increase on the number of HRA IFN-γ tests performed in 2020 (128,858), the rise is smaller than expected based on the number of eligible herds.

As in previous years, the proportion of animals testing positive to the IFN-γ test varied by HRA county: from 4% in Staffordshire, to 10% in Avon. Most tests were conducted in Devon (32%), an 18% increase from 2020. In Avon, the number of tests conducted increased almost twenty times between 2020 and 2021 (N=232 in 2020 vs N=4,153 in 2021) and quadrupled between 2021 and 2019 (N=1,937 in 2019). This increase in the past two years is most likely due to the change in eligibility for IFN-γ testing criteria. A decrease in the number of tests performed was seen in Cornwall, Dorset, and Wiltshire (Figure 4.1.14).

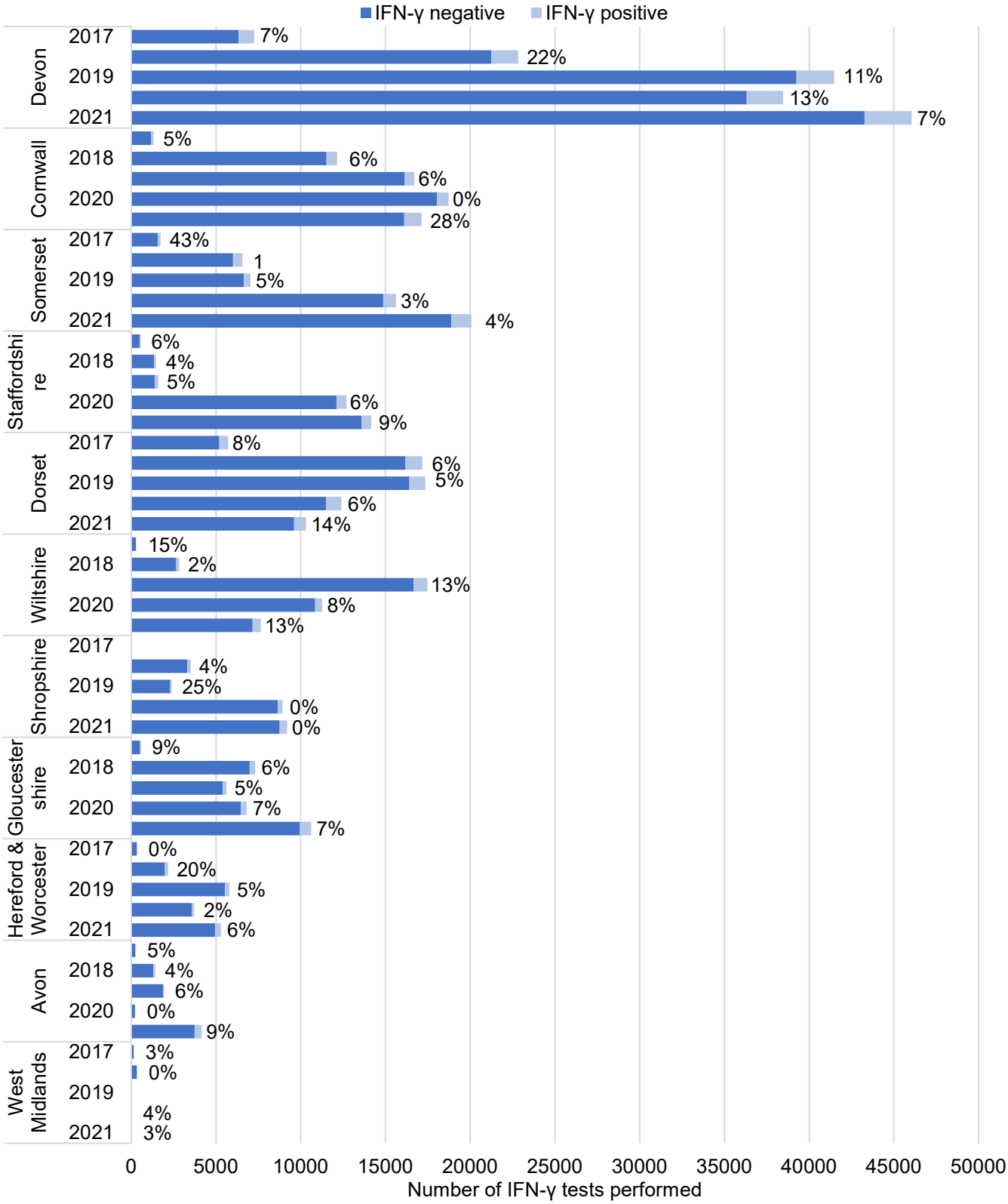


Figure 4.1.14 Number of IFN-γ tests performed in HRA counties, 2017-2021. The percentage of tests with a positive result are labelled on the chart. Note y axis scale is different between charts.

Sources of infection

In the HRA, one third of all new TB incidents are randomly selected are investigated to assess the hazard (source of infection) and risk pathway for TB infection within the herd. Up to three potential sources may be identified during the investigation, and these are weighted by the veterinarian's certainty about the source based on the available evidence. More details on the methodology for identifying and weighting sources of infection can be found in Chapter 3.2 Characteristics of herds found infected with TB and the Explanatory Supplement.

In 2021, 848 new TB incidents (39.4 % of the total number of new TB incidents in the region) were selected for an investigation in the HRA. Based on this sample, badgers were identified as the predominant source of infection in the HRA, accounting for a weighted contribution of 52% to the likely sources of breakdowns, after accounting for the inevitable uncertainty in this type of investigation. Badgers were also the most commonly identified source in all but one of the HRA counties, ranging from 100% of the weighted source in the West Midlands (one investigation) and 76% in Cornwall (116 investigations), to 34% in Wiltshire (51 investigations). In Somerset, badgers were identified as the second most likely source of infection – most incidents were attributed to an unknown source (38%). Unknown sources and cattle movements were identified as the predominant source of infection for 16% and 12% of incidents in the HRA. Cattle movements were the second most likely source of infection after Badger movements in new incidents in Devonshire (12%), Shropshire (11%), and Staffordshire (17%).

4.2 Epidemiology of TB in the Edge Area

- This chapter summarises key findings from the Edge Area Year End Descriptive Epidemiology Reports.
- Six-monthly routine herd surveillance testing was in operation in the endemic area of the Edge Area in 2021, although individual herds at lower risk of infection were eligible for annual testing under the Earned Recognition Scheme. In the remainder of the Edge Area, annual routine testing was complemented by compulsory radial testing for herds located within 3km of any OTF-W incident. The number of new TB incidents disclosed in the Edge Area in 2021 (n=573) decreased by 14.7% compared to 2020 (n=672), with the highest proportional decrease seen in Hampshire (43%) and East Sussex (34%). Decreases were seen in eight of 11 Edge Area counties, with increases in Berkshire, Buckinghamshire, and Nottinghamshire. In 2021, the greatest number of incidents were detected in Cheshire (n=141), the least in Berkshire (n=19).
- Overall, there was a statistically significant decrease in TB incidence per 100 herd years at risk (HYR) in the Edge Area in 2021 compared to 2020 (8.9 TB incidents per 100 HYR in 2021, 10.1 in 2020, p=0.026). Additionally, incidence per 100 unrestricted herds tested decreased in 2021 compared to 2020.
- The end-of-year herd prevalence in the Edge Area decreased in 2021 (4.5%) compared to 2020 (5.7%). A decrease was seen in most of the counties, except for Berkshire and Nottinghamshire.
- The average duration of TB incidents varied between counties. The longest average TB incidents (that ended in 2021) were in Oxfordshire, Buckinghamshire, and Hampshire, lasting around eight months.
- Forty-six percent of new TB incidents in the Edge Area in 2021 occurred in herds that had experienced at least one TB incident in the previous three years (recurrent breakdowns). Recurrence was highest in Berkshire (67%), Oxfordshire (67%) and Cheshire (57%).
- The sources of infection for herds with TB incidents varied between counties. Badgers were identified as the primary weighted source of TB infection in eight Edge Area counties, most prominently in Northamptonshire (69%), Cheshire (66%), Derbyshire (56%), Oxfordshire (56%) and Warwickshire (50%). Cattle movements were identified as the primary weighted source in Hampshire (47%) and Buckinghamshire (41%).
- New areas of endemic infection and new clusters are emerging in several counties in the Edge Area.

Geographical coverage of the Edge Area

The Edge Area forms a buffer separating the HRA of England to the south and west from the LRA of England to the north and east (Figure 4.2.1). In 2018, the Edge Area was expanded westward to fully include five counties that were previously split between the

HRA and Edge Area (Cheshire, Derbyshire, East Sussex, Oxfordshire and Warwickshire). Data reported in this chapter is for the 11 full counties that make up the Edge Area from 2018 onwards. TB trends over time compare TB incidents in the fully post-2018 Edge Area counties.

Six-monthly routine herd surveillance testing remained in operation in 2021 in the endemic area of the Edge Area adjoining the HRA after being introduced in January 2018 (Figure 4.2.1), following the reclassification of the HRA and Edge Area boundaries. From May 2019, some herds in the Edge Area with six-monthly surveillance testing could be eligible for annual testing, under the Earned Recognition Scheme if specific criteria are met. Herds must either have been in existence for at least six years and have not had a TB breakdown in the six year period (a single break from keeping cattle of less than four months is permitted), or be registered to a bovine TB health scheme accredited under the Cattle Health Certification Standards (CHECS) at level 1 or above. In the remainder of the Edge Area, compulsory radial testing for herds located within 3km of any OTF-W incident complemented routine annual testing.

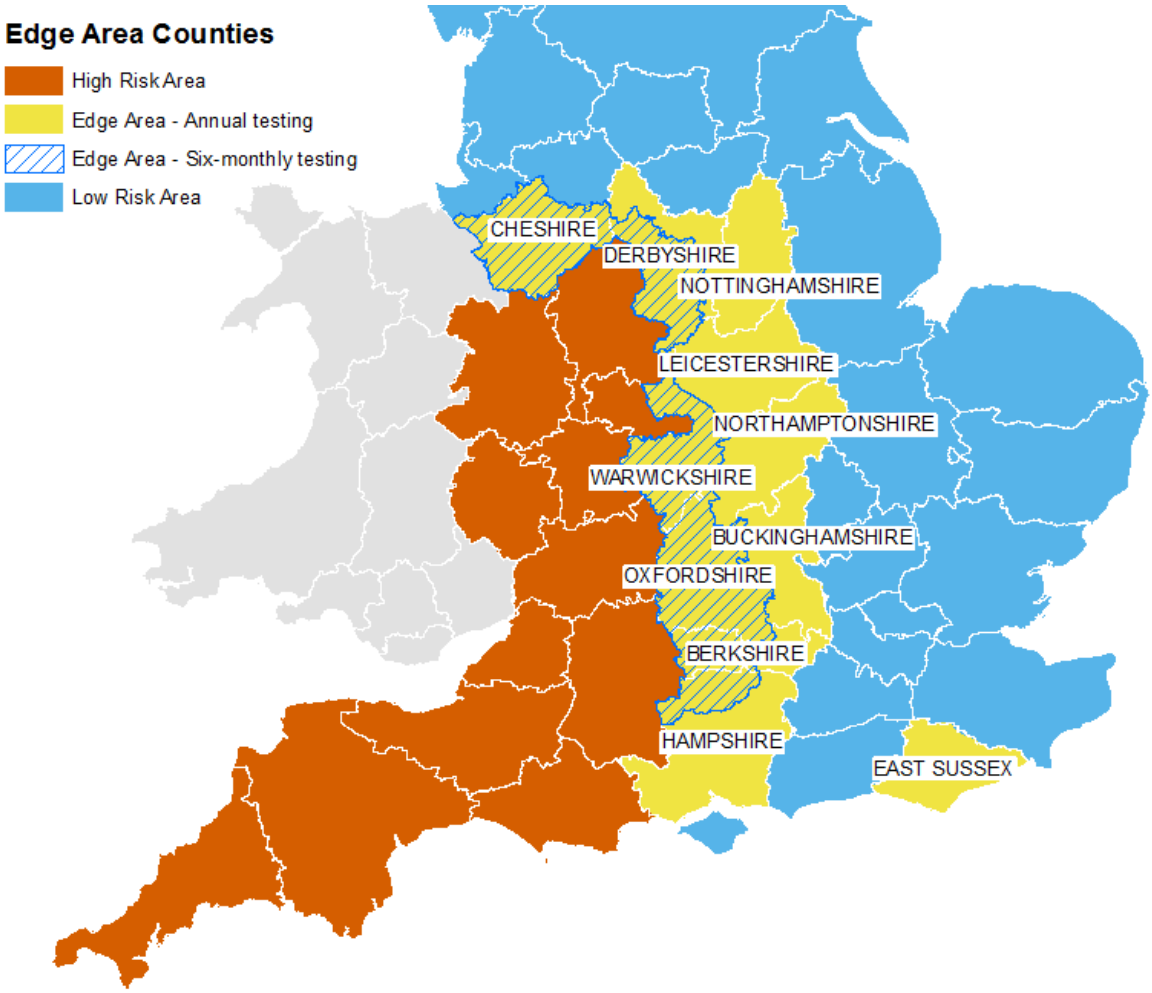


Figure 4.2.1 Edge Area county map, showing the areas under six-monthly routine herd testing

County level number of new TB incidents

The number of new TB incidents decreased in the Edge Area overall in 2021 (n=573) compared to 2020 (n=672). The total number of new TB incidents increased in just three of the 11 counties in 2021: Berkshire, Buckinghamshire and Nottinghamshire. In Berkshire and Buckinghamshire, the increase was due to OTF-S TB incidents (5 and 10 compared to 8 and 20, respectively). In Nottinghamshire the increase was due to OTF-W incidents (21 incidents, of which 11 were OTF-W in 2021, compared to 13 incidents with five OTF-W in 2020) (Figure 4.2.2). There was a decrease in the number of OTF-W incidents across all counties excluding Nottinghamshire.

The number of new incidents was highly variable between counties. The highest number of new incidents were disclosed in Cheshire, Derbyshire, Oxfordshire and Warwickshire. Historically counties adjacent to the HRA disclosed the highest number of new incidents. Notably, an almost 50% increase in incidents is observed in Nottinghamshire in 2021 (average of 14 incidents in the past four years up to 21 in 2021).

Six-monthly routine herd testing is carried out in either part, or the whole of the four counties with the highest number of new TB incidents, in addition to Berkshire and Hampshire (Figure 4.2.1). Despite Berkshire seeing an 18.8% increase in its total number of incidents in 2021, the county disclosed the lowest number of new TB incidents (Figure 4.2.2).

The percentage of new TB incidents that were OTF-W (i.e. those involving at least one test reactor with visible lesions of TB and/or a culture positive animal) in each county between 2017 and 2021 is shown in Figure 4.2.3. In 2021, the percentage of OTF-W incidents was highest in Berkshire (58%) and lowest in East Sussex (15%). The percentage OTF-W herd incidents has decreased over four consecutive years in Oxfordshire, from 75% in 2017 to 56% in 2021. Similarly, this percentage has decreased for three consecutive years in Cheshire, from 68% in 2018 to 51% in 2021. In Nottinghamshire and Northamptonshire, the percentage of OTF-W incidents increased over two consecutive years, from 2019 to 2021. A large decrease was seen in 2021 compared to 2020 for both Buckinghamshire and Leicestershire (52% and 50% in 2020 respectively, to 26% in 2021 for both counties, Figure 4.2.3).

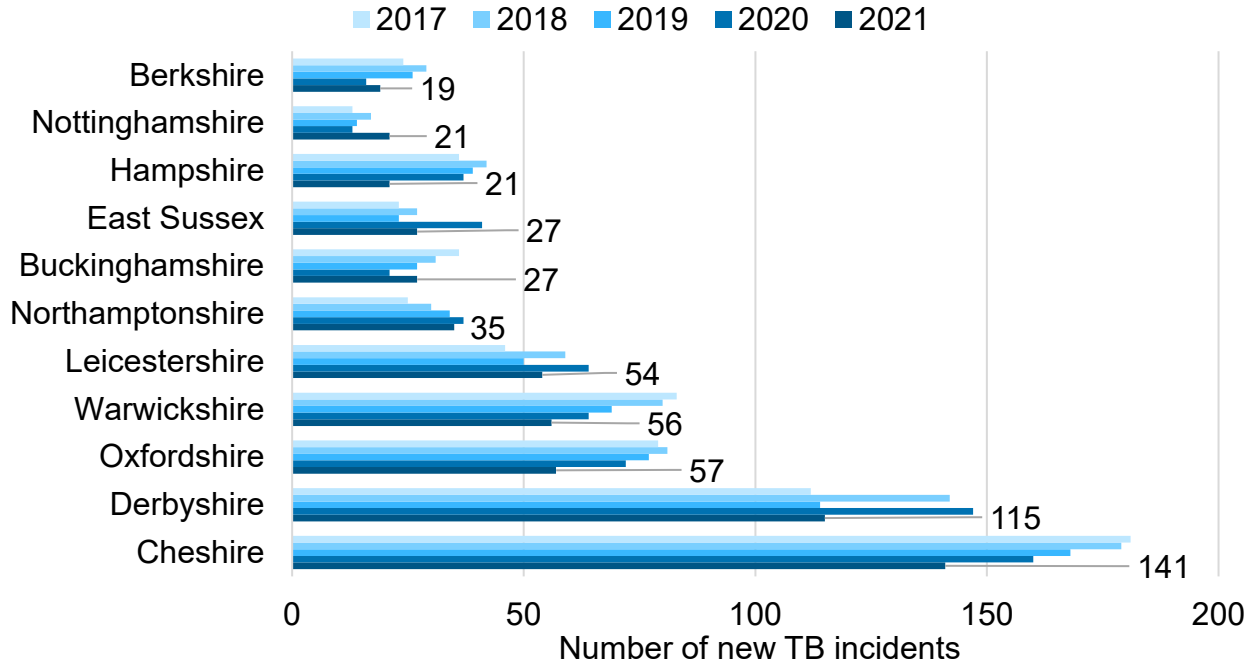


Figure 4.2.2 Annual total number of new TB incidents (OTF-W and OTF-S) by Edge Area county 2017 to 2021. 2021 incidents labelled on chart.

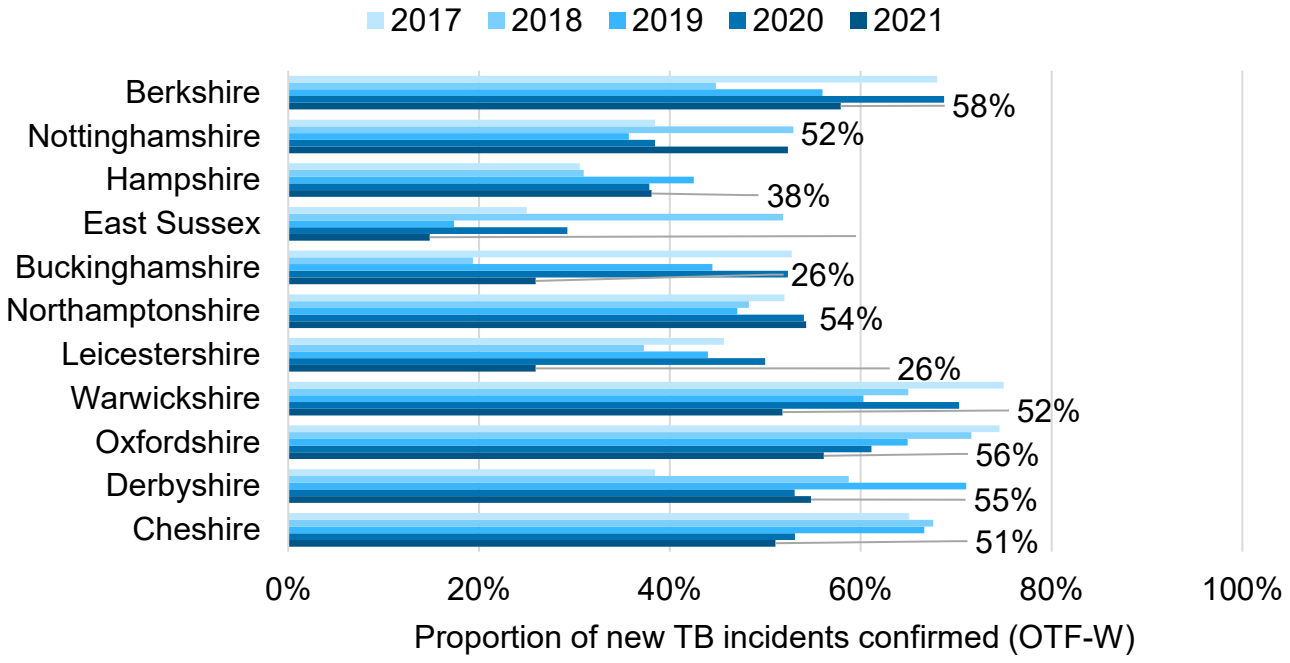


Figure 4.2.3 The percentage of new TB incidents with OTF-W status in Edge Area counties, 2017 to 2021. Counties ranked by total new TB incidents in 2021. Percentage of OTF-W incidents in 2021 labelled on chart.

County-level TB herd incidence rate

There was a statistically significant decrease in the TB herd incidence rate in the Edge Area in 2021 compared to 2020 (8.9 TB incidents per 100 HYR in 2021, down from 10.1 in 2020, p=0.026).

At the county level, incidence per 100 HYR increased in three counties (again, Berkshire, Buckinghamshire and Nottinghamshire) and decreased in eight. Changes in incidence per 100 HYR in 2021 compared to 2020 were non-significant for all Edge Area counties. Most incidents were in herds in the former HRA part of the Edge Area, where TB is endemic and there is a higher density of cattle. Measures of incidence presented here include all incidents (OTF-W and OTF-S). They may differ from those published in the Year End Descriptive Epidemiology reports, which exclude TB incidents in non-grazing Approved Finishing Units.

As in previous years, there was variation in the burden of TB across the Edge Area in 2021. Incidence ranged from 16.0 incidents per 100 HYR in Oxfordshire, down to 3.3 in Hampshire (Figure 4.2.4). Of note, the incidence rate reported in Oxfordshire is higher that the incidence per 100 herd years at risk reported in seven of the 11 HRA areas, ranking as the fifth highest county in England for this metric in 2021 (Figure 4.1.4, Chapter 4.1 Epidemiology of TB in the High Risk Area). The decrease in incidence per 100 HYR in Oxfordshire in 2021 from 2020 was non-significant (p=0.2432). For Warwickshire and Berkshire the incidence rate reported was higher than four HRA areas.

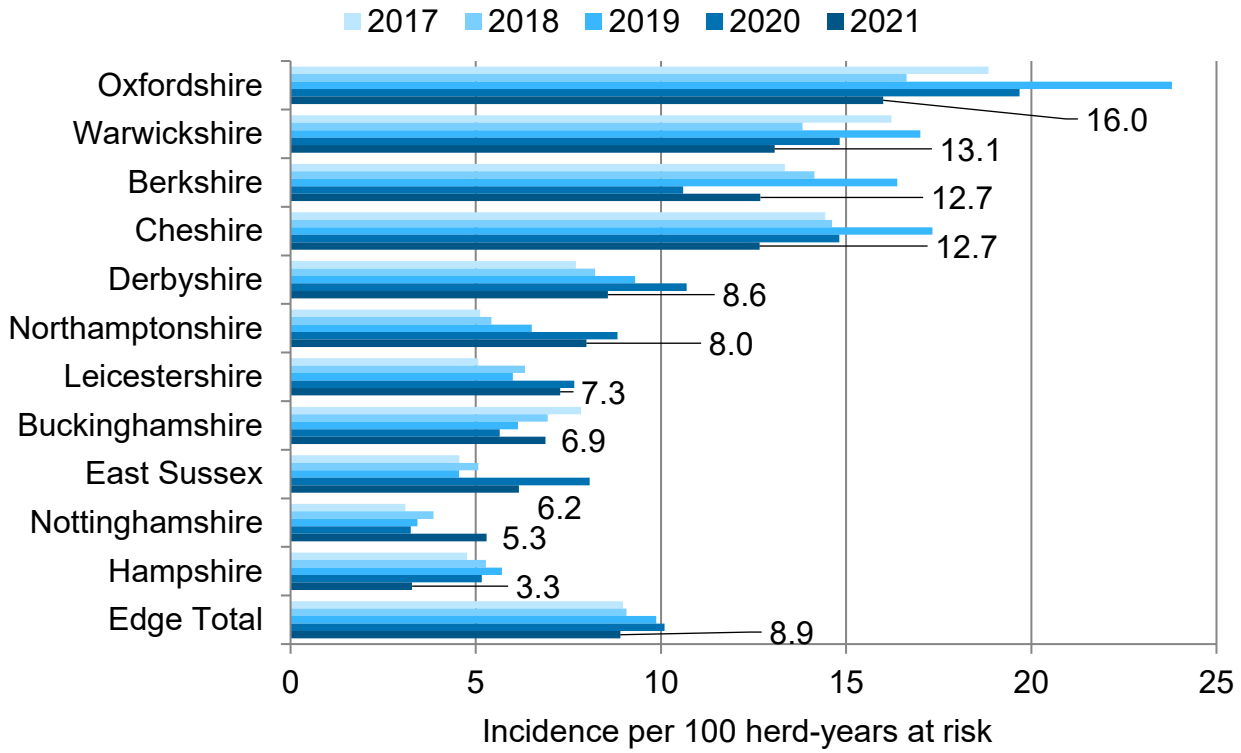


Figure 4.2.4 Incidence rate (per 100 herd-years at risk) from 2017-2021, by Edge Area county. Counties ranked by incidence in 2021.

- The incidence rate increased in 2021 compared to 2020 in Berkshire, Buckinghamshire, and Nottinghamshire.

Some of the variation in incidence rates between years may have been due to the changes in testing frequency. Oxfordshire, Cheshire, Warwickshire, Berkshire, Derbyshire, and Hampshire were all subject to enhanced six-monthly testing in 2021. When surveillance frequency changes, the sensitivity of the system changes and the number of herd-years at risk (denominator) can be artificially inflated or deflated. In 2018, when six-monthly testing was introduced to the reclassified Edge Area boundaries, incidence per 100 herd-years at risk initially declined. In 2019, when the Earned recognition scheme allowed eligible herds to revert to annual testing, incidence per 100 herd years at risk increased again. In 2020 and 2021, the frequency of surveillance did not change relative to the previous year.

A simpler measure of incidence, new cases per 100 unrestricted (OTF) herds tested, is provided in Figure 4.2.5. Incidence per 100 unrestricted herds tested is less susceptible to changes in surveillance testing frequency. It is not intended to replace the incidence per 100 HYR, but is particularly useful to provide clarity when surveillance intervals change, as was the case in 2018.

In the Edge Area overall, incidence per 100 unrestricted herds tested has fluctuated in the past five years, but showed an overall decreasing trend, from 8.4 in 2017 to 8.0 in 2021. Like the incidence rate per 100 HYR, incidence per 100 unrestricted herds tested decreased or remained the same in most of the counties in 2021 compared to 2020, except for Berkshire, Buckinghamshire and Nottinghamshire (Figure 4.2.5). In Nottinghamshire, incidence per 100 unrestricted herds increased sharply between 2020 and 2021 (from 3.2 to 5.2), consistent with the trend in new TB incidents and incidence per 100 HYR (Figures 4.2.2 and 4.2.4). In Oxfordshire, Warwickshire and Cheshire, incidence per 100 unrestricted herds has decreased annually since 2018.

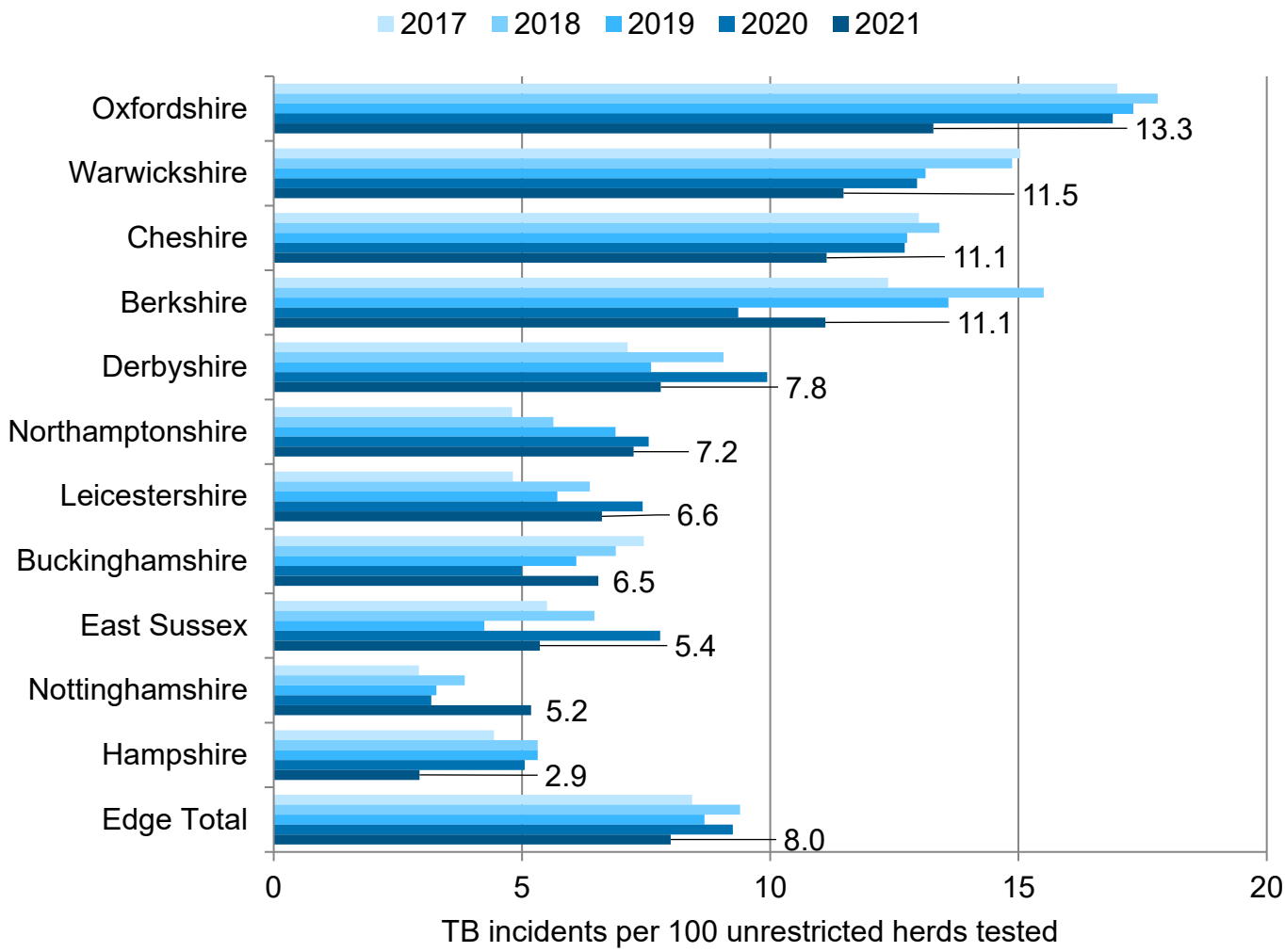


Figure 4.2.5 New TB incidents per 100 unrestricted herds tested from 2017-2021, by Edge Area county. Counties ranked by 2021 incidence value.

- The number of new incidents per 100 unrestricted herds tested has decreased every year since 2018 in Oxfordshire, Warwickshire, and Cheshire.
- The number of new incidents per 100 unrestricted herds tested generally decreased in most of other Edge Area counties in 2021 compared to 2020, except for Berkshire, Buckinghamshire, and Nottinghamshire.

- In Nottinghamshire, a 39% increase in number of new incidents per 100 unrestricted herds tested was observed compared to 2020.

County-level end-of-year herd prevalence

The end-of-year herd prevalence (proportion of herds under movement restrictions on 31st December due to an ongoing TB incident) decreased non-significantly in the Edge Area in 2021 compared to 2020 (4.7% and 5.7% respectively, z-test p=0.43, Figure 4.2.6). This decrease was observed in most Edge Area counties in 2021 compared to 2020, except for Berkshire and Nottinghamshire. Oxfordshire had the highest prevalence at the end of 2021 (10.5%), and prevalence was lowest in Hampshire (1.5%). Prevalence in Oxfordshire is higher than the percentage reported in 10 of the 11 HRA counties, ranking as the second highest county in England overall for this metric in 2021 (Figure 4.1.5, Chapter 4.1 Epidemiology of TB in the High Risk Area). Oxfordshire had a statistically non-significant decrease in end-of-year herd prevalence in 2021 compared to 2020 (z-test p=0.1907). As with incidence, prevalence figures presented here include all OTF-W and OTF-S incidents. Prevalence figures in the Year End Descriptive Epidemiology reports for Edge Area counties may differ slightly as they exclude TB incidents in Approved Finishing Units with no grazing.

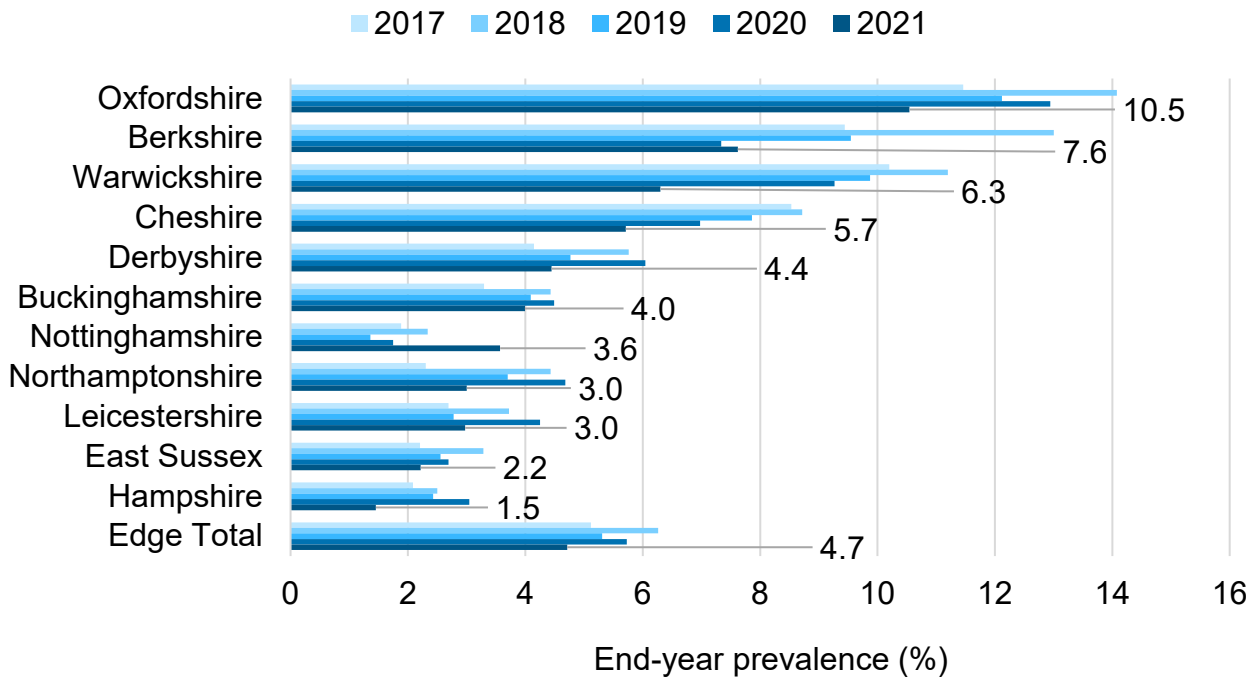


Figure 4.2.6 End of year prevalence from 2017-2021, by Edge Area county ranked by decreasing order of prevalence in 2021.

- End-of-year prevalence decreased in most of the counties in 2021 compared to 2020, except for Berkshire and Nottinghamshire.
- The overall end-of-year prevalence in the Edge area had a 1% decrease in 2021 compared to 2020.

TB incident duration and persistence

A total of 708 TB incidents closed in the Edge Area during 2021. The median duration for incidents that closed was 200 days (Interquartile Range (IQR) 165 to 276 days). At the county level, the longest median duration was observed in Oxfordshire, followed by Buckinghamshire and Hampshire. Counties with the shortest median durations were Nottinghamshire, Cheshire, East Sussex and Derbyshire (Figure 4.2.7).

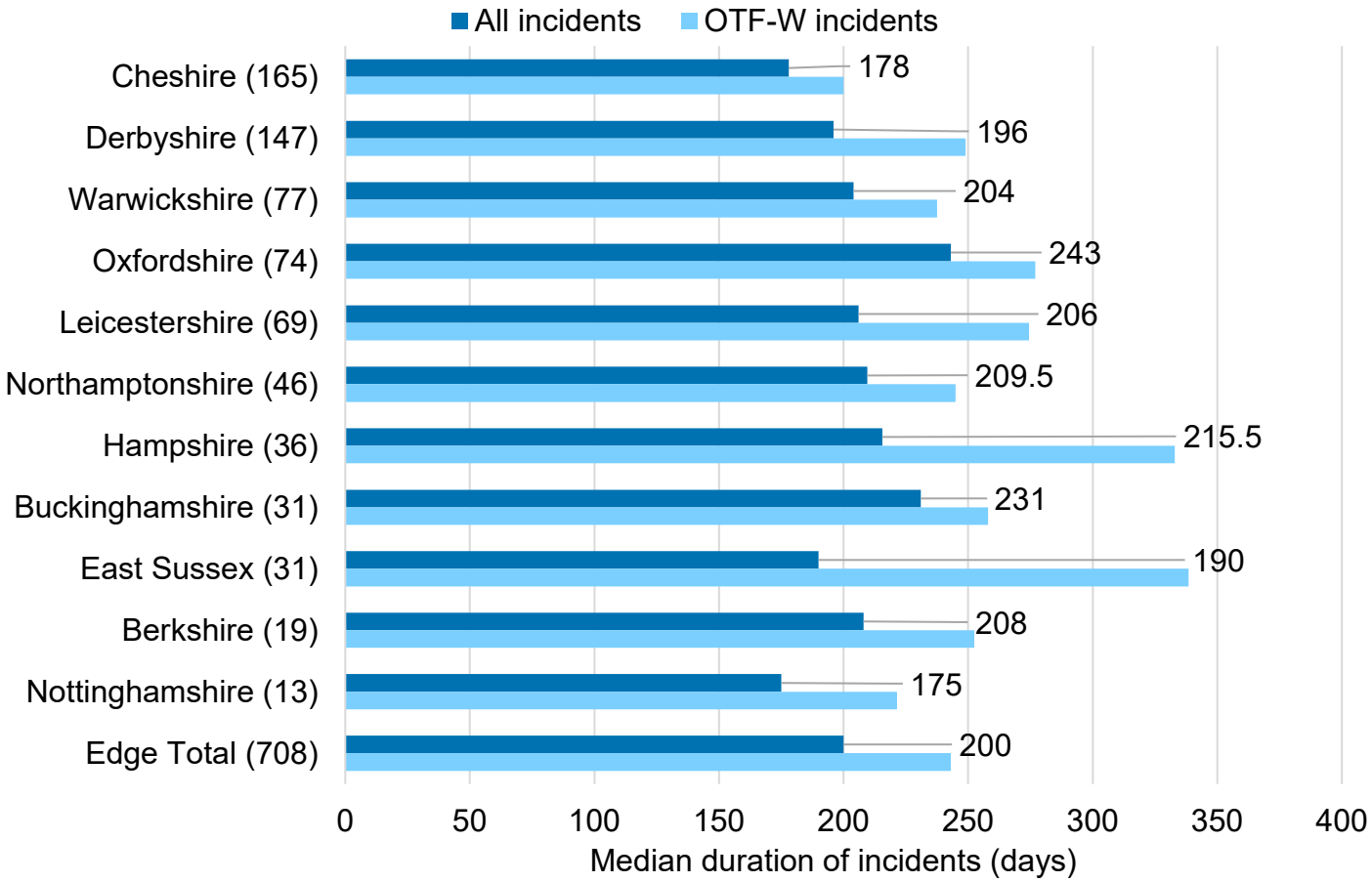


Figure 4.2.7 Median duration (days) of TB herd incidents that ended in 2021, by Edge Area county ranked by number of incidents (in parentheses).

- Median duration was highest in Oxfordshire for all TB incidents (243 days) and East Sussex for OTF-W incidents (338.5 days).

Recurrence of TB incidents

In the Edge Area in 2021, 46% of new TB incidents occurred in herds that had experienced at least one TB incident in the previous three years. Recurrence was highest in the Edge Area counties of Berkshire, Oxfordshire and Cheshire (Figure 4.2.8). Recurrence in Berkshire and Oxfordshire was higher than the percentage reported in all 11 HRA counties, therefore both counties had the highest percentage of recurrent TB

incidents in England (Figure 4.1.9, Chapter 4.1 Epidemiology of TB in the High Risk Area). Cheshire had a higher proportion of recurrence reported than six of the HRA counties.

Most (six out of eleven) counties in the Edge Area saw an increase in the proportion of recurrent TB incidents in 2021 relative to 2020; the exceptions were Warwickshire, Buckinghamshire, East Sussex, Hampshire, and Nottinghamshire, which experienced decreases (Fig 4.2.8).

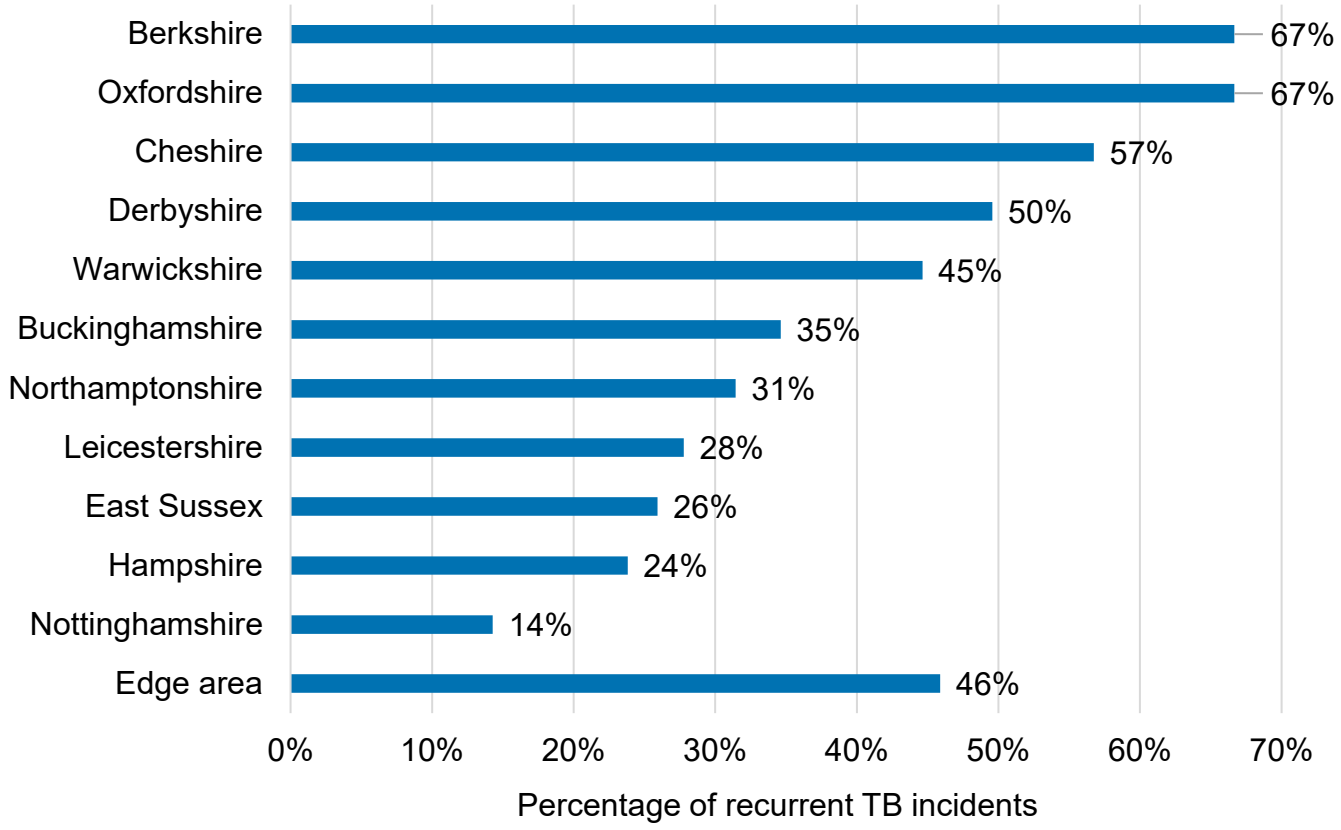


Figure 4.2.8 Percentage of TB incidents in 2021 in herds that had experienced any TB incident in the previous three years, by Edge Area county.

Source of infection

For herds with new TB incidents in the Edge Area, the predominant source of infection varied between counties. In 2019, incidents bordering the HRA were more frequently ascribed to badgers and those closer to the LRA were more commonly linked to cattle movements. In 2020 and in 2021, this relationship between source of infection and region of the Edge Area was not observed (Figure 3.2.11, Chapter 3.2 Characteristics of herds found infected with TB). Potential exposure to infected badgers was identified as the primary weighted source of TB infection in seven Edge Area counties, most prominently in Northamptonshire (68.9%), Cheshire (66.6%), Derbyshire (56.1%), Oxfordshire (56%), Warwickshire (49.7%) and Leicestershire (46.7%). Movement of undetected infection cattle was identified as the primary weighted source in Hampshire (47.4%),

Buckinghamshire (41.4%) and Berkshire (33.3%) (Table 3.2.1, Chapter 3.2 Characteristics of herds found infected with TB).Other/unknown sources also played a big role in the Edge Area (13.5%) and had the largest weighted contribution in Nottinghamshire (56.2%).

New areas of endemic infection and new clusters emerging

The Edge Area counties is strategically located along the endemic front of TB and as such, areas of spread and retraction often occur with Edge Area counties. Figure 3.1.6 (spread and retraction of endemic TB areas in 2021, Chapter 3.1) provides a visual depiction of changes to the endemic area in 2021. Areas of developing significance are also discussed in the Edge Area Year End Descriptive Epidemiology Reports, which provide a greater depth of discussion at the local level. Some of the highlighted areas of significance include:

- Buckinghamshire: a cluster of three new OTF-W incidents with Whole Genome Sequencing (WGS) clade B6-11 (17:b) was located in the east of the county within close proximity to Leighton Buzzard (on the Bedfordshire border). This new 2021 cluster could represent a potential reservoir of infection in wildlife.
- Cheshire: in 2021, a potential new cluster of four TB incidents with WGS clade B6-83 appeared along the M6 corridor centrally around Holmes Chapel. There was only one B6-83 incident in this area in 2020.
- Derbyshire: in North Derbyshire, there were multiple OTF-W incidents in the Bakewell area close to South Yorkshire. There are abundant TB-susceptible wildlife populations in the area.
- Northamptonshire: WGS evidence suggests that TB is now endemic in the west of the county, and clade B6-62 is expanding into the north. The county border with Leicestershire continued to show an increase in incidents, specifically the area south-west of Market Harborough. This increase was not mirrored on the Leicestershire side of the border.
- Nottinghamshire: the number of TB incidents increased in 2021, which was mainly due to an increase in OTF-W incidents (from five in 2020 to 11). Additionally, whole-county herd prevalence nearly tripled, which was driven by the increase in the south of the county, in or near Hotspot 23 (HS23). A cluster of TB incidents in the Newark area is being monitored.
- Oxfordshire: there were several persistent clusters in Oxfordshire in 2021. WGS has provided increased evidence of a local source of infection.
- East Sussex: TB incidents in the original Edge Area saw a sharp increase between 2019 to 2020 and remained high in 2021. This could suggest developing wildlife endemicity within the area.

Areas of observed improvement

- The total number of TB incidents, total and OTF-W incidence per 100 HYR and end-year prevalence all decreased in the Edge Area.

- Cheshire: the ratio of OTF-W to OTF-S incidents continued to reduce in 2021, from the high of 68% OTF-W in 2018 down to 51% during 2021. This likely indicates a lower burden of infection.
- Hampshire: the incidence rate in 2021 (3.3 incidents per 100 HYR) was the lowest reported since 2015, and the prevalence at the end of 2021 was half of that recorded at the end of 2020, returning back to 2013 levels. Additionally, the WGS clade B6-85 (11:a) was only identified once in 2021 after being identified four times in central Hampshire in 2020. The likely source for the 2021 incident was residual infection.
- Northamptonshire: in 2021 there was a reduction in the number of incidents along the route of high speed rail (HS2) construction. It is hoped that this was a transient increase in local incidents and there is no longer a concern. Also, there was no OTF-W incidents in the Thrapston-Oundle corridor in 2021 which was of concern in 2019.
- Oxfordshire: there was a 21% reduction in the number of new TB incidents in 2021 compared to 2020 (57 and 72 respectively). There was also no new TB incidents in a number of clusters in Oxfordshire.
- Derbyshire: incidents decreased in 2021 (115) compared to 2020 (147), and OTF-W incidents decreased for the third consecutive year (63 in 2021, from 84 in 2018).
- Leicestershire: the number of TB incidents, OTF-W incidents, annual incidence and prevalence decreased in 2021 compared to 2020.
- Warwickshire: TB incident numbers decreased for the fourth consecutive year.

4.3 Epidemiology of TB in the Low Risk Area

- This chapter summarises key findings from the LRA TB Epidemiology reports for 2021.
- The Low Risk Area (LRA) was established in 2013. It extends to the north and east of the Edge Area, excluding East Sussex, but including the Isles of Scilly (Figure 4.3.1). Data reported in this chapter are for the 25 counties that make up the LRA. The four-yearly routine surveillance testing regime for most cattle herds in the LRA is supplemented by targeted enhanced surveillance of any herds located within a 3km radius of a cattle herd with an OTF-W incident (known as 'radial' testing), including those triggering a TB hotspot area.

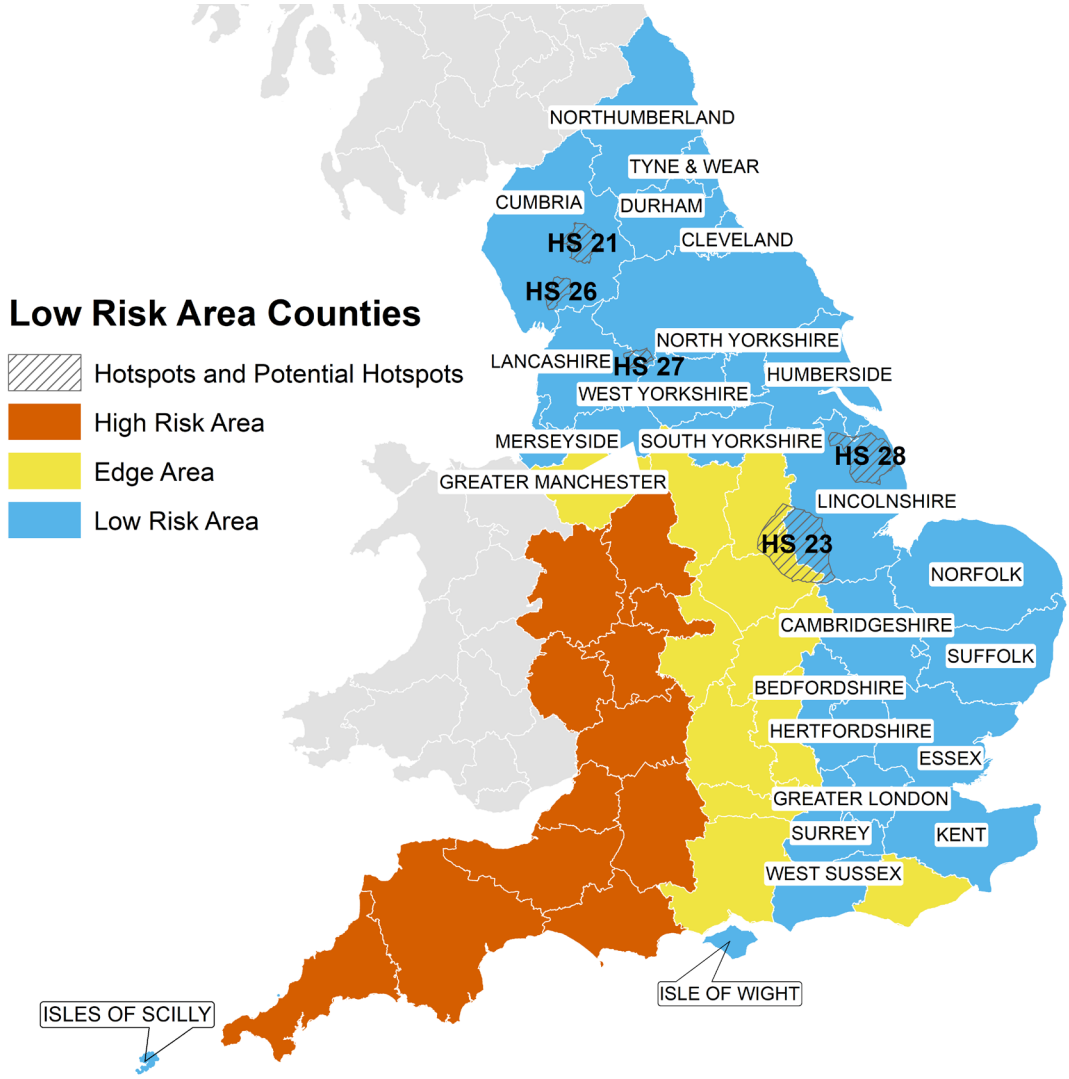


Figure 4.3.1 LRA county map, showing the two confirmed (HS21 and HS23) and three potential (HS26, HS27 and HS28) hotspots that were active in 2021.

- Overall, the herd incidence rate in the LRA remained very low and stable (1.1 incidents per 100 herd-years at risk and 0.34 OTFW incidents per 100 herd-years at risk).

The number of new incidents decreased in 2021 compared to 2020 (123 incidents and 135, respectively). Of those 123 new herd incidents in 2021, 38 (31%) were OTF-W (Figure 4.3.2), compared with 42 (31%) in 2020. A notable increase was seen in Lancashire (17 new TB incidents in 2021, 8 in 2020). Notable decreases were seen in Cumbria (23 in 2020 to 18 in 2021), Kent (8 in 2020 to 3 in 2021), West Yorkshire (11 in 2020 to 7 in 2021) and Northumberland (7 in 2020 to 3 in 2021) (Figure 4.3.3).

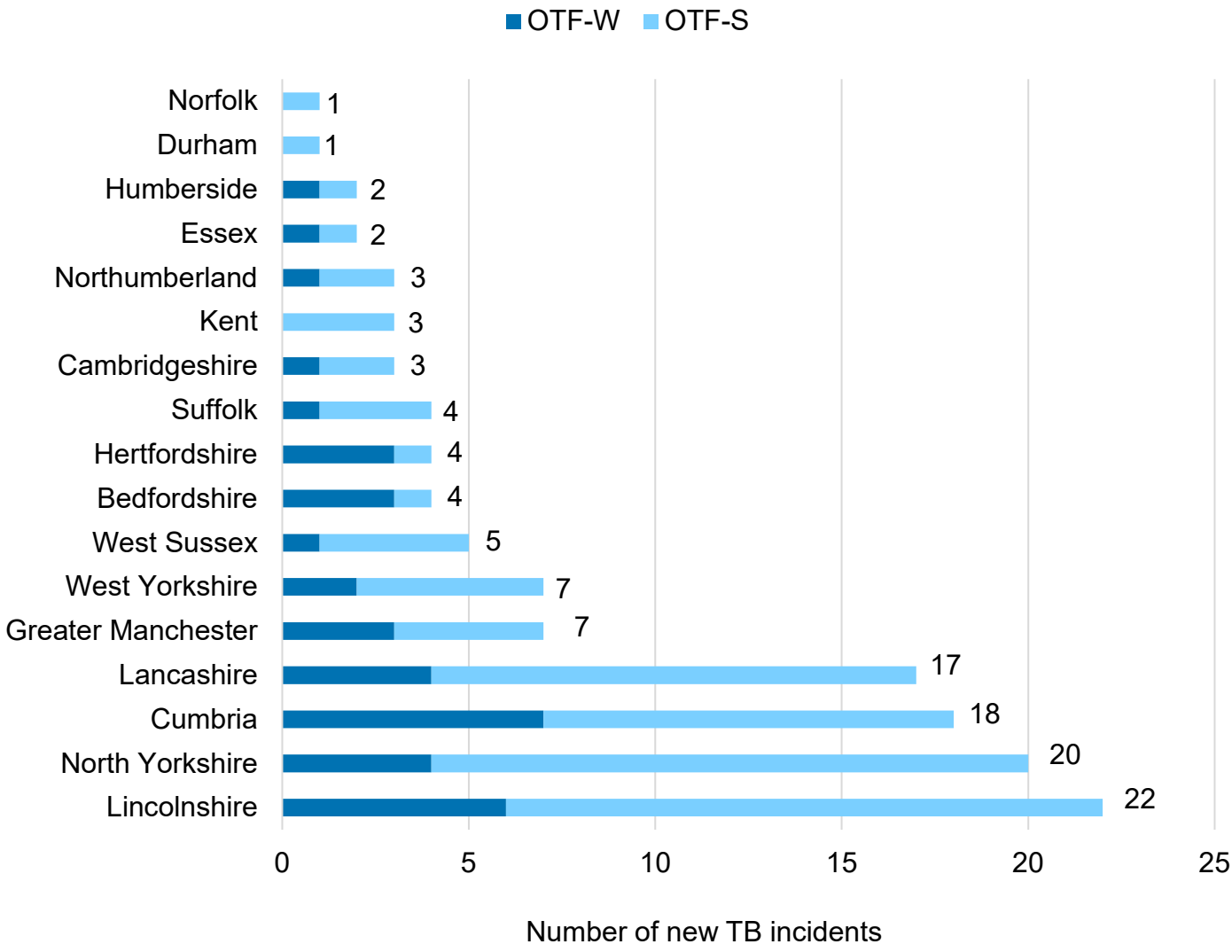
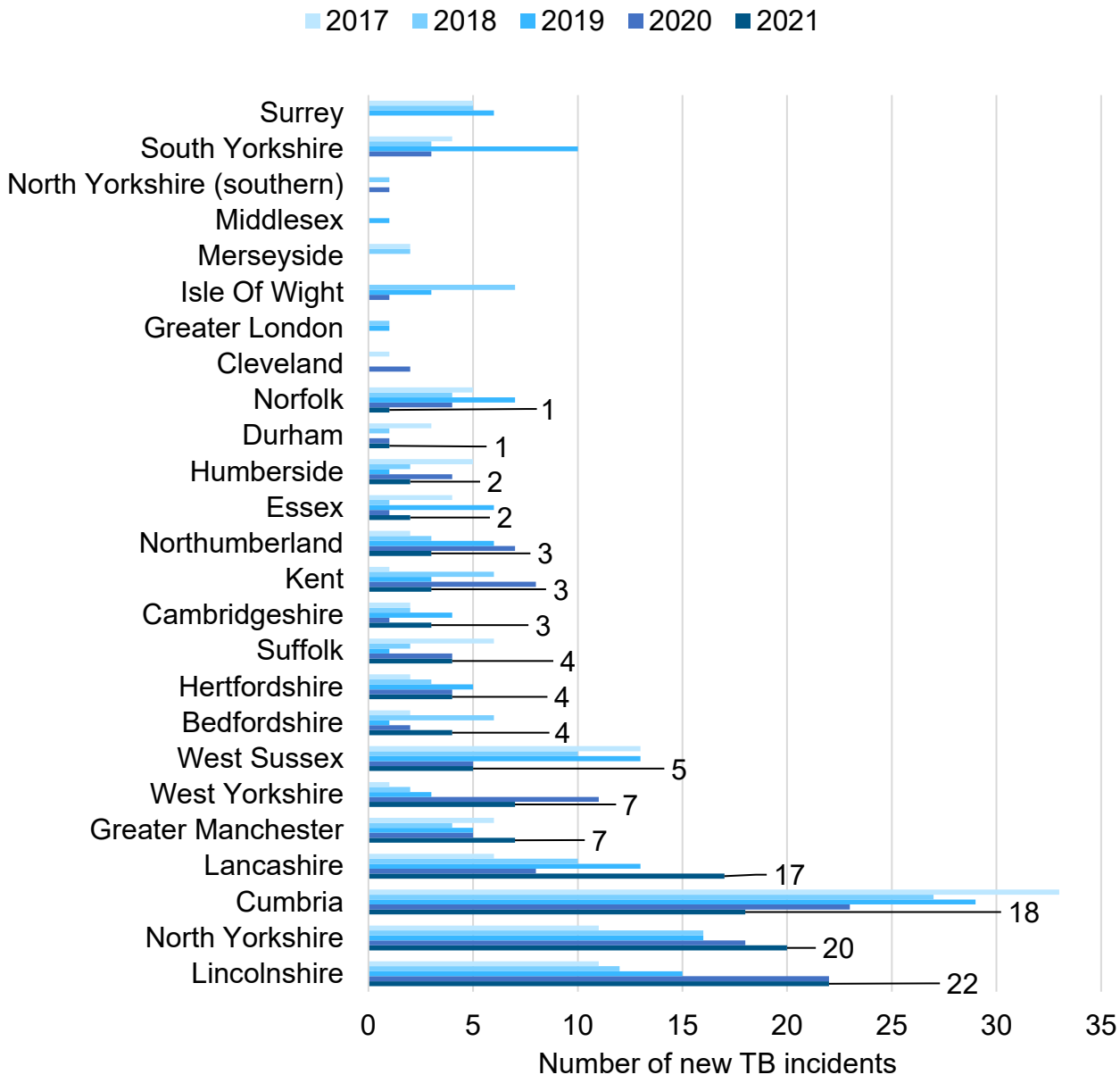


Figure 4.3.2 Total number of new TB incidents (OTF-W and OTF-S) by LRA county in 2021. Total incidents labelled on chart.



Not shown: two LRA counties that did not report any new TB incidents between 2015 and 2019 (Isles of Scilly

Figure 4.3.3 Annual total number of new TB incidents (OTF-W and OTF-S) by LRA county 2017 to 2021. Number of 2021 incidents labelled on chart.

- There is a higher degree of uncertainty around the source of TB in incidents detected in the LRA compared to the HRA and Edge Area. In part, this is related to the smaller proportion of OTF-W incidents in the LRA, where genotyping and Whole Genome Sequencing (WGS) of *M. bovis* isolates from culture-positive animals can provide key evidence as to the likely source of infection.
- Risk pathways were often identified with a low degree of certainty. In this situation, additional uncertainty is added to the determination of the likely sources of TB infection for the affected herds. See the explanatory supplement for further details. In 2021, this uncertainty accounted for 46% of the weighted risk pathways in the LRA. This was expected, due to the low proportion of OTF-W incidents detected. This was followed by movements of undetected infected cattle, which had a weighted source contribution of 22%. In previous years, cattle movements represented the main weighted source of infection in the LRA (39% in 2020 and 38% in 2019). Potential exposure to infected badgers was identified as 10% of the weighted source pathways for incidents in the LRA, compared to 9% in 2020. There were 86,208 cattle movements (excluding movements to slaughterhouses) from the HRA and Edge Area into the LRA in 2021. Compulsory post-movement skin testing for such animals goes some way towards mitigating the risks associated with sourcing cattle from outside the LRA.
- In the LRA, hotspot procedures are initiated around OTF-W incidents of undetermined origin. Within a potential hotspot area, cattle herds located within 3km of the index herd undergo enhanced (more frequent) TB testing, and a concurrent survey of found-dead badgers and wild deer is implemented. If *M. bovis* infection is confirmed by the wildlife survey, the potential hotspot becomes a confirmed hotspot (HS). In 2021, there was a total of two confirmed (HS21 in Cumbria and HS23 in Lincolnshire) and three potential hotspots (HS26 in Cumbria, HS27 spanning Lancashire and North Yorkshire and HS28 in Lincolnshire).
    - There were no new OTF-W incidents in HS21 (East Cumbria) in 2021, and no 17:z (WGS clade B6-23) isolates identified in the hotspot area for the third consecutive year. Similar to 2020, there were four new OTF-S incidents in HS21, which all remained open at the end of 2021. In 2021, 111 badgers were vaccinated in the outer area of HS21 and 62 removed from the core area where all previous badger infection had been located. All the culled badgers were subjected to post-mortem examination and culture, and all were negative for *M. bovis*, for the second year running. See TB surveillance in confirmed hotspots for further information.
    - In 2021 there were two new OTF-W incidents in HS23, down from three in 2020. No badgers or wild deer found dead in HS23 were examined in 2021. Licensed badger culling operations began in the LRA portion of HS23 in September 2020 and took place for a second year in 2021, with 161 badgers removed from the badger TB control area. Of those culled badgers, 156 underwent post-mortem examination and bacteriological culture by APHA, of

which 14 (9.0%) proved positive for *M. bovis*. See TB surveillance in confirmed hotspots for further information.

  - Since potential hotspot HS26 was established in 2019 in South Cumbria, wildlife surveillance has not identified *M. bovis* in local badgers or wild deer. In 2021 there was one new OTF-S case in HS26, with the most likely risk pathway attributed to badger exposure.
  - Potential hotspot HS27 was implemented in January 2020 in the south-west of North Yorkshire alongside the boundary with Lancashire. In 2021 there were no new OTF-W incidents in HS27, and one OTF-S incident detected in the Lancashire part of this hotspot area. Since its implementation, only one deer carcass has been submitted for examination, which was *M. bovis* negative.
  - There were four new OTF-W incidents in potential hotspot HS28 (East Lincolnshire) during 2021, which was a reduction from six in 2020. No WGS data could be gathered for the four incidents, as WGS analysis has not yet been carried out for two of the incidents, and the other two incidents failed to yield *M. bovis* on culture. Two of the positive herds had a previous incident in the preceding two years, indicating recurrent infection. No infection was detected in the 32 road-traffic accident badgers and six deer carcases examined in 2021.
  - Two potential TB hotspot areas closed in 2021; one in Norfolk (HS25) and one in West Sussex (HS24). This is because the enhanced TB surveillance regime detected no evidence of TB infection in badgers and wild deer carcases, or further OTFW incidents in cattle herds.

- As well as cattle movements, spread of infection from adjoining areas of endemic TB in the Edge Area poses an additional risk to the LRA. Parts of the LRA identified as being at particular risk for this reason included:
  - South-East Greater Manchester: two new incidents (one OTF-W and one OTF-S) occurred in Stockport in 2021. Due to its proximity to the Cheshire Edge Area, there are concerns there is disease spill over.
  - North-East Greater Manchester: there was one new OTF-W incident (clade B3-11) identified near Oldham in 2021, which was close to an OTF-W incident (also clade B3-11) identified in 2020. Both incidents were assessed as having a likely wildlife source of infection as no other source could be identified. Therefore, this area is being monitored in case the situation deteriorates further.
  - West Bedfordshire: in 2021 there was a cluster of incidents in the Leighton Buzzard area (three OTF-W incidents and two OTF-S incidents). Two of the OTF-W incidents were associated with the purchase of cattle, and one was identified as being caused by whole genome sequencing (WGS) clade B6-11

of *M. bovis*. The results of WGS analysis are awaited to see if this third incident is related to a B6-11 cluster in a neighbouring area of Buckinghamshire, and from this appropriate action can be determined.

  - Hertfordshire: in 2021, two OTF-W incidents (WGS clade B6-62) and one OTF-S incident were located close to a single OTF-S incident disclosed in 2020. The source of infection was uncertain, with fomites and cattle movements from the LRA both possible. WGS analysis in this area is pending, and in 2021 this triggered radial testing zones, and will continue to be monitored.

- Other areas that will require close monitoring include:

  - East Lancashire: two OTF-W incidents (clade B3-11) and three OTF-S incidents were disclosed near Burnley in 2021. This area disclosed three OTF-S incidents in 2020 and will require close monitoring in case the situation deteriorates further.

  - East Cumbria: there were six new TB incidents (four OTF-W incidents and two OTF-S incidents) north of HS21, in the Melmerby-Ousby area in 2021. This was an increase from two TB incidents in 2020. As all four OTF-W incidents were caused by clade B3-11 of *M. bovis* (different from the clade associated with HS21), exposure to badgers could not be ruled out and there was no clear evidence of introduction via animal movements.

  - North Cumbria: one new OTF-W incident in the Brampton area was disclosed in 2021, caused by infection with clade B6-86 of *M. bovis*. The most likely source of infection was direct or indirect contact with wildlife. No relationship was found to the OTF-S incident in 2021 and the previous OTF-W incident in the area.