Animal &
Plant Health
Agency

Bovine tuberculosis in England in 2022

Epidemiological analysis of the 2022 data and historical trends

November 2023

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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 more than three quarters (78%) of new TB incidents in 2022 (n=2,294). As in previous years, the Low Risk Area (LRA) in the north, east and south-east had very few TB incidents in 2022 (n=145). This represented around 5% of incidents in England. Of these, approximately only 28% 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test reactors with typical TB lesions or one or more animals with positive bacteriological results, or both (OTF status withdrawn – OTF-W incidents).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, which lies between the HRA and LRA, contained 17% of new TB incidents (n=490) in 2022 in England.
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 (for example tracings, cleansing and disinfection of cattle housing) and enhanced cattle testing (supplementary IFN-γ blood tests in parallel with more frequent SICCT testing using a lower positive cut-off, termed 'severe interpretation' of the reactions) 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, herds in lower incidence areas, in the east, or adjacent to the LRA (except for Cheshire) undergo routine annual tests. Six-monthly testing applies to most herds in the higher incidence portions of the Edge Area and the entire HRA. Eligible herds in the six-monthly testing areas can apply for 'earned recognition' and remain eligible for annual tests. M. bovis infection in badgers is controlled through licensed badger culling and vaccination.
3. The incidence rate of bovine TB in England increased steadily from 1986 to 2010, but has been decreasing significantly ($p<0.001$) since 2017. The herd incidence rate (new cases per 100 herd-years at risk; 100 HYR) in England fell from 8.8 in 2021 to 8.4 in 2022, although this change was not statistically significant. In 2022, the herd incidence rate in the HRA remained the same as in 2021, despite a 6% increase in the number of new incidents. This may have been influenced by the change in testing regimes in the HRA, where herds in Shropshire and Staffordshire were moved from annual to six-

monthly routine surveillance testing in September 2020 (with the first additional tests taking place from March 2021), and six-monthly testing rolled out in the rest of the HRA in June 2021 (with the first additional tests required from January 2022). This is reflected in the increase in Whole Herd Tests (WHTs) in the HRA in 2022, which rose by 64%.

4. However, the incidence rate in the Edge Area significantly declined for the second consecutive year, from 8.9 in 2021 to 7.7 in 2022 (incidence rate ratio, p=0.02). This represented a 14% decrease in incidents, which was observed in both the annual (10%) and six monthly (15%) testing parts of the Edge Area. Incidence remained very low in the LRA, despite new incidents also increasing compared to 2021 by 18%. Overall, the number of new TB incidents increased in England in 2022. Further details on incidence in England are discussed in Chapter 3.1.
5. Over half of herds with new TB incidents in the HRA (56%) were recurrent incidents that 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 6 to 12-month period after regaining OTF status, compared to post-incident herds in other risk areas.
6. In 2022, 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 experience a new TB incident. Dairy herds were also found to have an additional risk of infection that could not be fully explained by their herd size, testing history or location.
7. In 2022, the number of interferon gamma (IFN-γ) blood tests completed in England fell by a third (N=143,310). Decreases were seen across all risk areas but fell most in the Edge Area by 53% compared to 2021. This is likely due to a combination of factors, including fewer cattle herds being eligible for IFN-γ testing due to changes in the policy in 2021; fewer OTF-W incidents disclosed due to decreasing incidence and prevalence in England; and a proportion of tests, particularly supplementary tests where the use was discretionary, were not booked due to diversion of APHA resources as a result of the avian influenza outbreak.
8. Due to the impact of the avian influenza outbreaks in 2021 and 2022 on veterinary investigation into the source of infection for new TB incidents, novel data driven methods to quantify the likelihood of risk pathways for TB infection were developed by APHA. This new method combines cattle movement data with whole genome sequencing (WGS) data from M. bovis isolates in cattle to provide insights into possible risk pathways for new incidents.
   For most new TB incidents in 2022, across all risk areas, there was no evidence of cattle movements associated with a high likelihood of infection and there was no WGS data available to explore the presence of a local reservoir. Therefore, there is insufficient evidence for these herds to determine a likely infection pathway This applied to 56% incidents in the HRA, 52% in the Edge Area and 70% in the LRA.

WGS data identified a local reservoir of infection and there were no cattle movements associated with a high likelihood of infection for 19% new TB incidents in the HRA, 20% in the Edge Area and 7% in the LRA in 2022.

9. Between 2021 and 2022, there was a net retraction of 2,306.98 km^2 in the size of the overall area considered to harbour endemic M. bovis infection 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 around south Leicestershire, Nottinghamshire and Oxfordshire. There was however also some spread in Buckinghamshire, with the Bedfordshire/Buckinghamshire border becoming endemic in 2021/2022 period. There were small areas of spread in the LRA around hotspot HS21 in Cumbria. Areas of spread in Hertfordshire are under observation, with a small area in the west of the county being considered for TB hotspot controls in 2023. Most of the LRA remained free of endemic infection. Endemicity in this context is defined as a geographical unit with at least three OTF-W incidents within a 5 km radius within a two-year period. Further information on endemic infection is provided in Figure 3.1.6 and in Chapter 3.1: Incidence and Distribution.
10. Whole Genome Sequencing (WGS) has now fully replaced genotyping (spoligo- and VNTR-typing) of M. bovis isolates in England. The most frequent clades based on 1,683 TB incidents in 2022 were B6-11 (23%) followed by B6-85 (19%) and B3-11 (16%). 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 2022, with selected 2021 values in parentheses

	HRA	Edge Area	LRA	England
Number of new TB herd incidents detected	2,294	490	145	2,929
(2021)	(2,155)	(573)	(123)	(2,851)
Number of new OTF-W TB incidents that were lesion or culture positive, or both	1,079	232	40	1,351
(2021)	(1,265)	(270)	(38)	(1,573)
Number of open (continuing) TB incidents at the end of the year	1,488	288	66	1,842
(2021)	(1,505)	(328)	(51)	(1,884)
Herd incidence per 100 herd-years at risk	14.4	7.7	1.1	8.4
(2021)	(14.4)	(8.9)	(1.1)	(8.8)
Average monthly prevalence (%)				
(2021)	9.1	4.4	0.4	4.7
	(8.9)	(5.6)	(0.4)	(4.8)
Duration in days				
Median duration of restrictions for incidents that closed in 2022	190	185	150	187
(25th, 75th percentiles)	(163-279)	(160-266.5)	(98-194)	(160-273)
Median duration of restrictions for incidents that closed in 2021	202	200	138	198
(25th, 75th percentiles)	(167-291)	(165-273)	(98-199)	(166-280)
Percentage of incidents that ended in the year that were persistent, duration was greater than 550 days (%)	5.8	5.2	1.5	5.5
(2021)	(5.5)	(3.4)	(0)	(4.8)
Number of persistent incidents, with a duration greater than 550 days, ongoing at the end of the year	98	11	1	110
(2021)	(129)	(23)	(1)	(153)
Recurrence				
Percentage of new TB incidents in the year that occurred in herds that suffered another TB incident in the preceding 36 months (%)	55.8	48.0	15.3	52.4
(2021)	(56.1)	(43.6)	(9.9)	(51.5)

2. Preface

2.1 Intended audience

This report describes the level and distribution of tuberculosis in cattle herds in England in 2022[1]. Tuberculosis in cattle (bovine TB) 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 produced by APHA that provide surveillance information 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 2022 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 TB 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.

[1] Note – In this report, 'cattle herds' includes a small number of farmed water buffalo and bison herds, which are subject to the same TB surveillance and control regime as domestic cattle.

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 2022, 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.

The TB surveillance and control regime in cattle is complex 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

TB in cattle is generally a chronic and insidious infection where most infected animals do not display clinical signs. Therefore, the potential for finding herds infected with TB is directly related to (a) how hard we actively look for the infection (the type and frequency of on-farm surveillance and the thoroughness of post-mortem meat inspection at slaughter), 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

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 Great Britain 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).

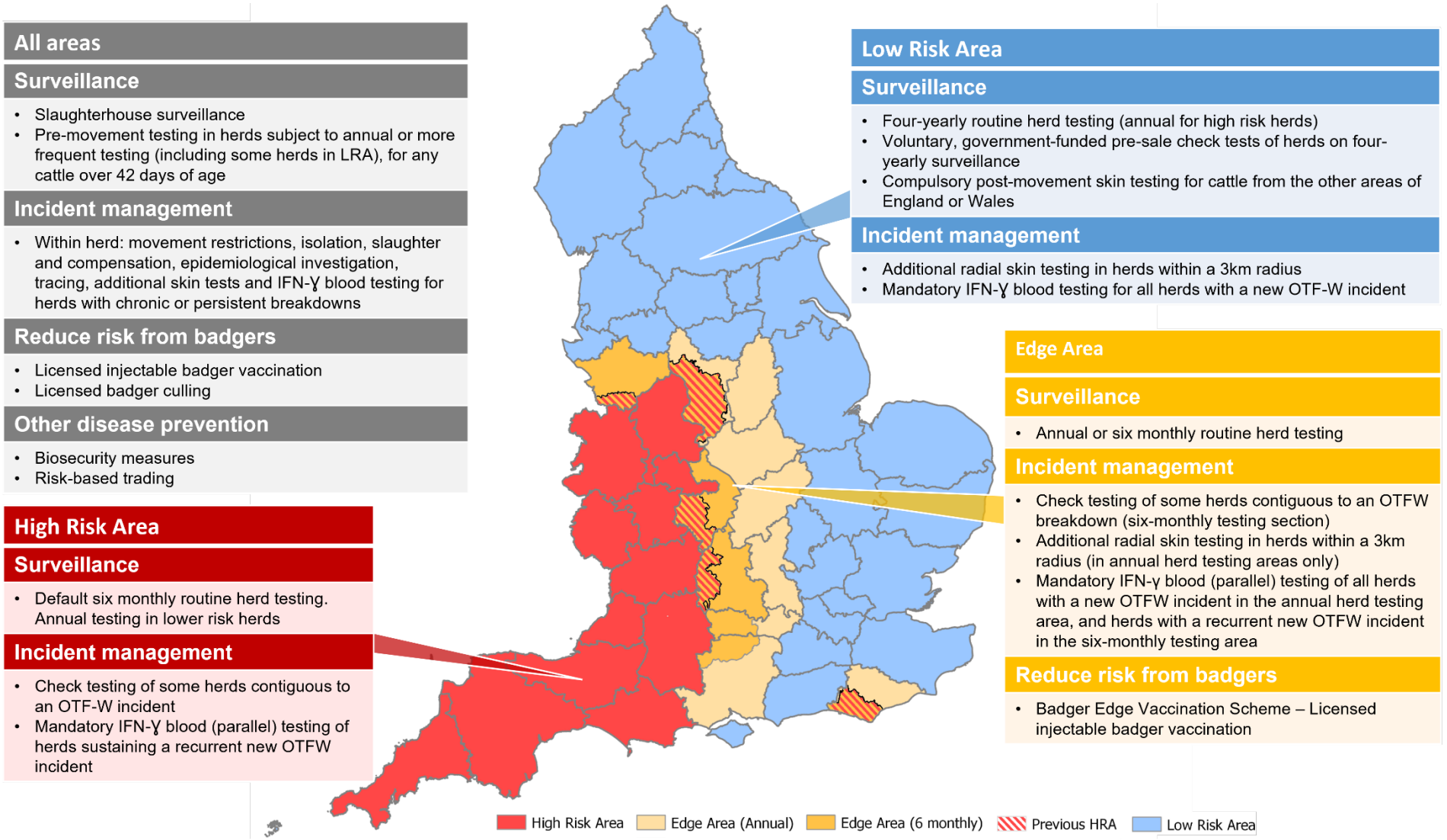


Figure 2.1 Summary graphic of the England TB Eradication Strategy.

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 2022

Six monthly testing in the HRA: Six-monthly testing in the HRA was introduced on 1 July 2021, however the first additional six-monthly tests conducted in the HRA took place from 1 January 2022. The exception to this was in Shropshire and Staffordshire, where six-monthly testing began in March 2021.

PCR test for direct detection of M. bovis in post-mortem tissue samples: The PCR test became operational from 30 March 2022 and initially is only being used in Great Britain for:

- TB slaughterhouse cases in cattle and non-bovines.
- Non-bovine animals removed by APHA as TB test reactors, direct contacts or clinical TB suspects, and cases where TB lesions are identified on diagnostic post-mortem examination.
- Domestic pets and exotic species of animals submitted to APHA for laboratory investigation.

Changes to pre-movement TB tests of cattle:

- From 31 December 2022, the validity of a pre-movement test for cattle from TB-restricted holdings entering a TB Isolation Unit increased from 30 to 60 days.
- In the HRA and Edge Area, since 31 December 2022 a pre-movement test is no longer required for cattle moving directly (or indirectly via an orange market) between AFUs in England and Wales.

Oxfordshire bovine TB cluster pilot: In October 2022, a new pilot scheme was launched in Oxfordshire in addition to existing TB control measures. The scheme aims to provide additional control measures to tackle TB, promote the opportunity for the design and implementation of bespoke approaches to control TB and help to understand the genetically linked clusters within the scheme.

Bovine TB: authorisation for badger control in 2022: 11 new badger control areas were added to the existing 69 which continued operations in 2022.

Badger vaccination in 2022: Badger vaccination is part of the government's strategy on tackling bovine tuberculosis in England. The numbers of badgers vaccinated in England were published in 'Summary of badger vaccination in 2022'.

ibTB: In January a new version of ibTB went live and included a new separate map showing the number of years herds in England have been clear of TB.

3. The TB epidemic in England

3.1 Incidence, geographic distribution, and trends over time

- In 2022, there were 2,929 new TB herd incidents in England, a 3% increase compared to 2021. As in previous years, most new incidents (78%) in 2022 occurred in the High Risk Area (HRA), with 17% in the Edge Area and the remaining 5% in the Low Risk Area (LRA).
- The number of new TB incidents increased by 7% in the HRA and 18% in the LRA between 2021 and 2022 – however neither of these increases were statistically significant. This was driven by an increase in the number of unconfirmed (Official Tuberculosis Status Suspended – “OTF-S”) incidents in these risk areas. However, the number of new incidents in the Edge Area fell for the second consecutive year (by 15%) to the lowest number since 2012.
- The number of OTF-W incidents disclosed in the HRA fell significantly ($p<0.001$) again in 2022 by 15%. OTF-W incidents also declined (although not significantly) in the Edge Area in 2022 compared to 2021, following a similar trend to previous years. However, OTF-W cases increased slightly in the LRA during the period, though this increase was not statistically significant.
- Since the start of 2011 the growth of the TB epidemic has slowed in England. In fact, when considering the last six years (2017-2022), there is evidence that the epidemic is now declining (halving time of 11.0 years, $p<0.001$). However, the quarterly total numbers of incidents in 2022 remain more than double the quarterly totals before the outbreak of foot-and-mouth disease in 2001.
- In the HRA, despite the growth in the number of new TB incidents, the herd incidence per 100 herd-years at risk (HYR) was the same in 2022 as in 2021 at 14.4 incidents per 100 HYR, the lowest rate since 2007. The incidence rate fluctuated between 18 and 20 incidents per 100 HYR in this area from 2011 to 2018 and has been falling since. Incidence per 100 HYR also fell significantly for the second consecutive year in the Edge Area to 7.7 (down from 8.9 in 2021). Incidence remained very low and stable during the same period in the LRA (1.1 TB incidents per 100 HYR), the same as 2021. Overall, the TB incidence rate in England decreased to 8.4 incidents per 100 HYR (from 8.8 in 2021), the lowest rate since 2010.

- Cattle with lesions typical of TB at slaughter, positive culture results for M. bovis, or both (i.e. OTF-W incidents), were found in 47% of all new incidents in the HRA (the so-called OTF-W herd incidents), 47% in the Edge Area and 28% in the LRA in 2022. This compares to 59% in the HRA, 47% in the Edge, and 28% in the LRA in 2021.

- There was a net retraction of 2,306.98 km^2 from 2021 to 2022 in the size of the overall area considered to harbour endemic M. bovis infection in England, meaning retraction of certain parts of the 'endemic TB area' exceeded expansion elsewhere.

- Eleven new Badger Control Programme (BCP) areas were licensed in 2022; five in the HRA and six in the Edge Area. Licences were issued to vaccinate, with 2,343 badgers vaccinated across nineteen counties in 2022.

Number of TB-infected herds

The number of Officially Tuberculosis Free (OTF) herds in which TB was detected in 2022 is referred to as the number of new incidents. The incidence rate shows the number of new incidents detected in herds over time, considering periods when herds are not at risk of infection for example because they are already under TB movement restrictions (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 HRA and the LRA contain 82% (41% each) of the cattle herds registered in England, while the remaining 18% are registered in the Edge Area. Approximately one in eight herds (12%) had a new TB incident in the HRA in 2022, compared to around one in 16 (6%) in the Edge Area. For both areas, this proportion decreased compared to 2021. In the LRA, fewer than 1 in a hundred herds had a new TB incident in 2022, with one in 500 herds having an OTF-W incident. However, it is important to note that most herds in the LRA are routinely tested once every four years.

The number of herd incidents increased by 3% in England in 2022 (2,929) compared to 2021 (2,851). This increase reflects the increased numbers of OTF-S incidents in the HRA and LRA compared to 2021. This was likely a result of the increased frequency of routine herd testing for most herds in the HRA, which led to the detection of infected herds earlier than in previous years, before animals could progress to the visible lesion stage.

In the HRA, the number of new incidents increased by 6% and they increased by almost a fifth (18%) in the LRA. However, neither of these increases were statistically significant. In the HRA, most herds in Shropshire and Staffordshire were moved from annual to six-monthly routine surveillance testing in September 2020 (with the first additional tests taking place from March 2021). In all the other HRA counties six-monthly testing was rolled out in June 2021 (with the first additional tests required from January 2022).

The largest decrease in incidents was seen in the Edge Area, where 14% fewer incidents overall were identified in 2022 (490) than in 2021 (573). This was a statistically significant decrease ($p=0.01$, incident rate ratio), and driven by the fall in the number of OTF-W and

OTF-S incidents, which fell by 14% and 15% respectively. For OTF-S incidents, this was a statistically significantly fall (p=0.04, incident rate ratio). However, single inter-year changes should be interpreted with caution and multiple measures should be used to explore TB trends, rather than be considered in isolation.

As the incidence of TB and number of incidents in the LRA remains low (1.1 incidents per 100 HYR and 140 new incidents in 2021), it is difficult to determine whether the fluctuations seen in this part of England 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 Edge and LRA reports.

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 OTF-W TB incidents in the HRA fell in 2022 for the third consecutive year to 47% (from 59% in 2021). The proportion of OTF-W incidents remained stable compared to 2021 for the Edge Area (47%) and the LRA (28%) (Table 3.1.1).

Table 3.1.1 Number of new TB incidents and herd incidence rate in England, by risk area, during 2021 and 2022

	HRA	Edge Area	LRA	England
All new TB incidents in 2022	**2,294**	**490**	**145**	**2,929**
(Percentage of total for England)	**78.3**	**16.7**	**5.0**	
All new TB incidents in 2021	2,155	573	123	2,851
(Percentage of total for England)	75.6	20.1	4.3	
New TB incidents in 2022 that were lesion and/or culture positive (i.e. OTF-W incidents)	**1,079**	**232**	**40**	**1,351**
(Percentage of total incidents for risk area)	**47.0**	**47.3**	**27.6**	**46.1**
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
TB incidence rate (OTF-W and OTF-S) per 100 HYR in 2022	**14.4**	**7.7**	**1.1**	**8.4**
TB incidence rate **(OTF-W and OTF-S)** per 100 HYR in 2021	14.4	8.9	1.1	8.8
Percentage change in TB incidence rate per 100 HYR from 2021 to 2022	**0%**	**-14%**	**3%**	**-5%**

NB: The 3% change in incidence rate between 2022 and 2021 for the LRA is due to the very small fluctuation in the low incidence rate (1.106 incidents per 100 HYR in 2021 and 1.141 incidents per 100 HYR in 2022).

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

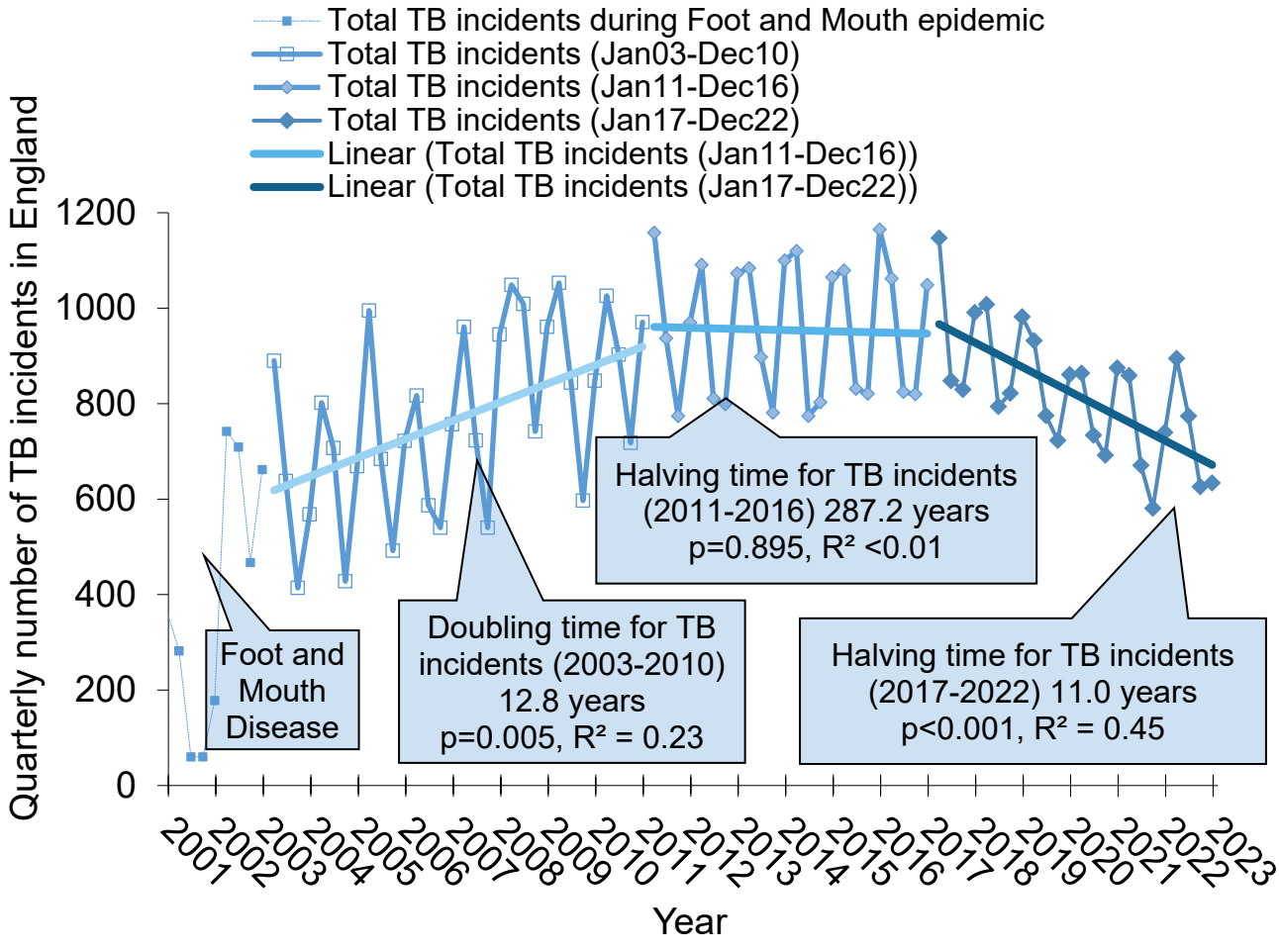
epidemic to double in size was estimated at 5.3 years (see Figure 3.1.1a in Bovine tuberculosis in England in 2018).

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 3.1.1). 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. Between 2017 and 2022, quarterly TB incidents had a halving time of 11.0 years (p<0.001), and an average annual rate of decrease of 6%. Although this is encouraging, the current quarterly number of incidents is still more than double 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 2022

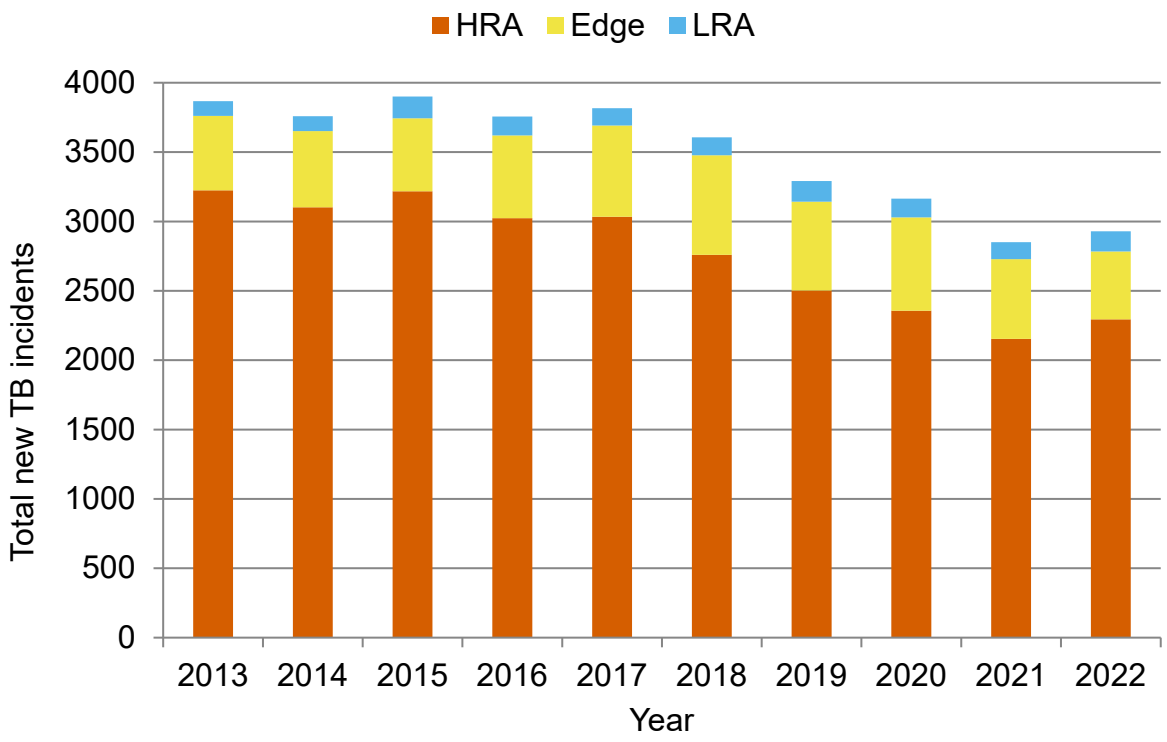
Figure



- Trend lines are shown for the three periods 2003-2010, 2011-2016 and 2017-2022. 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 R2 value indicates ‘goodness of fit’ of the trend line to the raw data (an R2 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 (12.8 years, $p=0.005$), as is the decreasing trend for the period 2017-2022 (11.0 years, $p<0.001$).

The total number of new TB herd incidents in England increased for the first time in five years in 2022, rising slightly from 2,851 in 2021 to 2,929. Previously, the number of incidents had been decreasing year on year since 2018. Prior to this 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).

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 increased by 3% between 2021 and 2022, driven by increases in the number of OTF-S incidents in the HRA and LRA.
- The number of new TB incidents in the Edge Area in 2022, for the second consecutive year.

In the HRA, most counties saw an increase in the total number of new incidents in 2022 compared to 2021 (see chapter 4.1 for more details). The exceptions were Avon, Hereford and Worcester, Shropshire and Staffordshire, all of which saw a decrease in the total number of incidents (by 7%, 1%, 16% and 29%, respectively). All four counties also saw decreases in the number of OTF-W incidents (by 15%, 16%, 33% and 35%, respectively).

Counties in the HRA experiencing increases in both the total number of incidents and number of OTF-W incidents were Cornwall, Gloucestershire, the West Midlands and Wiltshire.

Devon, Dorset and Somerset, had increases in the total number of incidents, but OTF-W incidents fell (by 10%, 24% and 21% respectively). An investigation into this increase in new TB incidents in most HRA counties during 2022 found the roll-out of six-monthly testing was an important factor in driving this trend. There was a small reduction in the percentage of routine herd tests that disclosed a new TB incident in the HRA over this time. The first additional six-monthly routine herd tests were performed in Shropshire and Staffordshire in March 2021, with the rest of the HRA adopting default six-monthly testing

in January 2022. Over the first 12 months following roll-out, the number of routine herd tests performed doubled. The number of new TB incidents disclosed by whole herd testing increased by 79% in the HRA, excluding Shropshire and Staffordshire.

Similarly, the picture in the Edge Area counties was not uniform, despite overall reductions in both the numbers of total and OTF-W incidents.

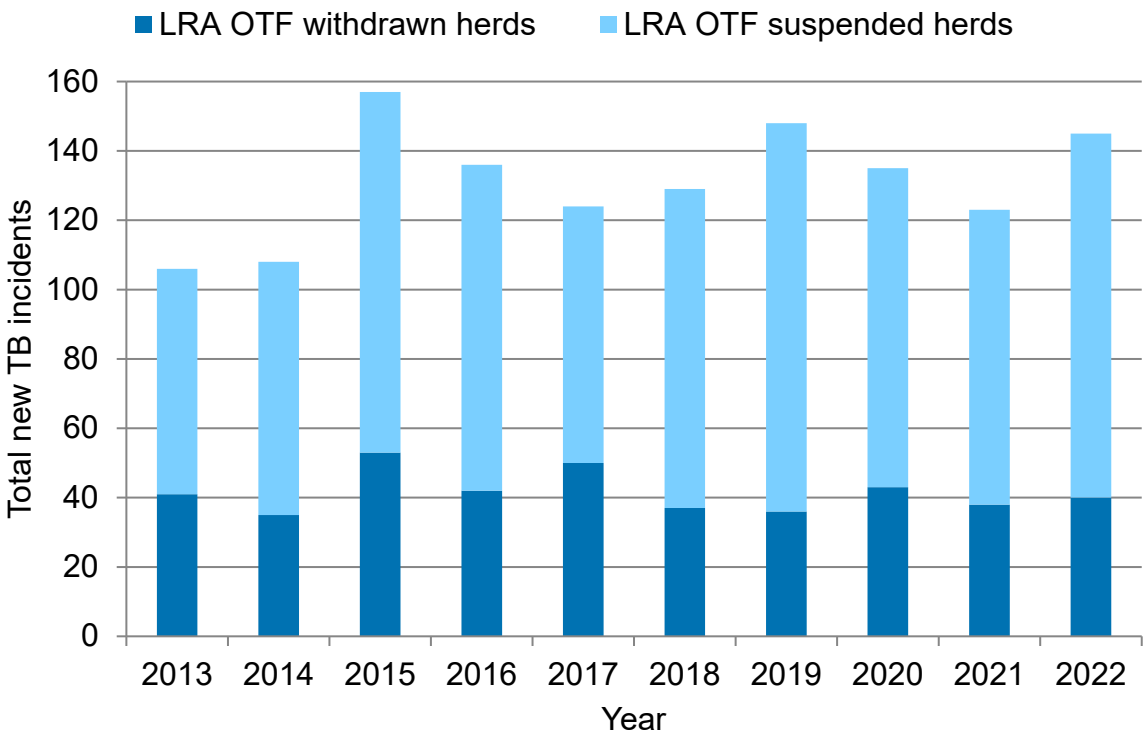
Buckinghamshire and Hampshire saw increases in the total number of incidents compared to 2021. For Buckinghamshire, this represented a 15% increase, driven by the number of OTF-W incidents doubling since last year. This was the second consecutive year that total incidents in Buckinghamshire increased, though the increase between 2020 and 2021 was due to higher numbers of OTF-S incidents. Veterinary assessment highlighted an increasing role of wildlife and spread of infection from Oxfordshire – this is discussed in more detail in the Oxfordshire County Report for 2022.

In East Sussex, Leicestershire and Warwickshire, the number of OTF-W incidents increased compared to 2021 (by 25%, 57% and 14% respectively). However, in East Sussex, this was due to variations involving a very small number of cases (4 in 2021 to 5 in 2022). Although the total number of incidents in all three counties decreased overall, these was not statistically significant.

The number of total incidents (145) and OTF-W incidents (40) in the LRA increased in 2022 compared to 2021 (123 total incidents and 38 OTF-W incidents). In the previous five years, the highest number of total incidents was 148, in 2019 (Figure 3.1.3).

The number of total incidents increased in most counties in the LRA, but a quarter of counties experienced a reduction between 2021 and 2022. These were Lincolnshire (17, down from 20 incidents), North Yorkshire (17 incidents, down from 20), Suffolk (3, down from 4), Hertfordshire (2, down from 4), Bedfordshire (0, down from 4), and Northumberland (0, down from 3). None of these decreases were statistically significant. A third of counties in the LRA experienced increases in the number of OTF-W incidents, which were very small, meaning the increase in incidents seen in the LRA overall was driven by an increase in the number of OTF-S incidents. More details about incidents in the LRA are available in Chapters 3.2 and 4.3 of this report, as well as in the individual 2022 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 new infected herds in the LRA containing at least one reactor with visible lesions and/or an M. bovis culture/PCR-positive animal (new OTF-W incidents) increased slightly in 2022 compared to 2021 (40 and 38, respectively), but the numbers have been relatively stable over the last decade. The number of new incidents was highest in 2015 (53), but there is no clear temporal trend.
- The percentage of new OTF-W incidents in the LRA fell slightly in 2022 compared to 2021 (28% and 31% respectively).

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 OTF 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 risk areas that have moved between annual and six-monthly testing (such as the Edge Area in 2018, Shropshire and Staffordshire in 2020, and all remaining HRA counties in 2021 – see above). A detailed description of the methodology used to calculate the incidence rate per 100 HYR is available in the Explanatory Supplement.

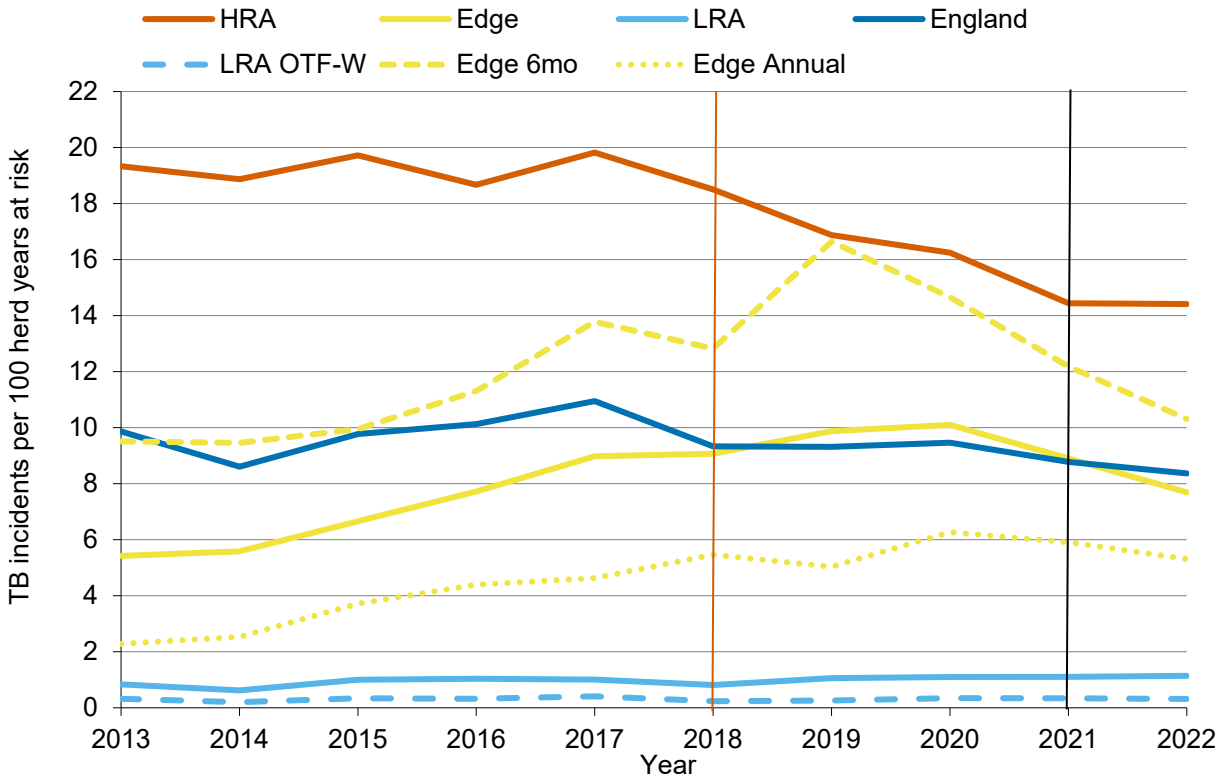
Figure 3.1.4 shows the annual incidence rate for England and by risk area, from 2013 to 2022. Annual rates are also presented separately for the six-monthly and annual testing portions of the Edge Area (according to parish testing status in 2022). Overall, the incidence rate of TB in England in 2022 fell to 8.4 TB incidents per 100 HYR. Although the decrease was not significant compared to 2021 (incidence rate ratio 0.95, p=0.07), this was 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 second consecutive year to 7.7 incidents per 100 HYR in 2022, from 8.9 incidents per 100 HYR in 2021 (Table 3.1.1 and Figure 3.1.4). This represents a significant decrease of 14% compared to 2021 (p=0.02). The fall in incidence in the Edge Area was driven by a reduction in the number of OTF-W incidents in 2022 compared to 2021, particularly in the 6 monthly testing area (160 incidents in 2022 compared to 198 in 2021).

In the LRA, the incidence rate remained stable in 2022 compared to 2021 (1.1 incidents per 100 HYR for both years, p=0.79). There was a non-significant fall in the OTF-W incidence rate in the LRA (0.31 incidents per 100 HYR in 2022 compared to 0.34 in 2021 (p=0.71)) – this was despite a very small increase in OTF-W cases in 2022, as the time at risk (the denominator) increased as well. However, the OTF-S incidence rate increased non-significantly in 2022 (0.76 in 2021 compared to 0.82 in 2022, p=0.59). These small fluctuations in the incidence rates for total, OTF-W and OTF-S cases reflect the very small number of cases present in the LRA.

Incidence rate in the HRA in 2022 was 14.4 incidents per 100 HYR, the same as in 2021. Both the denominator (herd-years at risk), and the numerator (number of TB incidents) increased non-significantly (p=0.95) in the HRA in 2022.

Figure 3.1.4 Annual incidence rate (per 100 HYR) for England and by risk area, including OTF-W incidence rate for the LRA, from 2013 to 2022. The orange vertical line represents the year part-HRA and part-Edge counties moved fully into Edge Area on six-monthly testing, and the black vertical line shows the year all HRA counties moved to six-monthly testing.



- The decrease in incidence rate in England overall was not significant in 2022 compared to 2021 (p=0.07).
- There was no change in incidence rate between 2021 and 2022 in the HRA (14.4 incidents per 100 HYR), following decreases for four years in a row since 2018.
- Incidence rate fell significantly (p=0.02) in the Edge Area for a second year in a row in 2022 compared to 2021, to a rate last seen in 2016 (7.7 incidents per 100 HYR).
- Incidence rates in both the six monthly and annual testing areas of the Edge Area fell in 2022 compared to 2021, for the third and second consecutive years respectively.
- In the LRA, the total incidence rate was unchanged between 2021 and 2022 (1.1 incidents per 100 HYR) and the OTF-W incidence rate fell marginally during that same period (0.34 incidents per 100 HYR in 2021 to 0.31 in 2022), but this was not statistically significant.

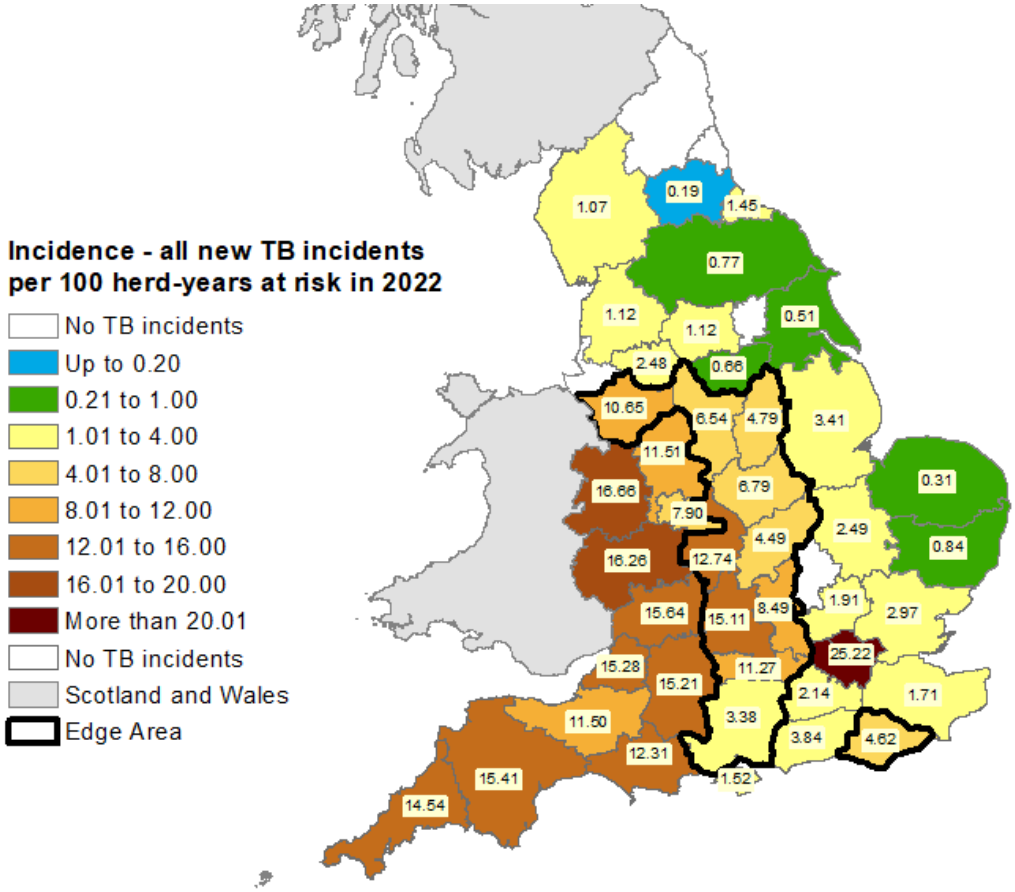
Figure 3.1.5 shows the incidence rate per 100 HYR for individual counties in England during 2022. In the HRA, the counties with the highest incidence in 2022 were Shropshire (16.7) and Hereford and Worcester (16.3). The incidence rate overall in 2022 was the

same as in 2021, remaining at its lowest level since pre-2013. At county-level, the incidence rate increased in Cornwall, Devon, Dorset, Gloucestershire, and the West Midlands in 2022 compared to 2021. However, this increase was only statistically significant in Cornwall (14.5 incidents per 100 HYR in 2022 compared to 11.7 in 2021, p=0.01).

In the Edge Area, the incidence rate decreased in 2022 for all but two counties, Buckinghamshire and Hampshire. Incidence increased by 23% and 3%, respectively, in these counties but these trends were not statistically significant. This is because there were only small increases in the number of incidents for both counties and the time at risk for herds in these counties remained similar between 2021 and 2022, and this is reflected in the statistically significant shorter amount of time that herds were under restriction for in 2022 compared to 2021 (Table 1.1, paired t-test p=0.0048).

The incidence rate remained low and stable in the LRA, with around half the counties seeing a non-significant increase in 2022 compared to 2021, and the other half a similar non-significant decrease over the same period.
Of note, the incidence rate increased in Cambridgeshire, Essex, Kent, Lancashire, and Lincolnshire. All these counties have seen overall increases in their incidence rates since 2018 – however, none of these upward trends were statistically significant.

Figure 3.1.5 County herd incidence (all new TB incidents per 100 HYR) in England in 2022



- There continues to be wide variation in incidence rates by county and risk area. Incidence was highest overall in the HRA counties Shropshire, and Hereford and Worcester.
- Incidence was inflated in Greater London in 2022 due to a single new OTF-S incident in this area and the low number of herds present in this urban environment.

Spatial changes in the TB epidemic

Changes between 2022 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 a 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 it borders the

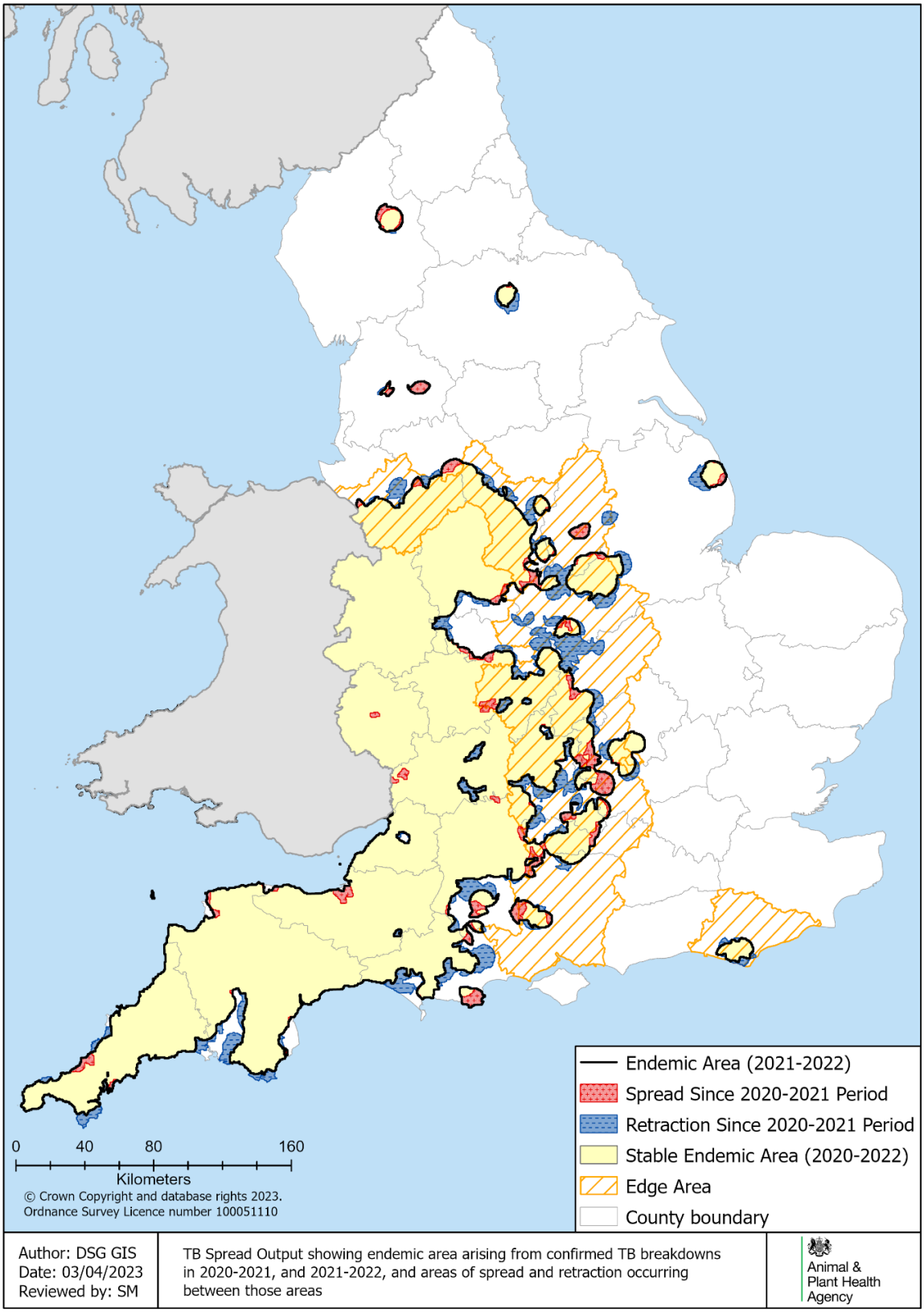
HRA. However, in the Edge Area, there were large areas of retraction of the endemic area, particularly around south Leicestershire and Nottinghamshire, and in Oxfordshire. There has been some spread into central Buckinghamshire, and an area of spread in 2020/2021 on the Bedfordshire/Buckinghamshire border became endemic in 2021/2022.

As seen in previous years, most of the rest of England, particularly the LRA, remains free of endemic infection. Small areas of retraction were seen within the LRA in Lincolnshire around confirmed hotspot 23 (in the southwest of the county) and potential hotspot HS28 (east of the county) and on the western side of the small endemic area in North Yorkshire. There was retraction in Lancashire between 2020 and 2021, but areas of spread towards the centre and east of the county have reversed that trend in 2021/2022. Additionally, areas of spread which appeared in 2020/2021 in Cumbria (near confirmed hotspot HS21) have now become endemic.

APHA veterinary assessment has highlighted that the spread of endemic disease from Buckinghamshire includes some areas in the LRA which are being kept under observation, such as the creation in 2023 of a new potential TB hotspot area straddling the border with Hertfordshire (HS30). Additionally, the areas of spread in the west of Hampshire are also being monitored. Further details on spread of the endemic TB areas can be found in the LRA and Edge County Reports for more information).

The endemically infected area of England spread by approximately 1,738.63 km² in some parts, but contracted by 4,045.61 km² in other parts, resulting in a net overall retraction of -2,306.98 km^2 since 2020-2021. The net change refers to the area for which rate of spread could 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 2022 compared to 2021. A geographical unit (500 by 500 metre grid cell) was considered endemic if there are at least three OTF-W incidents within a 5 km radius within a two-year period.



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). The current model of intensive badger culling for TB control purposes has been implemented in England since 2013, carried out by badger culling companies under licences issued by 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 2022 are summarised below.

Licensed badger culling

In 2022, eleven new intensive badger culling areas were licensed in England (five in the HRA and six in the Edge Area) in addition to 29 extant areas that were re-authorised. Therefore, a total 40 intensive badger control areas were in operation during 2022, as well as 29 additional areas where Supplementary Badger Control was undertaken (having already completed four annual seasons of intensive culling).

Badger removal results from 2022 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 2022.

Licensed badger vaccination

Badger vaccination was active in 19 counties in 2022: ten in the HRA, six in the Edge and three in the LRA. Badger vaccination operations were carried out between 1 May and 30 November 2022 on 2,343 badgers across England. Under the Licences to cage-trap and mark badgers for bovine TB vaccination, the area where the respective landholder has permitted access for badger vaccination, is not routinely mapped, and thus an estimation of the area covered by these licenses can no longer be provided. More details can be found in the Summary of Badger Vaccination in 2022.

TB in non-bovine domestic and captive species in 2022

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.

There is no statutory routine TB surveillance of non-bovine species, apart from post mortem examination (PME) of animals slaughtered for human consumption (deer goats, pigs and sheep). Targeted ante-mortem TB testing takes place in a small number of non-bovine herds with laboratory confirmed M. bovis infection, and in specific herds of camelids, goats and captive deer at an elevated risk of infection, such as those that are contiguous to (or co-located with) cattle herds affected by OTFW incidents.

The number of total ante-mortem TB tests carried out on individual animals in England for all non-bovine species was 13,591, a 46% decrease from 2021 (25,034).
This decrease was largely driven by an 82% fall in the number of goats submitted for testing (1,858 in 2022 compared to 10,093 in 2021). The number of tests carried out on pigs also fell by 88%, from 4,082 in 2021 to 480 in 2022. However, the number of pigs tested in 2022 was more similar to the annual numbers tested prior to 2020, after which there was a 14-fold increase in tests carried out. The number of South American camelids tested also fell by 39% in 2022 (3,880) compared to 2021 (6,343). In contrast, there was a 61% increase in the number of sheep tested for TB in 2022 (3,787) compared to 2021 (2,355) and a 66% increase in deer tested (3,545 in 2022 versus 2,132 in 2021). This is the highest number of TB tests in deer in England since 2011 and is explained partly by the partial slaughter of a single large herd of farmed red deer in Cornwall in 2022.

The number of test-positive animals slaughtered for TB control reasons increased slightly by 11% in 2022, mainly due to the number of slaughtered test-positive deer rising by almost a third (172 in 2022, 135 in 2021). Additionally, the number of culture positive tests (in individual animals) increased by 52% in 2022 (64) compared to 2021 (42). This was largely driven by a rise in culture-positive results from deer samples (34 in 2022, 20 in 2021).

Overall, the number of laboratory-confirmed TB incidents (in herds) fell by three-quarters between 2021 and 2022 (20 incidents to 5 in 2022), with a two-thirds decrease in the number of laboratory-confirmed TB incidents in deer (9 in 2021, 3 in 2022). These changes are not unexpected due to the small numbers of incidents involved.

Table 3.1.2: Results of TB surveillance in non-bovine farmed and captive animal species in England in 2021 and 2022. Data adapted from the statistics of TB in non-bovine species, 2011-2022.

	2021	2022
Total ante-mortem tests		
South American Camelids	6,343	3,880
Sheep	2,355	3,787
Goats	10,093	1,858
Pigs	4,082	480
Deer	2,132	3,545
Other	29	41
Total for all non-bovines	25,034	13,591
Total TB Positive animals slaughtered (%)		
SA Camelids	92 (1.5%)	92 (2.4%)
Sheep	16(0.7%)	3 (0.1%)
Goats	5 (0.0%)	8 (0.4%)
Pigs	0 (0.0%)	0 (0.0%)
Deer	135 (6.3%)	172 (4.9%)
Other	0 (0.0%)	0 (0.0%)
Total for all non-bovines	248	275
Total culture positive tests (%)		
SA Camelids	12 (14.5%)	10 (14.5%)
Sheep	1 (14.3%)	4 (57.1%)
Goats	1 (14.3%)	0 (0.0%)
Pigs	4 (2.1%)	9 (4.8%)
Deer	20 (48.8%)	34 (82.9%)
Other	4 (22.2%)	7 (38.9%)
Total for all non-bovines	42	64
Total laboratory confirmed TB incidents		
SA Camelids	2	0
Sheep	2	1
Goats	0	0
Pigs	3	0
Deer	9	3
Other	4	1
Total for all non-bovines	20	5

NB: The "Other" category includes mainly pets (cats and dogs) and the occasional sample from exotic mammals kept in zoos, safari parks. The percentage of culture positive tests is the proportion of culture positive tests from the number of animal specimens that underwent culture for the year of interest for each species of interest – this is provided the statistics of TB in non-bovine species, 2011-2022.

3.2 Characteristics of (and sources of infection for) herds with a new TB incident

- As in 2021, four key factors significantly increased the risk of a herd having a new TB incident in England in 2022 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 remains largely uninfected, showing that other factors are also important in the occurrence of TB. 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 four 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 were 42% more likely to have a TB incident 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 in the herd was also an important risk factor in all risk areas. Across England, over half the herds (52%) that were disclosed in 2022 had sustained a TB incident within the previous three years (recurrent infection). The probability of recurrence was highest in the HRA (56% of herds with new incidents in 2022), followed by the Edge Area (48%) and LRA (15%).
- Due to the impact of the avian influenza outbreaks in 2021 and 2022 on veterinary investigation into the source of infection for new TB incidents, novel data driven methods to quantify the likelihood of risk pathways for TB infection were developed by APHA. This new method combines cattle movement data with whole genome sequencing (WGS) data from M. bovis isolates in cattle to provide insights into possible risk pathways for new incidents. For most new TB incidents in 2022, across all risk areas, there was no evidence of cattle movements associated with a high likelihood of infection and there was no WGS data available to explore the presence of a local reservoir. Therefore, there is insufficient evidence for these herds to determine a likely infection pathway This applied to 56% incidents in the HRA, 52% in the Edge Area and 70% in the LRA. WGS data identified a local reservoir of infection but no cattle movements associated with a high likelihood of

infection for 19% new TB incidents in the HRA, 20% in the Edge Area and 7% in the LRA in 2022.

- Most TB incidents (84%) 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.

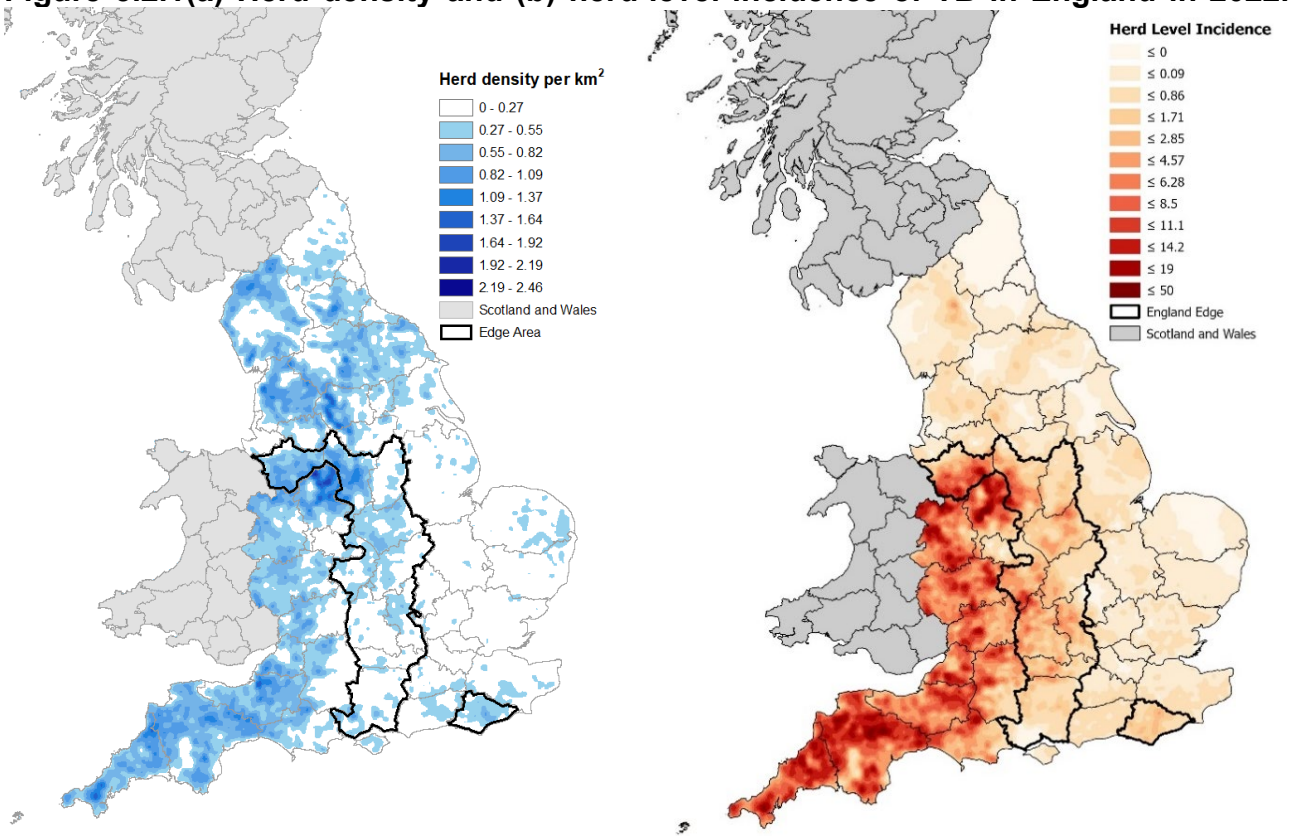
Factors associated with the likelihood that a herd will become infected

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 or wildlife factors.

Local herd density

Herd size and local density 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 2022.

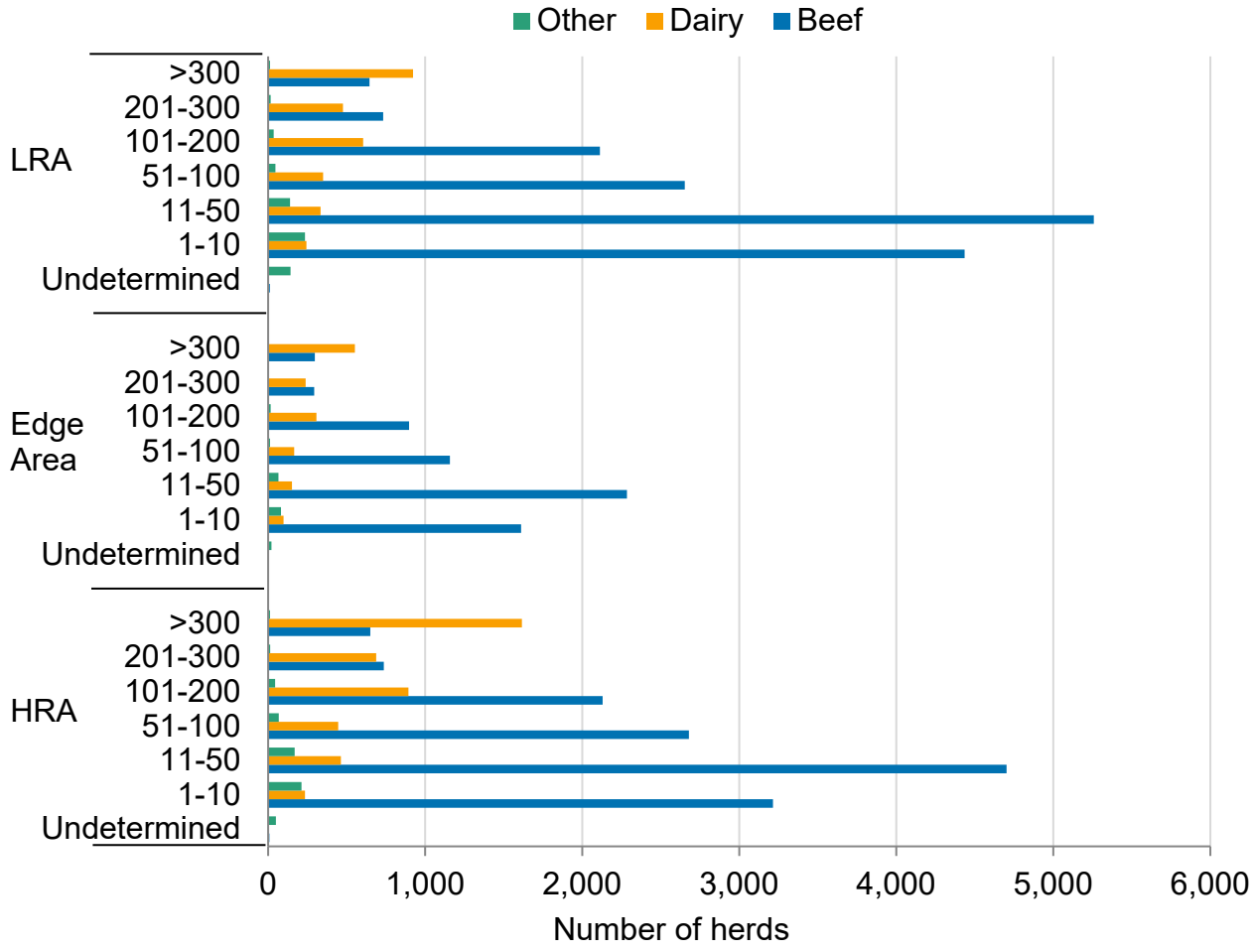


- Herd density is measured as the number of herds per square kilometre; herd incidence is the average incidence per 100 herd years at risk in the 100 closest herds to each herd location, which ‘smooths’ the effect of political boundaries.
- The highest numbers of cattle and herd density are primarily 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.

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 2021.

Figure 3.2.2: Number of herds by herd size and type in each risk area of England in 2022



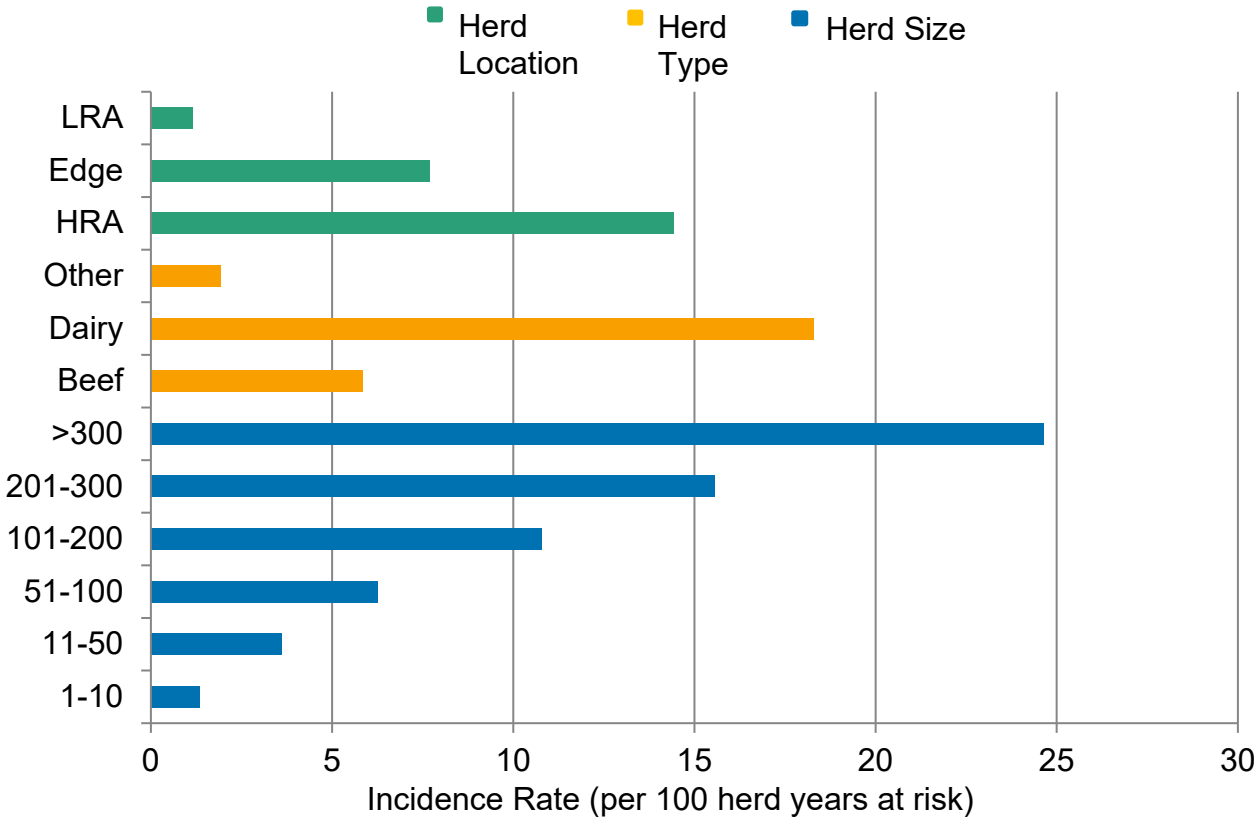
- There are proportionally more large herds and dairy herds in the HRA compared with the other two risk areas. This may explain some of the spatial distribution of TB infection.

The percentage of TB incidents disclosed in beef (54%), dairy (46%) and “other” (0.4%) herds in 2022 represented a decrease of 1.1% in beef herds and an increase of 1.6% in dairy herds compared to 2021. This increasing trend in the percentage of TB incidents affecting 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 (unadjusted) incidence rates according to different characteristics (size,

production type and location) of herds in England. This demonstrates that dairy herds were nearly three times more likely to become infected with TB than beef herds in 2022. 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 (unadjusted) in herds of different size and type, and in each risk area of England, in 2022



- Herd size, type and location are all 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 25 new TB incidents per 100 herd-years at risk in 2022, while it was under 5 in herds with 50 or fewer cattle.
- Dairy herds were three times more likely to suffer a TB incident in 2022 than beef herds.
- The herd incidence rate in the HRA was 1.9 times greater than when compared to the Edge Area and just over 13 times greater than that in the LRA.

Potential risk factors were explored further by comparing incidence rate ratios (IRR). 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 adjusted for. These comparative ratios are shown in Figure 3.2.3b.

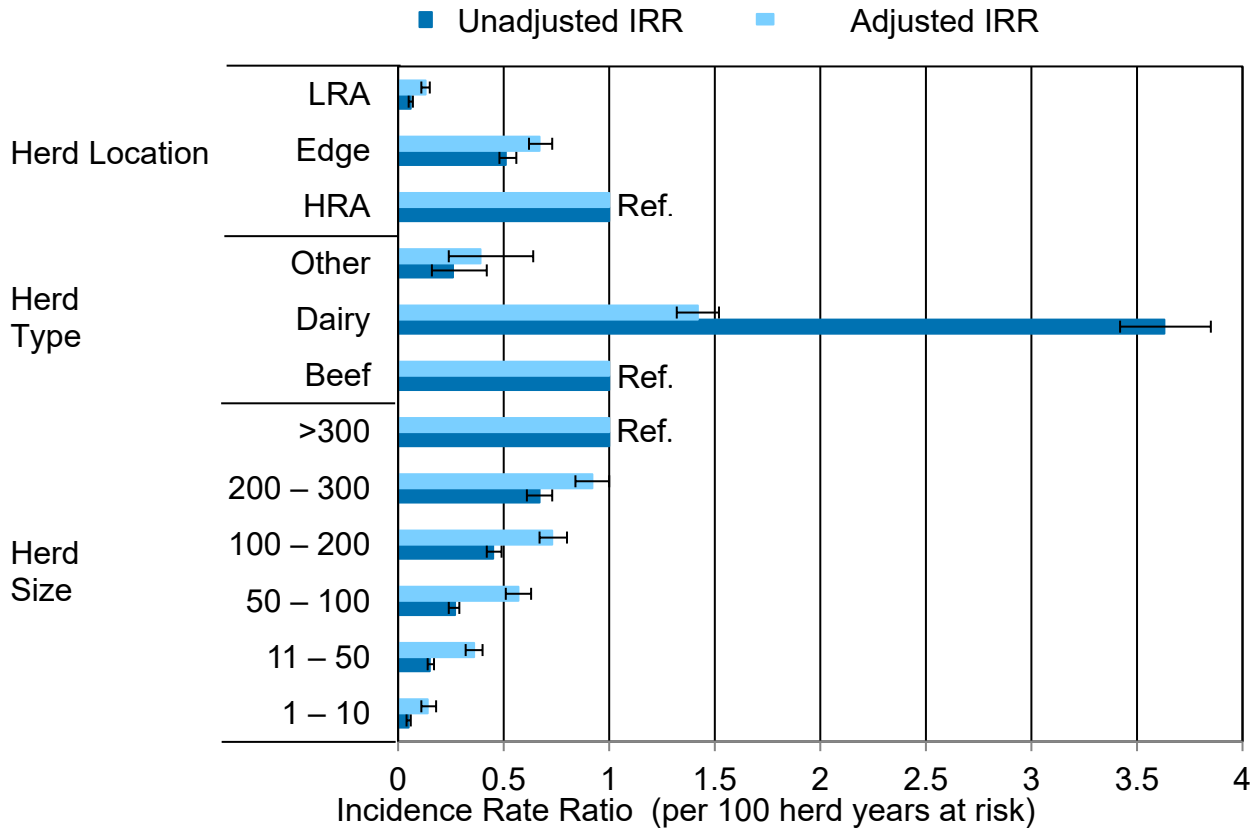
For herd size, if location and herd type are adjusted for when calculating the IRR, the adjusted IRR remains similar to the unadjusted IRR. This indicates that herd size may be the main factor driving the observed trends. The adjusted IRR for herds with 300 or fewer animals ranged from 0.14 to 0.92 times 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 primarily 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 infections in 2022 than beef herds of the same size and risk area (adjusted IRR=1.42, 95% CI 1.32 to 1.52, $p<0.001$).

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 2022, the adjusted IRR for herds in the Edge Area compared to the HRA was 0.67 (95% CI 0.62-0.73). 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, increasing to 0.49 in 2018, 0.6 in 2019, 0.64 in 2020 and 0.65 in 2021.

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 2022. The "Ref." acronym refers to the reference category used when calculating the incidence rate ratio.



- 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 over half 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 42% more likely to have a TB incident than beef herds (32% in 2021).

Recurrent TB incidents

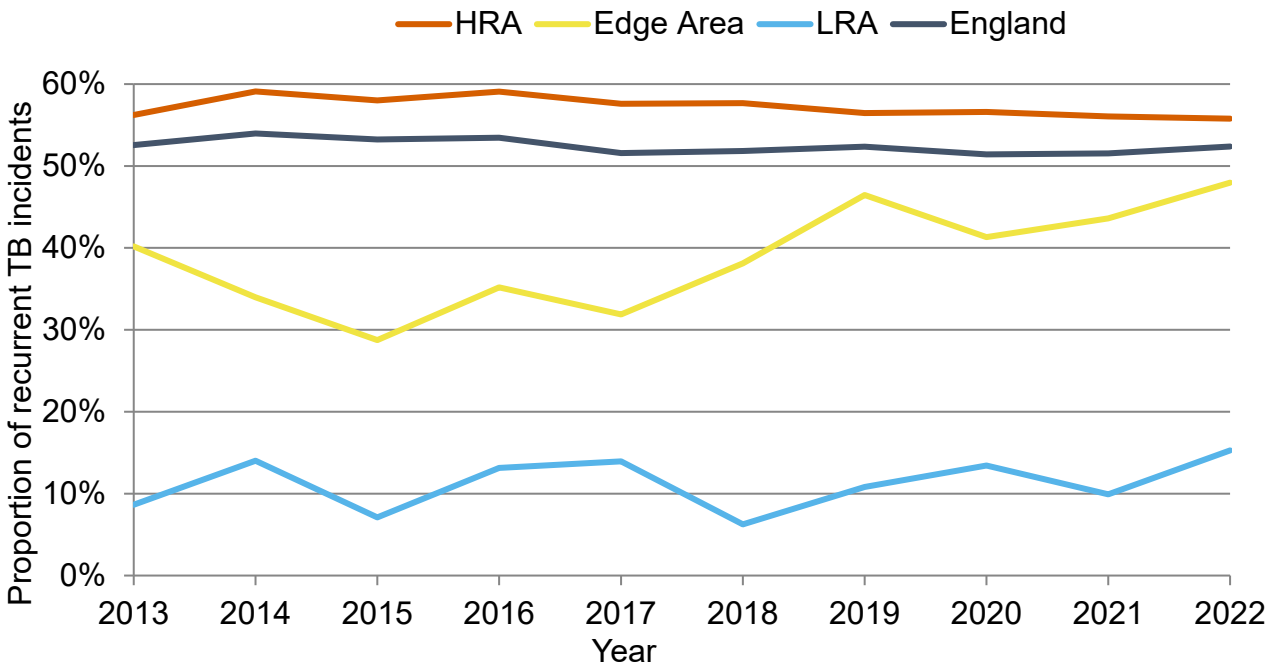
A herd's history of TB is linked to increased odds of infection occurring in any given year. A recurrent incident is a new TB incident in a herd that had another TB incident in the previous three years. The percentage of recurrent infected herds are explored in two ways.

1. The percentage of all herds with a history of TB in the last three years that went on to experience a TB incident in 2022, compared to the percentage of all herds without a history of TB in the last three years that went on to have a TB incident in 2022 (forward-looking recurrence – comparing a cohort of herds from the past to their present outcomes).
2. The percentage of TB incident herds in 2022 that had sustained a TB incident in the previous three years (backward-looking recurrence – looking at the TB history of herds that had an incident this reporting year).

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 and iBTB.

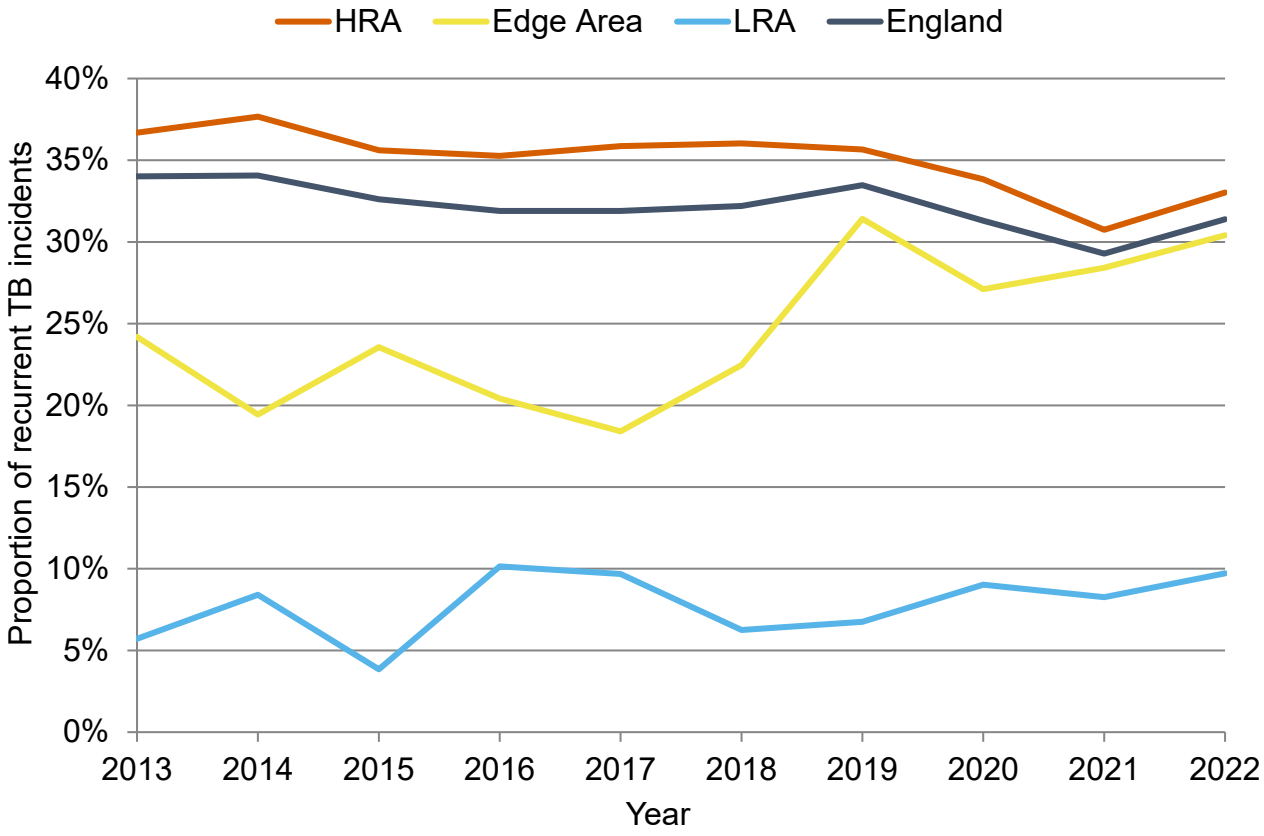
The annual trend in the percentage of new TB incidents detected in each year that had a history of TB in the preceding three years is shown in Figure 3.2.4. Recurrence in England overall was the same in 2021 and 2022 (52%). Recurrence was consistently highest in the HRA, and lowest in the LRA. The percentage of recurrent incidents remained the same in the HRA (56%) but increased in the Edge Area (from 44% to 48%). In the LRA, recurrence was much lower than in the other two TB risk areas of England, at 15%, which is the highest since 2007 (Figure 3.2.4). However, annual recurrence in this area has fluctuated over time with no significant increasing or decreasing trends.

Figure 3.2.4a Annual percentage of TB incidents with a history of TB in the previous three years, by risk area, from 2013 to 2022



- The percentage of recurrent TB incidents has shown a consistent (but not significant) downward trend in the HRA since 2013.
- The percentage of recurrent TB incidents has remained relatively stable LRA over the past ten years.
- The percentage of recurrent TB incidents increased for the second year in the Edge Area in 2022 (48%), the highest proportion seen since 2006 and higher than the previous peak of recurrence in 2019 (47%).
- In the LRA, the percentage of recurrent TB incidents increased to 15% in 2022, following the decrease between 2020 (13%) and 2021 (10%) and is the highest proportion since 2007.

Figure 3.2.4b Annual percentage of TB incidents with a history of TB in the previous 18 months, by risk area, from 2013 to 2022



- The percentage of recurrent TB incidents in the HRA increased from 31% in 2021 to 33% in 2022.
- The percentage of recurrent TB incidents has remained relatively stable LRA over the past ten years.
- The percentage of recurrent TB incidents increased for the second year in the Edge Area in 2022 (30%) but was lower than the previous peak of recurrence in 2019 (31%).
- In the LRA, the percentage of recurrent TB incidents increased to 10% in 2022, following the decrease between 2020 (9%) and 2021 (8%) and is the highest proportion since 2017.

Forward-looking recurrence

In 2022, herds in the HRA with a history of TB (in the previous three years) were twice as likely to have an incident compared to herds with no history of TB (95% CI: 1.8 - 2.2.), and similarly herds with a history of TB in the Edge Area were 2.5 times as likely to have an incident than herds without a TB history (95% CI 2.1-3.0). The odds of forward recurrence was highest in the LRA, where herds with a history of TB (in the previous three years) were 6.5 times more likely to have a TB incident in 2022 (95% CI 3.9-10.0). The

confidence interval also does not overlap with either the HRA or the Edge Area intervals, highlighting that the risk of an incident in the LRA is associated with previous TB history to a greater extent than it is in either the HRA or Edge. This is potentially due to the impact of hotspot areas and recurrent independent incidents in beef fattening units which regularly bring in cattle from the higher TB risk areas of England and Wales.

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 2022, the Edge Area recurrence odds ratio remained similar to the previous years (OR 2.2 [95% CI 1.8-2.6] in 2021 and 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 TB in the Edge Area is heterogenous). When recurrence is calculated for the Edge Area, the odds of herds with a TB history having a new incident in 2022 is higher than the odds in the HRA. However, the odds of TB in herds with no TB history is lower than in the HRA.

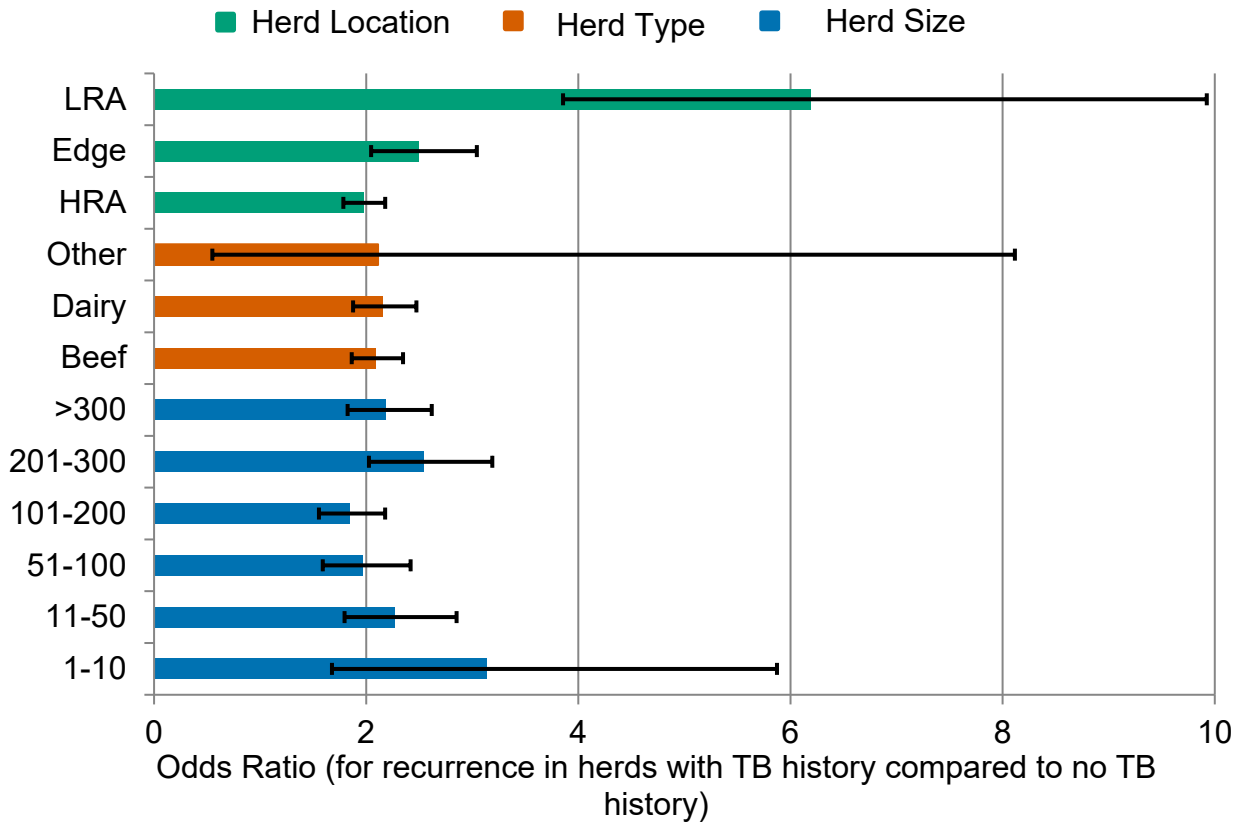
The odds of having TB was roughly two times higher in any herd type (beef, dairy and ‘other’ herds) with a TB history, compared to herds with no TB history, showing that production type was not important in determining the risk of recurrence in a herd.

When the same analyses were run on herds which had suffered previous OTF-W incidents only (rather than any incident), the odds of recurrence remained broadly the same, which was also the case in 2021.

The odds ratios for recurrent incidents compared to new incidents in herds with a history of an OTF-W incident were lowest in the HRA (OR=1.7, 95% CI 1.5-1.8), increasing to 2.4 in the Edge (95% CI 1.9-3.0) and 6.0 in the LRA (95% CI 2.5-14.0).

The odds of having a TB incident in herds with a TB history, compared to herds without a history of TB incident, was similar between herd size categories (Figure 3.2.5a) as in 2021. However, for all herd sizes, the confidence intervals overlapped, showing that the risk of having a TB incident was similar for all herds regardless of size.

Figure 3.2.5a: The odds of recurrent infection in 2022 in herds with a history of TB (in the previous three years) compared to herds with no TB history, by herd size, herd type and risk area (error bars show 95% confidence intervals)

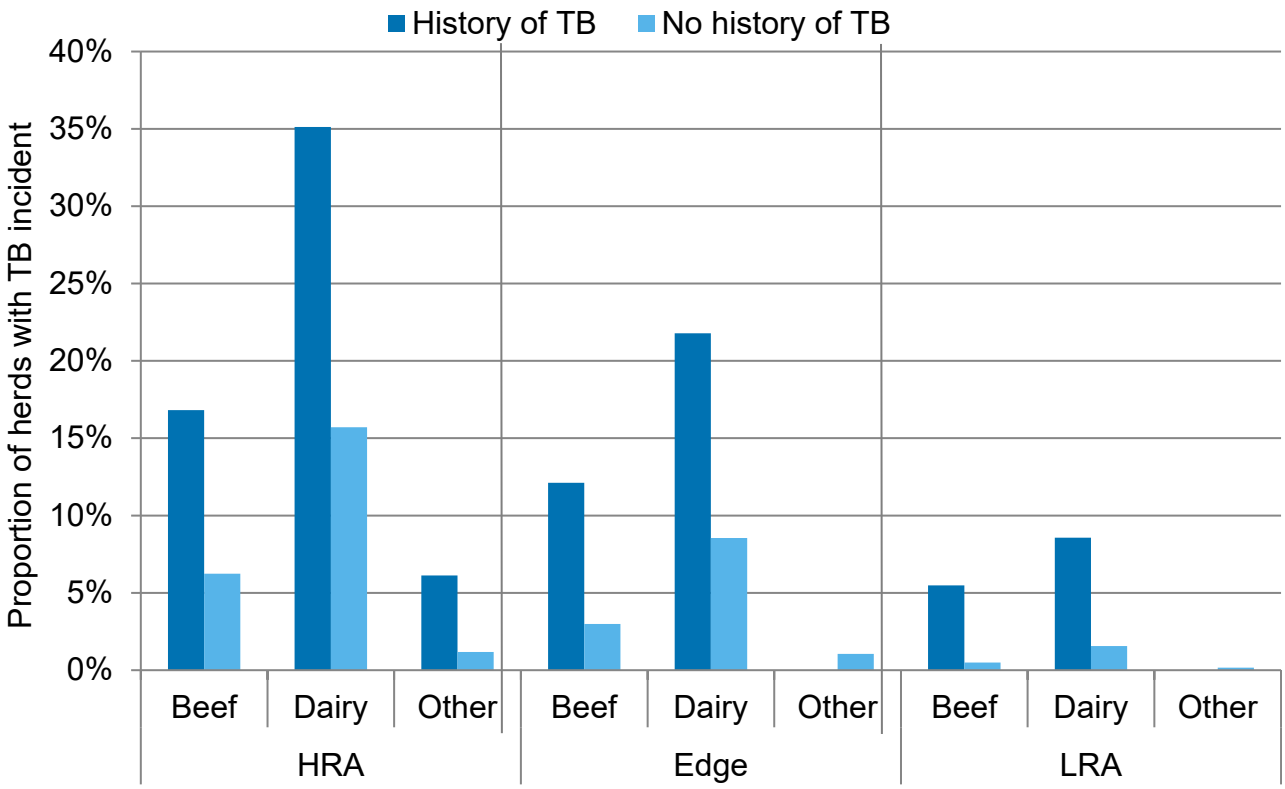


- The risk of recurrence was similar regardless of herd type.
- The risk of a recurrent incident was similar for all herds regardless of size.
- Odds of recurrence in the HRA or Edge is approximately twice as high in herds with a TB history compared to those without, but this increases to six times higher in the LRA
- Odds of recurrence in herds with history of an OTF-W incident was broadly similar as the odds seen for recurrence in herds with a history of any TB incident.

Backward-looking recurrence

Backward-looking recurrence, as a percentage of all herds that were positive in 2022 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 15% of beef herds experiencing a recurrent infection, which was the same as in 2021.

Figure 3.2.5b: The percentage of herds that went on to disclose a TB incident in 2022 with and without a history of TB in the previous three years, by risk area and herd type



- The percentage of beef and dairy herds with a TB incident in 2022 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.

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, in Great Britain 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. As in 2021, WGS clades, instead of

genotypes, are reported for culture-positive samples.

A clade is a group of genetically related isolates, based on similarities between their whole genome sequences. Most genotypes can be ascribed to a single WGS clade, but this is not always the case. The combination of infected herd location and clade detection frequency can be used to describe areas where particular clades are common or endemic (so-called ‘home ranges’). This then enables isolates from new TB incidents to be compared with the previous known geographic distribution of that clade. The improved granularity of WGS data provides greater discrimination between strains of M. bovis than the previous genotyping method, enabling evolutionary relatedness to be determined at a greater resolution. This allows more accurate determination of transmission pathways in incidents.

Of the 1,683 isolates with location and a full clade that had a calculated home range identified in 2022, 1,409 (84%) were in their home range and 274 were out-of-home range. The most frequent clade found in England in 2022 was B6-11, which accounted for 23% of the M. bovis isolates subjected to WGS. This was followed by B6-85 (19%) and B3-11 (16%). These three clades accounted for 58% of all clades disclosed and cover extensive areas in the South West and West of England (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 WGS data, where available. Further statistics on the clades of M. bovis identified in 2022 are included in the GB Data Report.

Figure 3.2.6a. Home ranges of WGS clades B6-11, B6-62 and B6-85 of M. bovis, based on data from 2022.

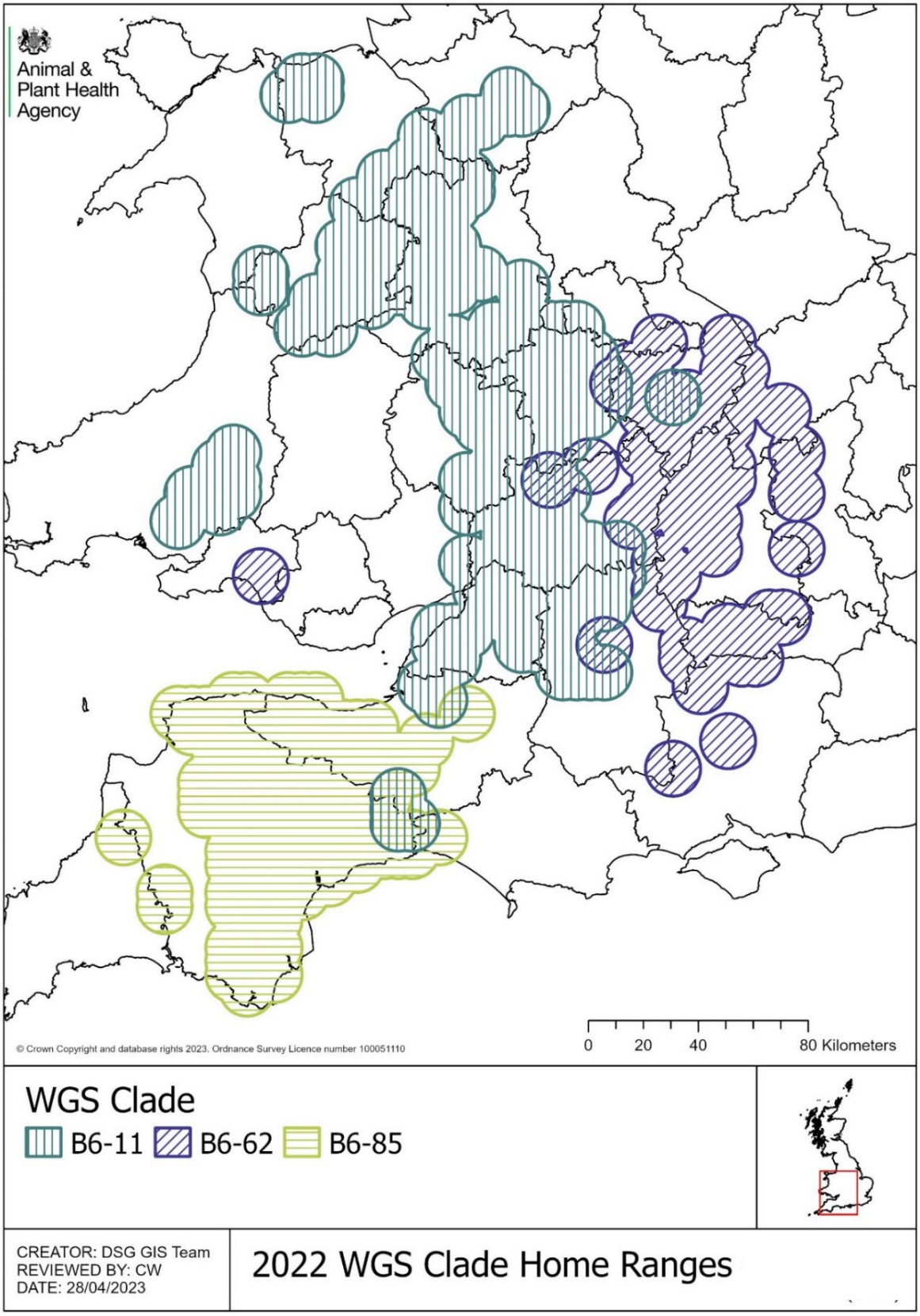


Figure 3.2.6: Map showing the three main homeranges across England. Figure 3.2.6b. Home ranges of WGS clades B3-11, B6-14, B6-83, B4-11 and B6-51 of M. bovis, based on data from 2022.

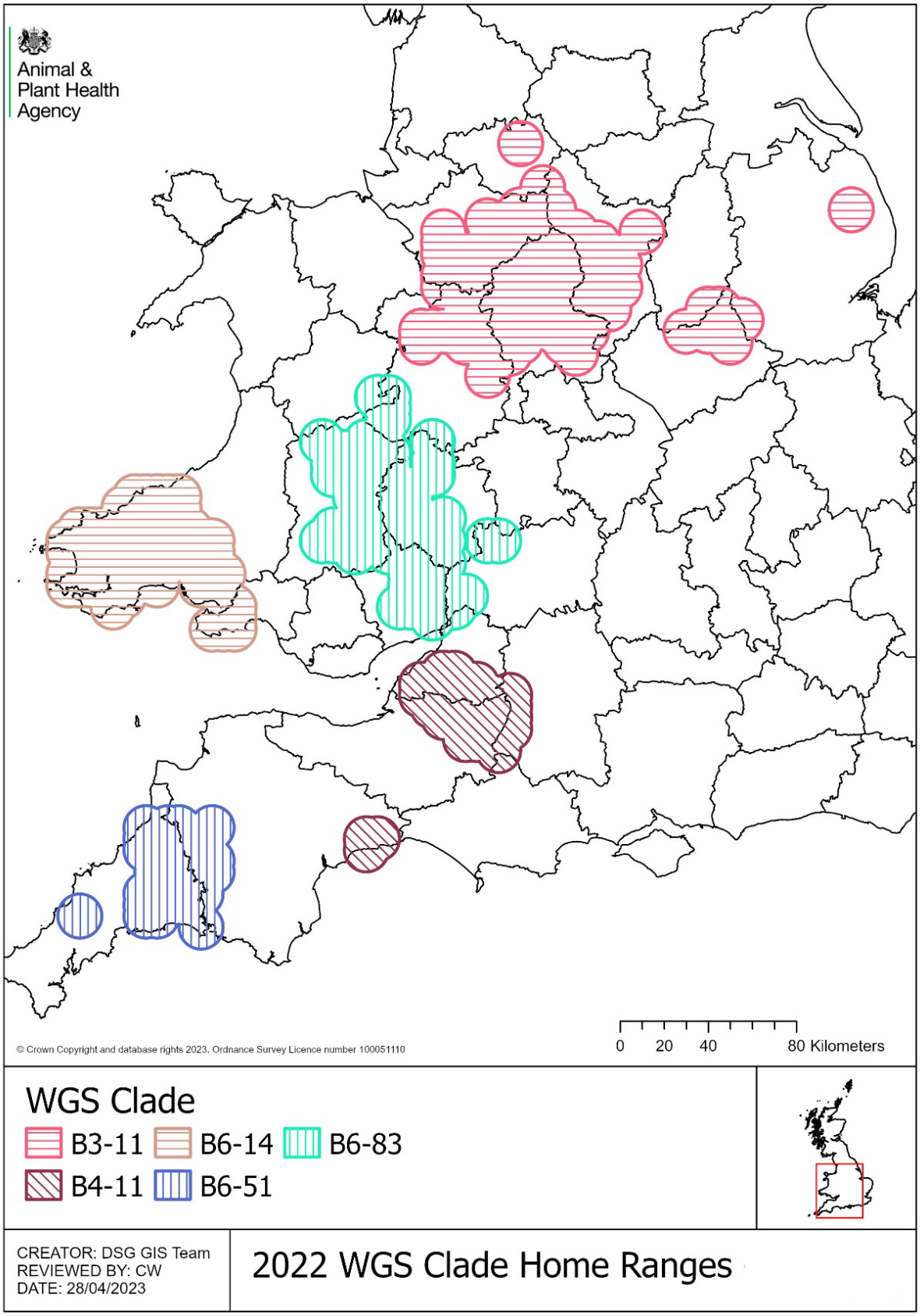
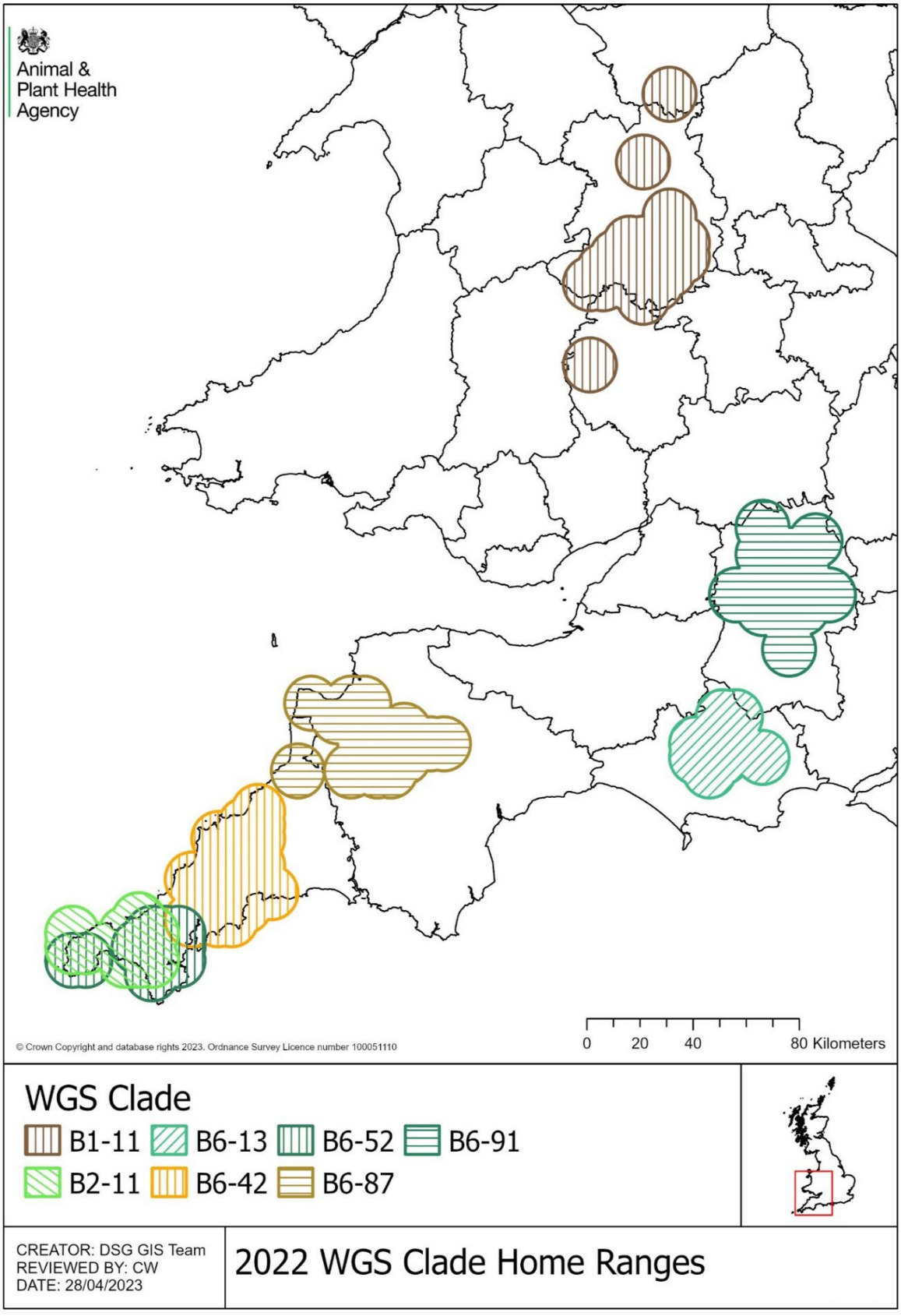


Figure 3.2.6c. Home ranges of other (less widespread) WGS clades of M. bovis, based on data from 2022.



Sources of infection for herds with a new TB incident in 2022

During 2022, fewer TB incidents received a preliminary or final APHA veterinary investigation to identify the source of infection than are usually undertaken. This was due to the diversion of resource to the avian influenza outbreaks of 2021 and 2022.

New data-driven methods to quantify the likelihood of risk pathways for TB infection have been developed by APHA to provide insights into the main drivers for TB at the county and risk area level. These new methods include the:

- Cattle Movement Algorithm
- WGS Local Reservoir Indicator

The Cattle Movement Algorithm uses cattle movement data to identify individual animals that were moved into a TB incident herd as having a negligible, very low, low, medium, high or very high likelihood of being the source of the TB infection. Herds are classified as having either:

- cattle movements associated with a high likelihood of infection (a herd with any movements scored as a high or very high likelihood)
- no cattle movements with a high likelihood of infection (the highest likelihood score was negligible, very low, low or medium)

The cattle movement likelihood score is dictated by the highest likelihood animal movement into that herd, or where ten or more movements at low or medium level occur, then the likelihood is increased to the next level up. For example, ten medium-likelihood rated individual movements for animals in an incident herd would cause the likelihood of introduction to that herd via cattle movements to be rated as high. Where the risk of individual movements is very low, the threshold for aggregation of very low likelihood to low likelihood at the herd-level is 100 individual movements.

The WGS Local Reservoir Indicator uses whole-genome sequencing (WGS) data from cattle M. bovis isolates to identify TB incidents that are linked by genetics, time, and space. A local reservoir is indicated for a new TB incident where at least one other TB incident is identified that satisfies all the following 3 criteria:

- it has a WGS with no more than three single nucleotide polymorphism (SNP) differences relative to the TB incident of interest.
- it is within 4 years before or 6 months after the start date of the incident of interest.
- it is within a 9km radius of the incident of interest.

Further details about the methodology used can be found in the explanatory supplement to the annual reports 2022.

There is always a variable degree of uncertainty about the estimated true routes of TB infection into a herd. However, the absence of a local reservoir, or cattle movements

associated with a high likelihood of infection does not completely negate these pathways. Nonetheless, the evidence provided by cattle movement and WGS data, when combined, can provide valuable insights into the possible risk pathways. Table 3.2.1 provides the combination of each evidence source for each new TB incident in 2022, summarised by TB risk area and county.

Table 3.2.1a: Number and percentage of new TB incidents by result of the WGS local infection indicator and cattle movement algorithm combined, for all new TB incidents (OTF-W and OTF-S) in 2022, by county in the HRA

Risk area or county	Local reservoir identified from WGS, no cattle movements associated with a high likelihood of infection	Local reservoir identified from WGS, local cattle movements associated with a high likelihood of infection	Local reservoir identified from WGS, non-local cattle movements associated with a high likelihood of infection	Local reservoir not identified from WGS, cattle movements associated with a high likelihood of infection	Local reservoir not identified from WGS, no cattle movements associated with a high likelihood of infection	No WGS available, cattle movements associated with a high likelihood of infection	No WGS available, no cattle movements associated with a high likelihood of infection	Total number of new TB incidents
Avon	30 (33%)	5 (5%)	2 (2%)	1 (1%)	7 (8%)	5 (5%)	42 (46%)	92
Cornwall	59 (18%)	16 (5%)	-	14 (4%)	27 (8%)	23 (7%)	198 (59%)	337
Devon	90 (15%)	13 (2%)	-	17 (3%)	53 (9%)	56 (9%)	378 (62%)	607
Dorset	7 (6%)	-	-	5 (4%)	13 (11%)	11 (9%)	80 (69%)	116
Gloucestershire	20 (15%)	4 (3%)	-	5 (4%)	23 (17%)	12 (9%)	71 (53%)	135
Hereford & Worcester	50 (21%)	11 (5%)	-	9 (4%)	33 (14%)	14 (6%)	122 (51%)	239
Shropshire	66 (29%)	9 (4%)	-	7 (3%)	22 (10%)	16 (7%)	111 (48%)	231
Somerset	47 (22%)	6 (3%)	-	5 (2%)	23 (11%)	18 (8%)	119 (55%)	218
Staffordshire	44 (26%)	9 (5%)	-	7 (4%)	19 (11%)	12 (7%)	81 (47%)	172
West Midlands	3 (50%)	-	-	-	1 (17%)	1 (17%)	1 (17%)	6
Wiltshire	27 (19%)	4 (3%)	-	5 (4%)	19 (13%)	10 (7%)	76 (54%)	141
HRA total	**443 (19%)**	**77 (3%)**	**2 (0.1%)**	**75 (3%)**	**240 (10%)**	**178 (8%)**	**1279 (56%)**	**2,294**
England total	**550 (19%)**	**93 (3%)**	**4 (0.1%)**	**98 (3%)**	**304 (10%)**	**244 (8%)**	**1636 (56%)**	**2,929**

Table 3.2.1b: Number and percentage of new TB incidents by result of the WGS local infection indicator and cattle movement algorithm combined, for all new TB incidents (OTF-W and OTF-S) in 2022, by county in the Edge Area

Risk area or county	Local reservoir identified from WGS, no cattle movements associated with a high likelihood of infection	Local reservoir identified from WGS, local cattle movements associated with a high likelihood of infection	Local reservoir identified from WGS, non-local cattle movements associated with a high likelihood of infection	Local reservoir not identified from WGS, cattle movements associated with a high likelihood of infection	Local reservoir not identified from WGS, no cattle movements associated with a high likelihood of infection	No WGS available, cattle movements associated with a high likelihood of infection	No WGS available, no cattle movements associated with a high likelihood of infection	Total number of new TB incidents
Berkshire	6 (33%)	2 (11%)	-	0%	2 (11%)	-	8 (44%)	18
Buckinghamshire	5 (16%)	2 (6%)	-	3 (10%)	3 (10%)	3 (10%)	15 (48%)	31
Cheshire	33 (29%)	4 (4%)	-	1 (1%)	13 (11%)	10 (9%)	53 (46%)	114
Derbyshire	8 (9%)	-	-	4 (5%)	9 (11%)	14 (16%)	50 (59%)	85
East Sussex	3 (14%)	-	-	1 (5%)	1 (5%)	2 (9%)	15 (68%)	22
Hampshire	2 (9%)	-	-	0%	2 (9%)	3 (14%)	15 (68%)	22
Leicestershire	5 (10%)	1 (2%)	-	2 (4%)	8 (16%)	8 (16%)	27 (53%)	51
Northamptonshire	4 (21%)	3 (16%)	-	-	4 (21%)	1 (5%)	7 (37%)	19
Nottinghamshire	-	-	-	2 (11%)	1 (6%)	2 (11%)	13 (72%)	18
Oxfordshire	21 (38%)	3 (5%)	1 (2%)	1 (2%)	2 (4%)	7 (13%)	21 (38%)	56
Warwickshire	10 (19%)	1 (2%)	1 (2%)	3 (6%)	8 (15%)	-	31 (57%)	54
Edge Area total	**97 (20%)**	**16 (3%)**	**2 (0.4%)**	**17 (3%)**	**53 (11%)**	**50 (10%)**	**255 (52%)**	**490**
England total	**550 (19%)**	**93 (3%)**	**4 (0.1%)**	**98 (3%)**	**304 (10%)**	**244 (8%)**	**1636 (56%)**	**2,929**

Table 3.2.1c: Number and percentage of new TB incidents by result of the WGS local infection indicator and cattle movement algorithm combined, for all new TB incidents (OTF-W and OTF-S) in 2022, by county in the LRA

Risk area or county	Local reservoir identified from WGS, no cattle movements associated with a high likelihood of infection	Local reservoir identified from WGS, local cattle movements associated with a high likelihood of infection	Local reservoir identified from WGS, non-local cattle movements associated with a high likelihood of infection	Local reservoir not identified from WGS, cattle movements associated with a high likelihood of infection	Local reservoir not identified from WGS, no cattle movements associated with a high likelihood of infection	No WGS available, cattle movements associated with a high likelihood of infection	No WGS available, no cattle movements associated with a high likelihood of infection	Total number of new TB incidents
Cambridgeshire	-	-	-	1 (17%)	-	1 (17%)	4 (67%)	6
Cleveland	-	-	-	-	-	1 (50%)	1 (50%)	2
Cumbria	3 (14%)	-	-	-	1 (5%)	1 (5%)	17 (77%)	22
Durham	-	-	-	-	-	-	1 (100%)	1
Essex	-	-	-	-	-	1 (11%)	8 (89%)	9
Greater Manchester	3 (33%)	-	-	-	1 (11%)	-	5 (56%)	9
Hertfordshire	-	-	-	-	-	-	2 (100%)	2
Humberside	-	-	-	-	-	1 (50%)	1 (50%)	2
Isle of Wight	-	-	-	-	1 (100%)	-		1
Kent	-	-	-	1 (13%)	-	1 (13%)	6 (75%)	8
Lancashire	-	-	-	-	4 (24%)	1 (6%)	12 (71%)	17
Lincolnshire	4 (24%)	-	-	1 (6%)	1 (6%)	-	11 (65%)	17
Middlesex	-	-	-	-	-	-	1 (100%)	1
Norfolk	-	-	-	-	-	-	2 (100%)	2
North Yorkshire	-	-	-	1 (6%)	1 (6%)	4 (24%)	11 (65%)	17
South Yorkshire	-	-	-	-	-	-	2 (100%)	2
Suffolk	-	-	-	-	-	1 (33%)	2 (67%)	3
Surrey	-	-	-	2 (40%)	-	1 (20%)	2 (40%)	5
West Sussex	-	-	-	-	-	2 (22%)	7 (78%)	9
West Yorkshire	-	-	-	-	2 (20%)	1 (10%)	7 (70%)	10
LRA total	**10 (7%)**	**-**	**-**	**6 (4%)**	**11 (8%)**	**16 (11%)**	**102 (70%)**	**145**
England total	**550 (19%)**	**93 (3%)**	**4 (0.1%)**	**98 (3%)**	**304 (10%)**	**244 (8%)**	**1636 (56%)**	**2,929**

Risk pathway combinations identified by the WGS local reservoir indicator and cattle movement algorithm for all new TB incidents in the HRA, Edge Area and LRA are depicted in Figures 3.2.7 to 3.2.9, respectively.

WGS data is only available for OTF-W incidents where M. bovis was successfully cultured and the resulting genetic sequence was of a sufficient quality for the analysis. This applied to 836 (36%) new TB incidents in the HRA, 183 (38%) in the Edge Area and 27 (19%) in the LRA.

The WGS Local Reservoir Indicator identified a local reservoir of infection for 23% new TB incidents in the HRA, 23% in the Edge Area and 7% in the LRA in 2022.

In the HRA and Edge Area, most of the TB incidents where a local reservoir was identified also had no cattle movements with a high likelihood of infection, which accounted for 19% and 20% of all new TB incidents in these areas respectively. In the LRA, all new TB incidents with a local reservoir identified also had no cattle movements with a high likelihood of infection. These incidents are symbolised in dark green in Figures 3.2.7 to 3.2.10.

For these incidents, a broad spectrum of local pathways cannot be ruled out, including:

- residual infection in the herd
- contiguous contact with infected cattle
- direct or indirect contact with potentially infected wildlife.

In both the HRA and Edge Area, 3% of new TB incidents had evidence of both a local reservoir and cattle movements with a high likelihood of infection within 25km. For these TB incidents, local cattle movements may have played a part in the spread of this local infection, in addition to the previously listed local pathways. These incidents are symbolised in light green in Figures 3.2.7 to 3.2.10.

For 4 TB incidents in England (one in Oxfordshire, one in Cheshire and 2 in Avon) there was both evidence of a local reservoir and evidence of cattle movements with a high likelihood of infection, all of which were over a distance greater than 25km. There was a high degree of uncertainty around the source of infection for these incidents. With multiple likely risk pathways identified, it is possible there was more than one route of disease incursion into those herds.

In all risk areas in England, 3% to 4% of new TB incidents had cattle movements with a high likelihood of infection, and no evidence of a local reservoir based on the WGS evidence. For those herds it was considered more likely than not that cattle movements played a part in the introduction of infection. These incidents are symbolised in dark purple in Figures 3.2.7 to 3.2.10.

Cattle movements with a high likelihood of infection were identified, but WGS was not available for analysis, for 8% of incidents in the HRA, 10% in the Edge Area and 11% in the LRA. Although the movement algorithm suggests cattle movements played a part in disease introduction into these herds, the lack of genetic information introduces uncertainty as to full range of the risk pathways for these TB incidents. These incidents are symbolised in light purple in Figures 3.2.7 to 3.2.10.

In both the HRA and Edge Area 11%, and in the LRA 8%, of new TB incidents had WGS available but a local reservoir was not identified, coupled with no evidence cattle movements with a high likelihood of infection. The available evidence to assess risk pathways for these herds was good, but the source of infection remains unclear. These incidents are symbolised in grey in Figures 3.2.7 to 3.2.10.

For most new TB incidents in 2022, across all risk areas, there was no evidence of cattle movements with a high likelihood of infection and there was no WGS data available to explore the presence of a local reservoir. This applied to 56% incidents in the HRA, 52% in the Edge Area and 70% in the LRA. There is insufficient evidence for these herds to determine a likely infection pathway. These incidents are symbolised in white in Figures 3.2.7 to 3.2.10.

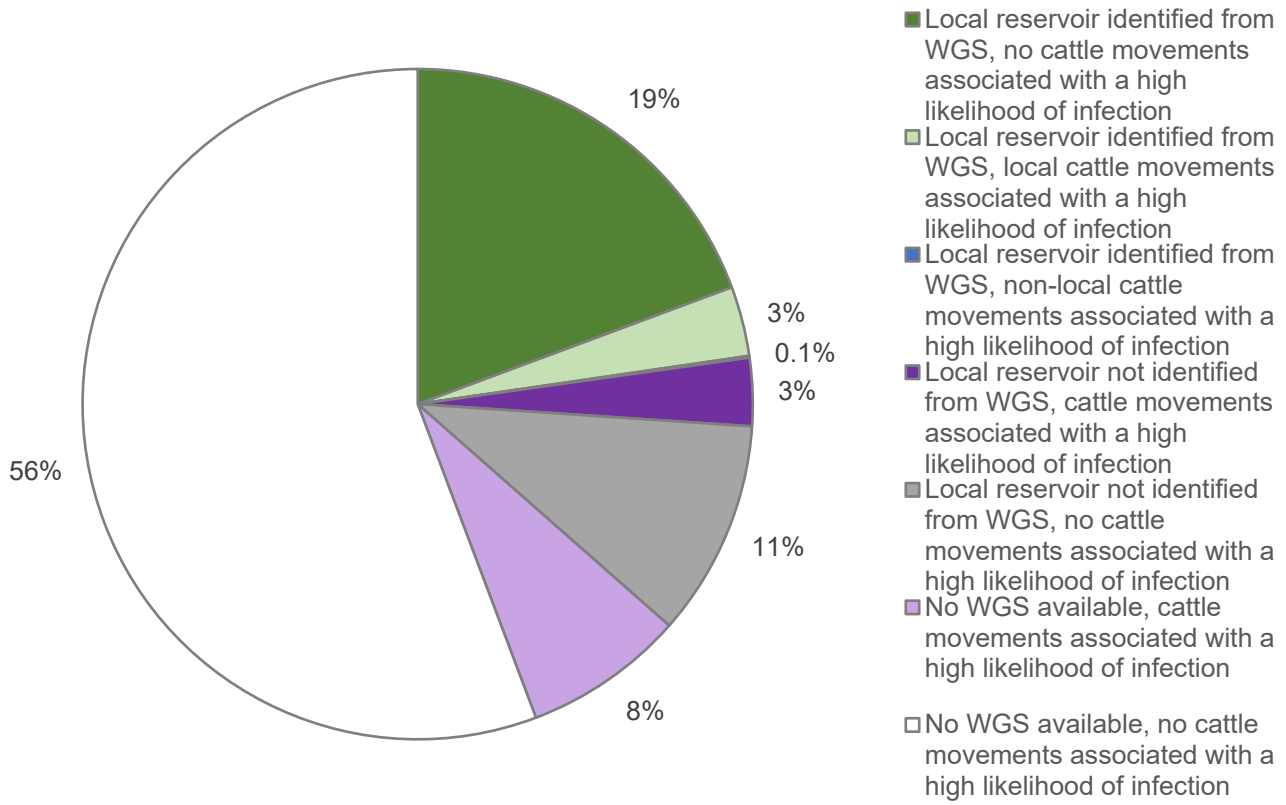


Figure 3.2.7: Risk pathway combinations identified by the WGS local reservoir indicator and cattle movement algorithm for all new TB incidents (OTF-W and OTF-S) in the HRA in 2022

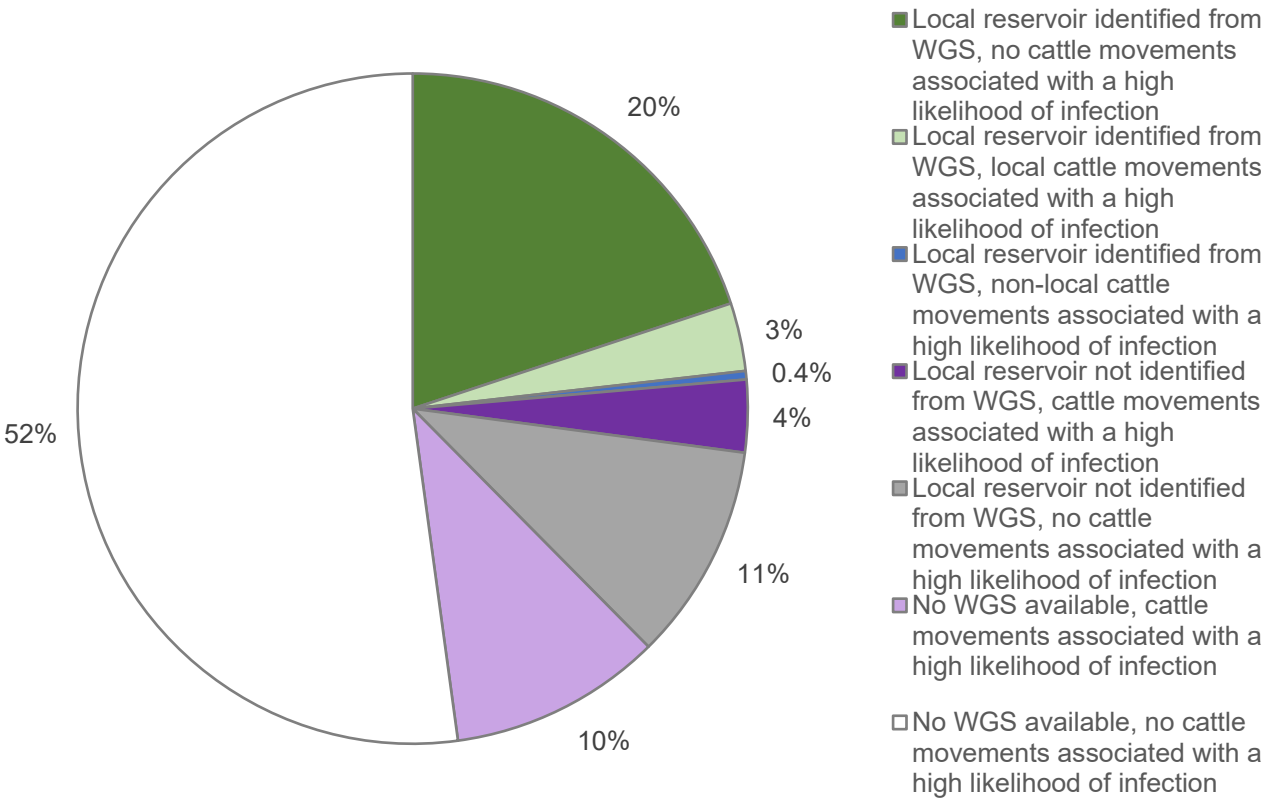


Figure 3.2.8: Risk pathway combinations identified by the WGS local reservoir indicator and cattle movement algorithm for all new TB incidents (OTF-W and OTF-S) in the Edge Area in 2022

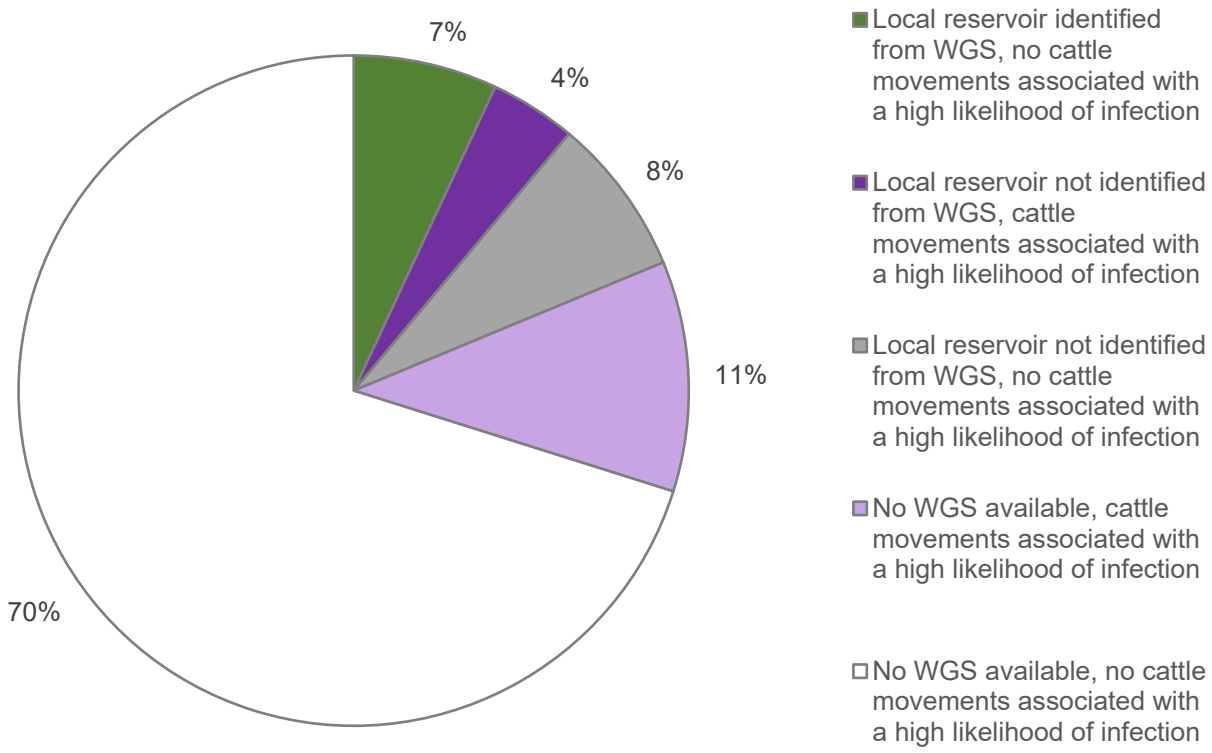


Figure 3.2.9 Risk pathway combinations identified by the WGS local reservoir indicator and cattle movement algorithm for all new TB incidents (OTF-W and OTF-S) in the LRA in 2022

The spatial distribution of the risk pathway combinations for each new TB incident in 2022 are indicated in Figure 3.2.10. TB incidents where a local reservoir was identified were mostly located within the HRA or Edge Area counties bordering the HRA. Outside of this area a few pockets of local infection were identified.

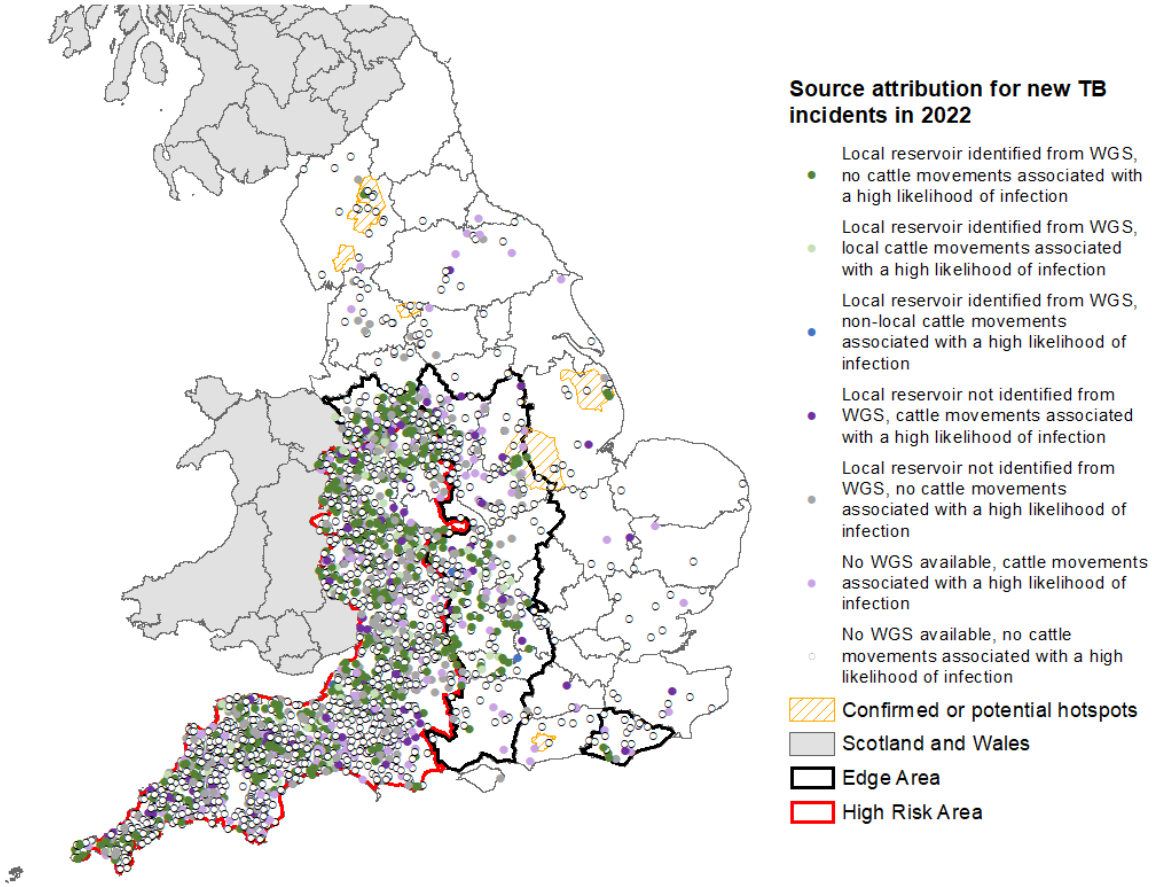
In the Edge Area these areas include:

- Northamptonshire along the western border
- east Leicestershire, within HS23
- south-west East Sussex, in the former HRA portion of the county
- Buckinghamshire, along the western border, but also one incident on the eastern border near the LRA counties of Hertfordshire and Bedfordshire.

In the LRA there were 3 areas with a local reservoir identified:

- east Lincolnshire, within PHA28
- north Cumbria, within PHA29.
- south Greater Manchester, at the Cheshire and Derbyshire border.

Figure 3.2.10. Map of the available evidence for risk pathways of TB infection into the herd,



3.3 Finding infected herds: effectiveness of different TB surveillance streams

- In 2022, over 5 million TB skin tests were carried out in bovine animals (domestic cattle, water buffalo and farmed bison) in England, nearly half of which in the HRA. Additionally, over 1.5 million carcases of commercially slaughtered, non-reactor cattle underwent *post-mortem* meat inspection in abattoirs for pathological evidence (gross lesions) of TB.
- In the HRA and Edge Area, TB incidents were most often disclosed by routine surveillance herd tests (60% in the HRA and 56% in the Edge Area). In the LRA, most TB incidents and OTF-W incidents were detected by Area and Herd Risk surveillance, 46% and 48%, respectively.
- The total number of new TB incidents disclosed by slaughterhouse surveillance in England decreased between 2021 (337) and 2022 (336). By contrast, the proportion of all new OTF-W incidents detected in 2022 and 2021 through this TB surveillance stream stayed the same at 21%. In the Edge Area the proportion of all TB incidents disclosed through slaughterhouse surveillance increased in 2022 (10%) compared to 2021 (8%), however this increase was not statistically significant. It decreased in the HRA from 13% in 2021 to 10% in 2022 and this drop was statistically significant ($p=0.0017$). The LRA saw a non-significant decrease from 10% in 2021 to 8% in 2022.
- Within the Area and Herd Risk surveillance stream, 91% of TB incidents in the HRA, and 61% in the Edge Area, were detected by six or 12-month post-incident tests; compared to 17% 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 better understanding of the factors that lead to recurrent TB incidents on cattle farms.
- Enhanced, targeted TB surveillance around OTF-W incidents (radial testing) detected the majority (65%) of new TB incidents in the LRA, a decrease compared to 2021 (69%). Some TB incidents detected this way are likely to be the result of lateral spread (e.g. spread between neighbouring cattle herds and/or a common source in the local environment). As such, reducing transmission from local cattle movements and contact with contiguous cattle herds could reduce TB incidence in the LRA.
- In the HRA, 41% of OTF herds that only disclosed inconclusive reactors (IR) went on to have a TB incident within the following 15 months. The equivalent percentages for the Edge Area and LRA were 32% and 23% respectively. This indicates that IRs are an important predictor of the presence of infection in a herd 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 bespoke pre-movement tests of individual animals) disclosed only 4% of TB incidents in 2022 compared to 6% in 2021. Cattle are predominantly moved within, rather than between, risk areas. A total of 104 new TB incidents were detected in 2022 by pre-movement tests, of which 81% occurred in the HRA; 13% in the Edge Area and 6% 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.

- in live cattle using antemortem tests that measure immunological markers of *M. bovis* infection, and
- in dead animals by inspecting carcases for pathological evidence of infection (visible lesions characteristic of TB).

The TB surveillance programme thus involves both active surveillance (TB testing of live farm animals) and passive surveillance (post-mortem meat inspection of cattle carcases for TB and other notifiable diseases in the slaughterhouse).

Slaughterhouse surveillance is carried out by meat inspectors and veterinarians employed by or working on behalf of the Food Standards Agency (FSA).

On-farm testing is usually performed by Official Veterinarians appointed by APHA, or occasionally by APHA veterinarians 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 exposure to other mycobacteria present in the farm environment, which can confound the animal’s reaction to bovine tuberculin.

TB surveillance activities in England have been categorised into 4 different streams for the purposes of this report (see detailed description of the surveillance streams and associated tests in the TB Explanatory Supplement):

- **Routine:** active surveillance through systematic herd level (skin) testing of all or the majority of animals in 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 that are deemed to be at an increased risk of infection; including contiguous herd, radial, hotspot and tracing tests, and check tests conducted a few months after the conclusion of a TB incident.

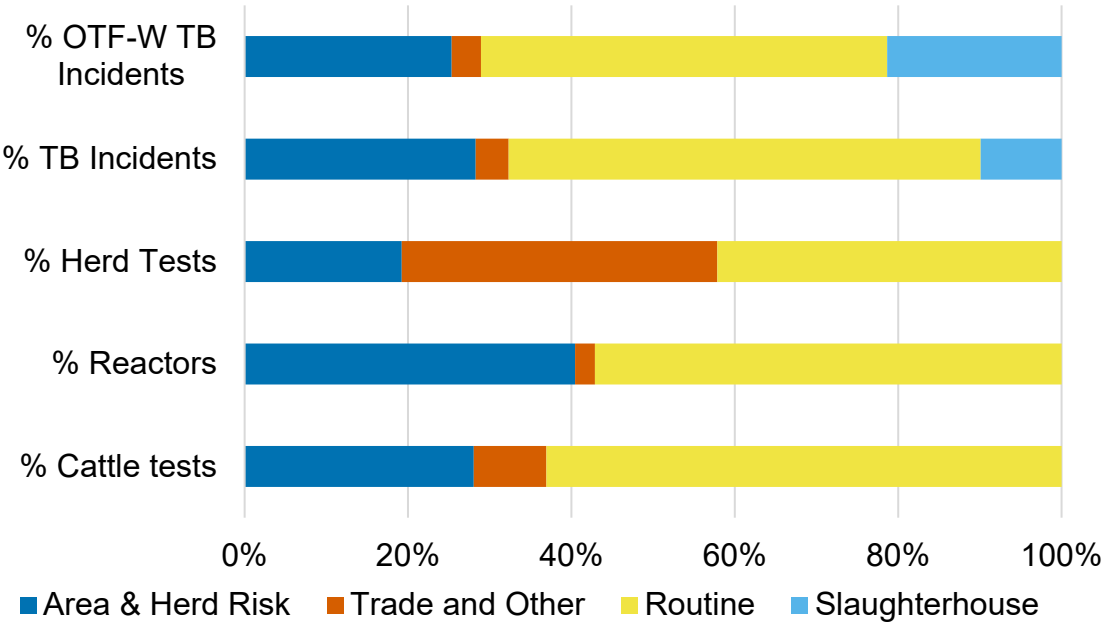
- **Slaughterhouse:** *post-mortem* meat inspection of all cattle commercially slaughtered for human consumption, as well as cattle that die on farm and are disposed of at an animal by-products processing facility.
- **Trade and Other:** active targeted surveillance through skin tests of individual animals moved between OTF herds. These are generally conducted to reduce the risk of inadvertently moving infected cattle between herds, such as: compulsory pre- and post-movement testing, 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, water buffalo and farmed bison were kept in 43,119 holdings in England in 2022, with the total number of animals representing a 1% increase compared to 2021 and the total number of active holdings decreased by 2% compared to 2021. Nearly 5 million individual TB skin tests were carried out on live animals in OTF herds. Furthermore, over 1.5 million animals from cattle holdings in England underwent *post-mortem* meat inspection. Though this is higher than previous years, where around 4 million skin tests occur, this reflects the impact of moving most of the HRA onto six-monthly testing, with the first additional routine tests taking place in the HRA in January 2022. This suggests that neither the COVID-19 outbreak, and the temporary extensions granted by APHA until July 2021 for the completion of routine skin tests (see Preface 2.1), or the serious avian influenza epidemic disrupted the overall TB surveillance programme for new TB incidents in cattle.

Overall, this testing effort equated to over 72,823 testing events in OTF herds, which led to the detection of 2,929 new TB incidents in 2022.

The relative proportions of individual cattle tests, herd tests, test reactors and incidents for the four surveillance streams in OTF cattle herds in 2022 are shown in Figure 3.3.1 and Table 3.3.1. For the purposes of this report, 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). References to 'cattle' include domestic cattle (Bos taurus), farmed water buffalo and farmed bison.

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 2022



In addition to the tests in Table 3.3.1, a further 2,682 cattle herds under movement restrictions due to a TB incident 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 control and eradicate infection from TB incident herds to regain OTF herd status. These include short interval (SI) tests, 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 18 new TB incidents were disclosed by these test types, mostly through the testing of cattle at epidemiologically linked premises during short interval testing (11 incidents).

Routine surveillance in England contributed to a significantly higher proportion of overall cattle tests than Area and Herd Risk surveillance in 2022 (Figure 3.3.1). Routine surveillance testing also detected the most reactors, TB incidents and OTF-W incidents in 2022, followed closely by Area and Herd Risk surveillance testing.

In the HRA, over half (60%) of all incidents were detected by Routine (annual or six-monthly) surveillance, followed by Area and Herd Risk surveillance (26, (Table 3.3.1a)). The increase in the detection of incidents from Routine surveillance is likely to be due to the switch from annual to six-monthly testing for most cattle herds in the HRA. This was effectively implemented in two stages: March 2021 for herds in Shropshire and Staffordshire and January 2022 for herds in the other counties of the HRA (see Chapter 3.1). In 2022 there was a 64% increase in Whole-Herd tests compared to 2021.

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

In the LRA, 46% of all TB incidents and 48% of OTF-W TB incidents were detected by Area and Herd Risk surveillance (Table 3.3.1c). One in three TB incidents were detected by Routine surveillance (33%), which reflects a higher proportion compared to the number of tests of this type conducted in this risk area (26%). 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.

As in previous years, except for 2021, the proportion of incidents detected through Trade and other surveillance was higher in the LRA compared to the other TB risk areas. This highlights the importance of pre- and post-movement testing of cattle moving into the LRA from higher TB risk areas of GB. Even so, in 2022 the proportion of TB incidents and OTF-W incidents detected through pre- and post-movement testing across England was much lower (6% and 8% respectively) than in 2021, 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, and could be a logical consequence of the increased frequency of routine TB surveillance of herds in the HRA and reducing incidence of infection. 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 8%, a slight decrease compared to 2021 (10%). 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.a Total number of tests, reactors, and TB incidents by risk area and surveillance stream in 2022 in the High Risk Area of England.

Surveillance Stream	Herd tests N (%)	TB incidents N (%)	OTF-W incidents N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Routine	20,671 (47.8)	1,370 (59.7)	551 (51.4)	6.6	1.5
Area and Herd Risk	7,335 (17.0)	607 (26.4)	253 (23.6)	8.3	2.6
Slaughterhouse	0 (0.0)	231 (10.1)	229 (21.3)	0.0	0.0
Trade and other	15,263 (35.3)	85 (3.7)	39 (3.6)	0.6	0.5
HRA Total	**43,269 (59.4)**	**2,295 (78.4)**	**1,073 (79.8)**	**3.9**	**1.1**
England Total	**72,823**	**2,929**	**1,345**	**1.7**	**1.4**

Table 3.3.1.b Total number of tests, reactors, and TB incidents by risk area and surveillance stream in 2022 in the Edge Area of England.

Surveillance Stream	Herd tests N (%)	TB incidents N (%)	OTF-W incidents N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Routine	6,779 (39.2)	273 (55.8)	112 (48.3)	4.0	0.9
Area and Herd Risk	3,462 (20.0)	155 (31.7)	68 (29.3)	4.5	2.4
Slaughterhouse	0 (0.0)	47 (9.6)	47 (20.3)	0.0	0.0
Trade and other	7,073 (40.9)	14 (2.9)	5 (2.2)	0.2	0.9
Edge Total	**17,314 (23.8)**	**489 (16.7)**	**232 (17.2)**	**2.2**	**1.0**
England Total	**72,823**	**2,929**	**1,345**	**1.7**	**1.4**

Table 3.3.1.c Total number of tests, reactors, and TB incidents by risk area and surveillance stream in 2022 in the Low Risk Area of England.

Surveillance Stream	Herd tests N (%)	TB incidents N (%)	OTF-W incidents N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Routine	3,234 (26.4)	48 (33.1)	6 (15.0)	1.5	0.2
Area and Herd Risk	3,204 (26.2)	66 (45.5)	19 (47.5)	2.1	0.3
Slaughterhouse	0 (0.0)	12 (8.3)	11 (27.5)	0.0	0.0
Trade and other	5,802 (47.4)	19 (13.1)	4 (10.0)	0.3	0.2
LRA total	**12,240 (16.8)**	**145 (5.0)**	**40 (3.0)**	**1.0**	**0.2**
England total	**72,823**	**2,929**	**1,345**	**1.7**	**1.4**

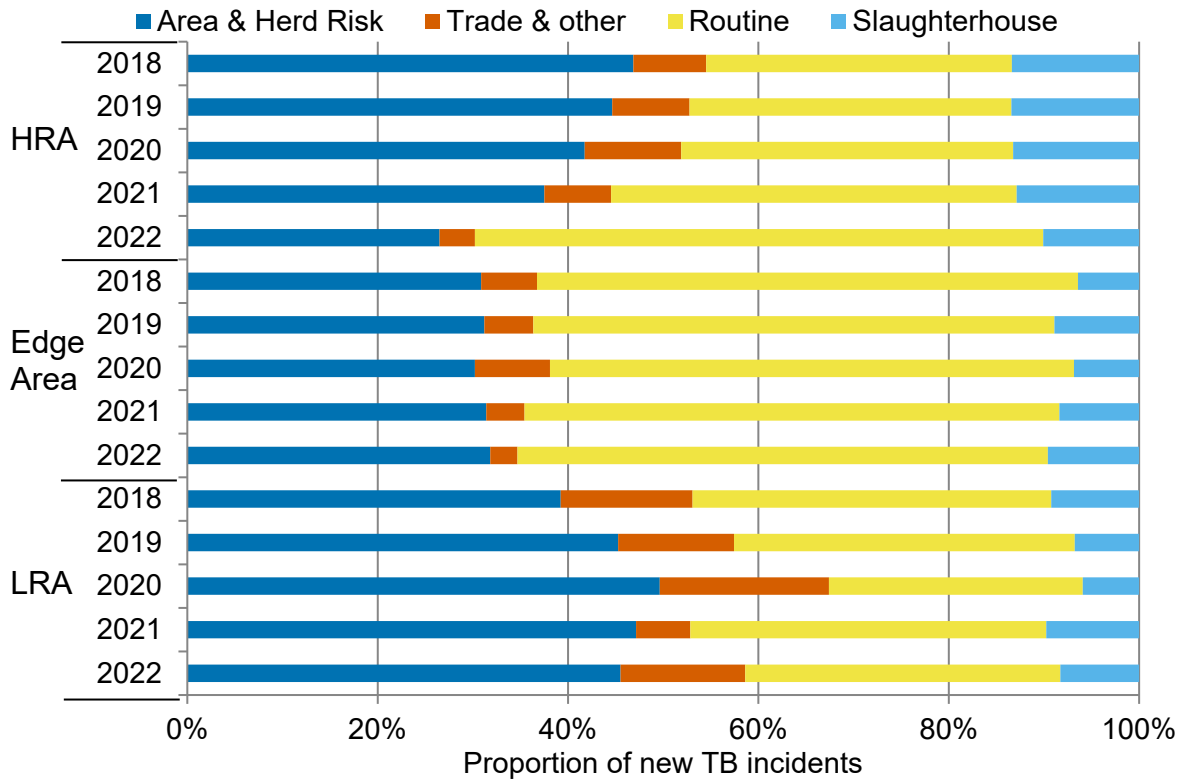
Over the past five years, the annual proportions of new TB incidents disclosed by each surveillance stream has varied more in the LRA compared to the HRA and Edge Area. This is due in part, to the low number of TB incidents (small denominator) in the LRA. In the HRA, recent surveillance policy changes are likely to be a contributing factor in the fluctuation in the proportion of TB incidents detected by different surveillance streams in 2021 and 2022 (Figure 3.3.2).

The annual proportion of new incidents detected by Routine surveillance in the Edge Area fell slightly between 2017 and 2019 but has since stabilized around 56%. This is following the introduction of six-monthly testing in parts of the Edge Area, which started in 2018. The proportion of new incidents detected by Routine surveillance in the HRA increased in 2022 to 60% compared to 2021 (43%) and 2020 (35%), following the rollout of six-monthly testing for most herds in the HRA in 2021 and 2022.

In the HRA, the annual proportion of new TB incidents detected through Slaughterhouse surveillance has been gradually declining since 2019 (13% in 2019 compared to 10% in 2022). In contrast, this proportion has been increasing in the Edge Area since 2020 (7% in 2020 compared to 10% in 2022). In the LRA, a downward trend was observed between 2015 (14%) and 2020 (6%). The proportion of new TB incidents then increased to 9.8% in 2021 before falling again in 2022 (8%).

In England, the annual proportion of new TB incidents detected by Slaughterhouse surveillance has fallen over the past seven years (16% in 2015 compared to 10% in 2022). 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 and before they reach slaughter age.

Figure 3.3.2 Annual proportions of new TB incidents detected by different surveillance streams within each risk area from 2018 to 2022.



Routine surveillance stream

The Routine surveillance stream includes WHTs and Routine Herd Tests (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 (annually) 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 6% of herds receiving WHTs in 2022. Whole herd tests disclosed 8% of incidents and new Herd tests disclosed 2% of incidents found by routine herd testing in this risk area, but none were

OTF-W incidents. Slightly more TB incidents per 100 herd tests were detected by WHTs (2.0) compared to RHTs (1.7), as herds receiving WHTs in the LRA are 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 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 herd test events	Reactors per 1000 cattle tested
New Herd Tests	659 (3.2)	17 (1.2)	7 (1.3)	49 (1.5)	2.6	2.1
Whole Herd Tests	20,011 (96.8)	1,353 (98.8)	544 (98.7)	3,328 (98.5)	6.8	1.5
HRA Routine Total	**20,670**	**1,370**	**551**	**3,377**	**4.7**	**2.9**

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).

Table 3.3.2.b Performance of main test types within the Routine surveillance stream in the Edge Area in 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 herd test events	Reactors per 1000 cattle tested
New Herd Tests	206 (3.0)	1 (0.4)	0 (0.0)	0 (0.0)	0.5	0.0
Whole Herd Tests - Total	6,572 (97.0)	272 (99.6)	112 (100.0)	670 (100.0)	4.1	0.9
Whole Herd Tests - 6M	4,153 (38.7)	198 (42.1)	88 (44.0)	525 (43.9)	4.8	1.0
Whole Herd Tests - 12M	2,419 (36.8)	74 (27.2)	24 (21.4)	145 (21.6)	3.1	0.7
Edge Routine Total	**6,778**	**273**	**112**	**670**	**2.3**	**0.5**

Note: For Whole Herd Tests, data is split between the 6 monthly (6M) and annual (12M) regions of the Edge Area. 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).

Table 3.3.2.c Performance of main test types within the Routine surveillance stream in the LRA in 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 herd test events	Reactors per 1000 cattle tested
New Herd Tests	439 (13.6)	1 (2.1)	0 (0.0)	1 (1.8)	0.2	0.1
Whole Herd Tests	201 (6.2)	4 (8.3)	0 (0.0))	1 (1.8)	2.0	0.0
Routine Herd Tests	2,594 (80.2)	43 (89.6)	6 (100.0)	54 (96.4)	1.7	0.3
LRA Routine Total	**3,234**	**48**	**6**	**56**	**1.3**	**0.1**

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 includes tests in OTF herds deemed to be at higher risk of infection, 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 TB incidents and OTF-W incidents initiated by Area and Herd Risk surveillance were detected by post-incident tests (91% and 90% respectively), followed by contiguous herd tests (6%) (Table 3.3.3a), as in the previous three years. 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 number of incidents per 100 herd tests (20.0) and had the second highest detection rate for reactors, with 2.1 reactors for every 1,000 cattle tested (Table 3.3.3a).

In the Edge Area, 61% of TB incidents and 52% of OTF-W incidents were detected by post-incident tests in this surveillance stream, similar to in 2019 and 2020 (Table 3.3.3b). Post-incident tests also detected the highest number of TB incidents per 100 test events (12.5) which differed to 2021 where source tracing tests detected the highest number (16.7) despite representing less than 1% of all test events.

In the LRA, 54% of the Area and Herd Risk herd tests carried out were radial tests, and they disclosed a higher proportion of OTF-W incidents (74%) compared to TB incidents (65%) (not necessarily confirmed as the same *M. bovis* genotype as the index case) (Table 3.3.3c). Radial tests enable the early detection of any local spread of infection from the index OTF-W incident herd or a common local wildlife source. They also provide

evidence for the presence or absence of endemic disease around incidents in the LRA. In this risk area of England, source tracing tests detected the highest proportion of TB incidents per 100 test events (11%) despite representing less than 1% of total test events.

Post-incident, radial, contiguous herd and tracing tests are not 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 303 herd hotspot tests were carried out in the LRA in 2022 (46,726 individual cattle tests) with ten reactors disclosed from eight TB incidents, two of which was OTF-W. In 2022, there were 112 hotspot herd tests in parts of the Edge Area spanned by a hotspot area in an adjoining LRA county (e.g. hotspot HS23 straddling Lincolnshire, Leicestershire and Nottinghamshire. Eleven reactors were disclosed from seven TB incidents, two of which were OTF-W.

Table 3.3.3.a Percentage of main test types within the Area and Herd Risk surveillance stream in the HRA in 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 test events	Reactors per 1000 cattle tested
Contiguous tests	487 (9.2)	33 (5.6)	15 (6.0)	83 (4.2)	6.8	1.9
Hotspot tests	2 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.0	0.0
Spread tracing tests	1,634 (30.8)	7 (1.2)	4 (1.6)	12 (0.6)	0.4	1.7
Source tracing tests	45 (0.8)	9 (1.5)	4 (1.6)	22 (1.1)	20.0	2.1
Post-incident tests	3,070 (58.0)	534 (90.7)	224 (90.3)	1,868 (93.4)	17.4	2.7
Check tests	53 (1.0)	6 (1.0)	1 (0.4)	15 (0.8)	11.3	1.6
AFU tests	6 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0.0	0.0
HRA Area and Herd Risk Total	**5,297**	**589**	**248**	**2,000**	**8.0**	**1.4**

Table 3.3.3.b Percentage of main test types within the Area and Herd Risk surveillance stream in the Edge Area in 2022

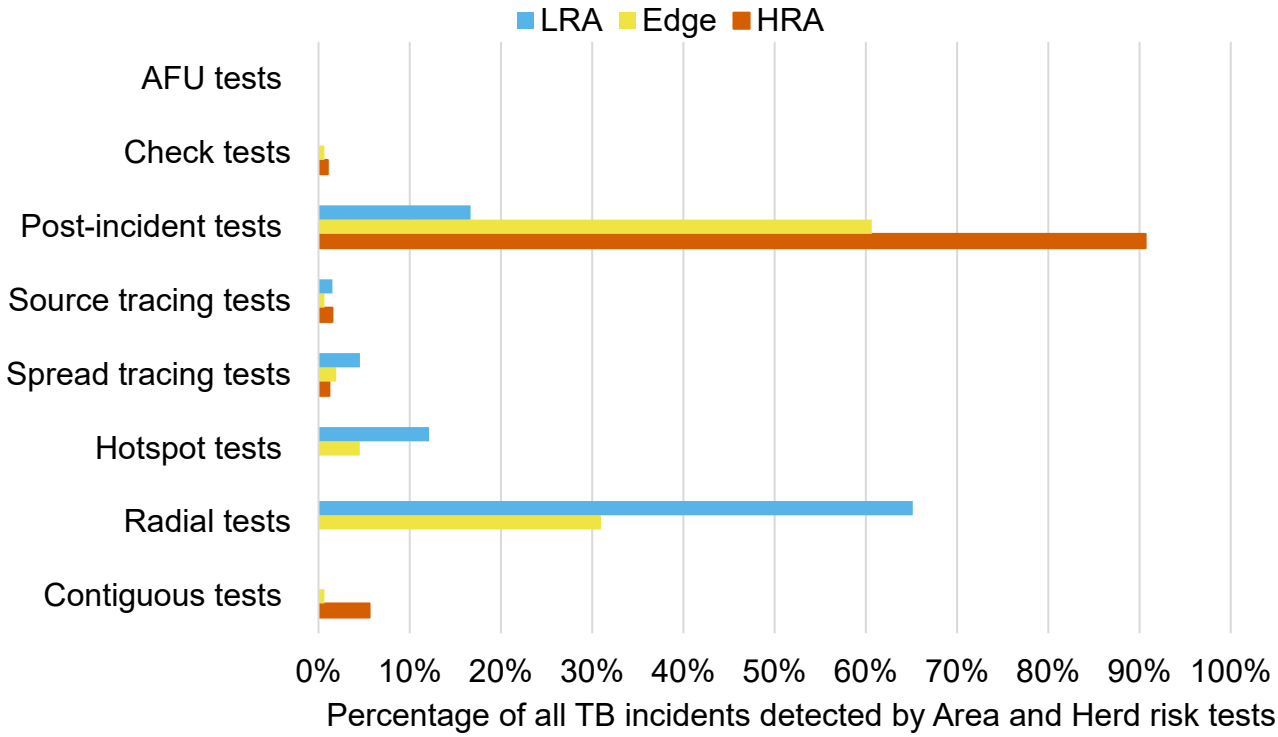
Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 test events	Reactors per 1000 cattle tested
Contiguous tests	17 (0.6)	1 (0.6)	1 (1.5)	1 (0.1)	5.9	1.9
Radial tests	1,042 (34.9)	48 (31.0)	27 (39.7)	96 (12.8)	4.6	0.8
Hotspot tests	112 (3.7)	7 (4.5)	2 (2.9)	11 (1.5)	6.3	1.2
Spread tracing tests	1,024 (34.3)	3 (1.9)	2 (2.9)	7 (0.9)	0.3	1.6
Source tracing tests	22 (0.7)	1 (0.6)	1 (1.5)	11 (1.5)	4.5	2.4
Post-incident tests	750 (25.1)	94 (60.6)	35 (51.5)	626 (83.2)	12.5	3.7
Check tests	21 (0.7)	1 (0.6)	0 (0.0)	0 (0.0)	4.8	0.0
Edge Area and Herd Risk Total	**2,988**	**155**	**68**	**752**	**5.6**	**1.7**

Table 3.3.3.c Percentage of main test types within the Area and Herd Risk surveillance stream in the LRA in 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 test events	Reactors per 1000 cattle tested
Radial tests	1,640 (54.1)	43 (65.2)	14 (73.7)	44 (50.0)	2.6	0.2
Hotspot tests	303 (10.0)	8 (12.1)	2 (10.5)	10 (11.4)	2.6	0.2
Spread tracing tests	924 (30.5)	3 (4.5)	0 (0.0)	3 (3.4)	0.3	0.8
Source tracing tests	9 (0.3)	1 (1.5)	0 (0.0)	1 (1.1)	11.1	0.4
Post-incident tests	143 (4.7)	11 (16.7)	3 (15.8)	30 (34.1)	7.7	1.0
Check tests	14 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)	0.0	0.0
LRA Area and Herd Risk Total	**3,033**	**66**	**19**	**88**	**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 that were detected by each of the main test types within the Area and Herd Risk surveillance stream by surveillance risk area in 2022



Slaughterhouse Surveillance Stream

Slaughterhouse surveillance for TB is provided by compulsory post-mortem meat inspection (visual inspection of carcases with palpation and incision of lymph nodes) of all cattle slaughtered for human consumption. Any suspicious lesions of TB must be notified to APHA, who will in turn arrange for suitable tissue samples to be submitted to one of our TB reference laboratories for PCR testing and, if positive for *M. bovis*, bacteriological culture and whole-genome sequencing (WGS) of the bacterial isolate. It is an ongoing, supplementary TB surveillance stream that helps detect infected cattle missed by active surveillance, or infected since their last skin test.

The probability of detecting TB incidents 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 and contribution of slaughterhouse surveillance and monitoring performance may be found in the Slaughterhouse surveillance report (2016-2019). Herds are skin tested more frequently in the Edge Area and HRA than in the LRA. Therefore, a higher proportion (but lower number) of TB-infected herds is expected to be detected at routine slaughter of cattle in the LRA. However, in 2022, the proportion of TB incidents disclosed by slaughterhouse surveillance was highest in the HRA and Edge Area, both 10%, followed by the LRA (8%). As expected, the proportion of OTF-W incidents disclosed by slaughterhouse surveillance, was highest in the LRA (28%) compared to the HRA and Edge Area (21% and 20%, respectively) (Table 3.3.1 a-c).

Slaughterhouse surveillance primarily detects OTF-W incidents because, by definition, the identification of visible lesions of TB at routine slaughter must be confirmed by positive laboratory test results. Slaughterhouse cases that prove negative on PCR testing in OTF herds trigger temporary movement restrictions pending the completion of laboratory tests, but do not generate a new TB incident. Every year, however, a very 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 negative by laboratory testing, but a skin check test in the source herd identified reactors without visible lesions.

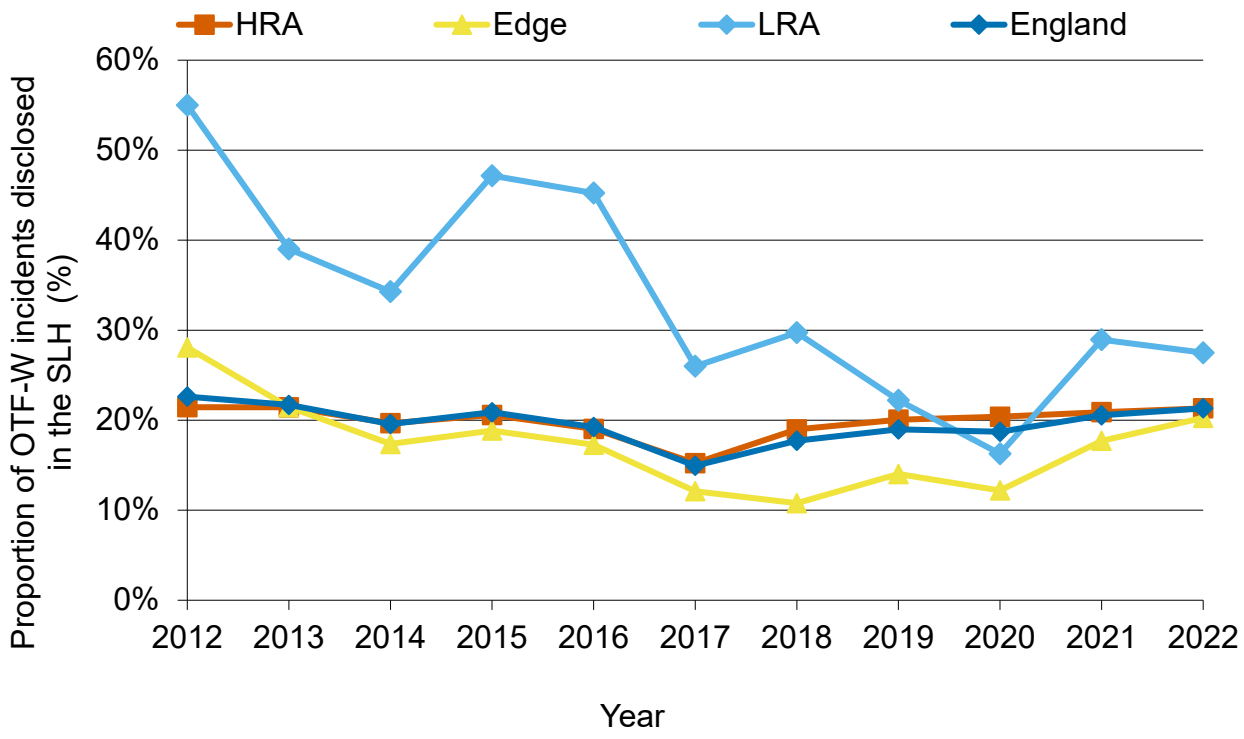
Since 2011, the proportion of OTF-W incidents disclosed through slaughterhouse surveillance in the HRA has remained stable. In the Edge Area and LRA, by contrast, there has been greater annual fluctuation (Figure 3.3.4).

The proportion of OTF-W incidents disclosed by slaughterhouse surveillance in the Edge Area increased from 12% in 2020 to 20% in 2022, but remains below the HRA and LRA. The proportion disclosed also remains lower than that observed in 2011 (29%). The reduction in slaughterhouse cases in this area since 2011 is most likely due to the increased frequency of routine herd surveillance.

In the LRA, the proportion of OTF-W incidents dropped from 29% in 2021 to 28% in 2022, however this drop was not statistically significant. This was in contrast to that observed in

2021, where the proportion increased (16% in 2020). The highest proportion of OTF-W incidents initiated by slaughterhouse surveillance was once more found in the LRA.

Figure 3.3.4 Annual proportion of new OTF-W incidents in each risk area that were disclosed by slaughterhouse surveillance from 2012 to 2022



Trade and other surveillance stream

Trade surveillance includes pre-export and post-import tests, private skin or interferon-gamma tests, tests at semen collection centres and statutory (but privately-funded) pre- and post-movement skin tests. Typically, only single animals or a batch of animals are included in such tests 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). A government-funded TB herd test completed with negative results within the required timeframe (i.e. 60 days before the date of movement) qualifies as a pre-movement test so that a bespoke privately-funded test is not required for such animals. Therefore, the number of PrMTs cannot be counted within surveillance data. Trade and other tests detect the lowest proportion of TB incidents of all the surveillance streams in England (4% in 2022). The number of reactors per 1,000 tests disclosed by Trade and other tests was 0.5 in the HRA, where most tests in this stream are conducted, and 0.2 in the Edge Area. This rate decreased in the HRA in 2022 (0.5) compared to 2021 (0.8) and 2020 (1.4). This could be due to the large amount of IFN-γ testing in the HRA

overall, which could have reduced the animal level prevalence. The primary purpose of Trade and other tests is to reduce the risk of spreading TB via movements of undetected infected cattle between herds. A secondary objective of pre-movement testing in particular 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 (54%) compared to the Edge Area (25%) and LRA (21%) (Table 3.3.1). In the HRA and Edge Area, virtually all Trade and other surveillance stream tests in 2022 were PrMTs (Table 3.3.4); whereas in the LRA, the proportion of post-movement tests and PrMTs were more evenly split. 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, if not slaughtered within 120 days of arrival in the LRA.

In 2022, private tests represented less than 1% of cattle tests within this surveillance stream in the HRA and Edge Area and 3% of cattle tests in the LRA (as in 2021 and 2020) and disclosed one TB incident which was in the HRA. 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 2022 (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 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Pre-export	2 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Post-import	31 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Post-movement	40 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0	0
Pre-movement	15,181 (99.5)	84 (98.8)	38 (97.4)	128 (99.2)	0.6	0.5
Private	9 (0.1)	1 (1.2)	1 (2.6)	1 (0.8)	11.1	11.8
HRA Trade Total	**15,263**	**85**	**40**	**129**	**2.3**	**2.5**

Table 3.3.4.b Performance of main test types within the Trade and other surveillance stream in the Edge Area in 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Pre-export	6 (0.1)	0 (0.0)	0	0	0	0
Post-import	21 (0.3)	0 (0.0)	0	0	0	0
Post-movement	57 (0.8)	0 (0.0)	0	0	0	0
Pre-movement	6,972 (98.6)	14 (100.0)	5 (100.0)	25 (100.0)	0.2	0.2
Private	17 (0.2)	0 (0.0)	0	0	0	0
Edge Trade Total	**7,073**	**14**	**5**	**25**	**0.04**	**0.04**

Table 3.3.4c Performance of main test types within the Trade and other surveillance stream in the LRA in 2022

Test type	Test events N (%)	TB incidents N (%)	OTF-W incidents N (%)	Reactors N (%)	TB incidents per 100 herd tests	Reactors per 1000 cattle tested
Pre-export	42 (0.7)	0 (0.0)	0 (0.0)	0	0	0
Post-import	39 (0.7)	0 (0.0)	0 (0.0)	0	0	0
Post-movement	2,437 (42.0)	13 (68.4)	4 (100.0)	17 (81.0)	0.5	0.3
Pre-movement	3,088 (53.2)	6 (31.6)	0 (0.0)	4 (19.0)	0.2	0.1
Pre-sale check	1 (0.0)	0 (0.0)	0 (0.0)	0	0	0
Private	195 (3.4)	0 (0.0)	0 (0.0)	0	0	0
LRA Trade Total	**5,802**	**19**	**4**	**21**	**0.1**	**0.1**

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), Pre-sale check LRA (VE-CT-LRA-SA).

Pre-movement testing (PrMT)

There were over 2.8 million cattle movements within GB in 2022, excluding direct and indirect movements to slaughter, for example via slaughter markets and AFUs. This was a decrease of 74,272 movements compared to 2021. Farms in all TB risk areas move more cattle within their area than without. Further, there are more cattle movements 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 61% of Edge Area cattle.

Table 3.3.5 Summary of number of cattle movements between risk areas and countries, 2022

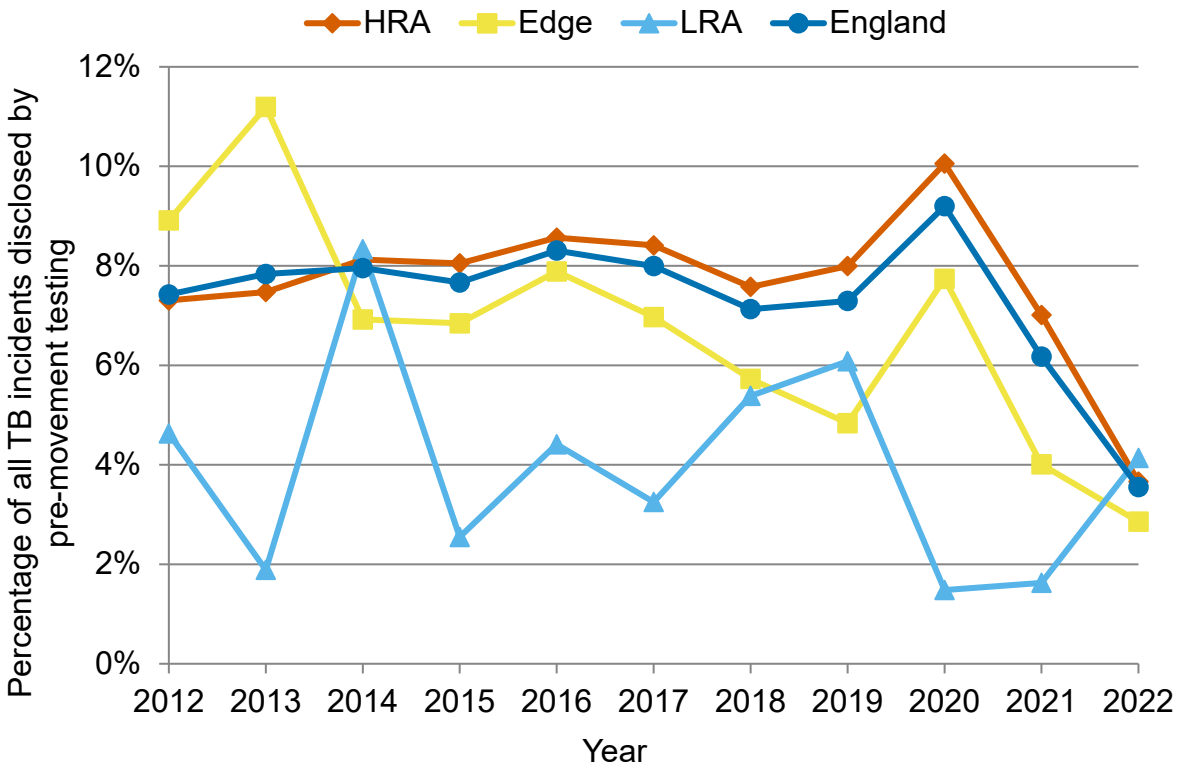
Cattle movements in 2021	To HRA	To Edge	To LRA	To Scotland	To Wales	Total
From HRA	651,383	93,863	39,752	1,024	33,337	819,359
From Edge	67,484	209,989	44,930	1,399	19,414	343,216
From LRA	15,220	41,364	631,207	21,557	7,729	717,077
From Scotland	1,991	6,899	65,399	427,515	1,508	503,312
From Wales	90,231	39,149	30,796	832	268,330	429,338
Total	**826,309**	**391,264**	**812,084**	**452,327**	**330,318**	**2,812,302**

Over 1.1 million cattle movements in 2022 originated in the HRA or Edge Area, similar to 2018 to 2021.

The proportion of TB incidents disclosed by PrMTs in the HRA was stable between 2011 and 2019 (around 8%). However, in 2020 it increased to 10%, before dropping to 7% in 2021 and 4% in 2022 (Figure 3.3.5). There has been more variability in the Edge Area and LRA over this 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. In the Edge Area, PrMT disclosure was 5% in 2019, 8% in 2020, but decreased to 4% in 2021 and 3% in 2022.

Figure 3.3.5 Annual proportion of total TB incidents disclosed by pre-movement testing between 2012 and 2022, 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 must 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 removed as test reactors, 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) were detected in the HRA (66%). Similarly, most IRs were identified in the HRA (70%).

Between 2021 and 2022, there was a fall in the number of IR-only herds and IRs disclosed in the HRA and a rise in both the Edge Area and LRA, as seen in previous years, with the exception of 2021. In 2021, the number remained the same or increased in both the Edge

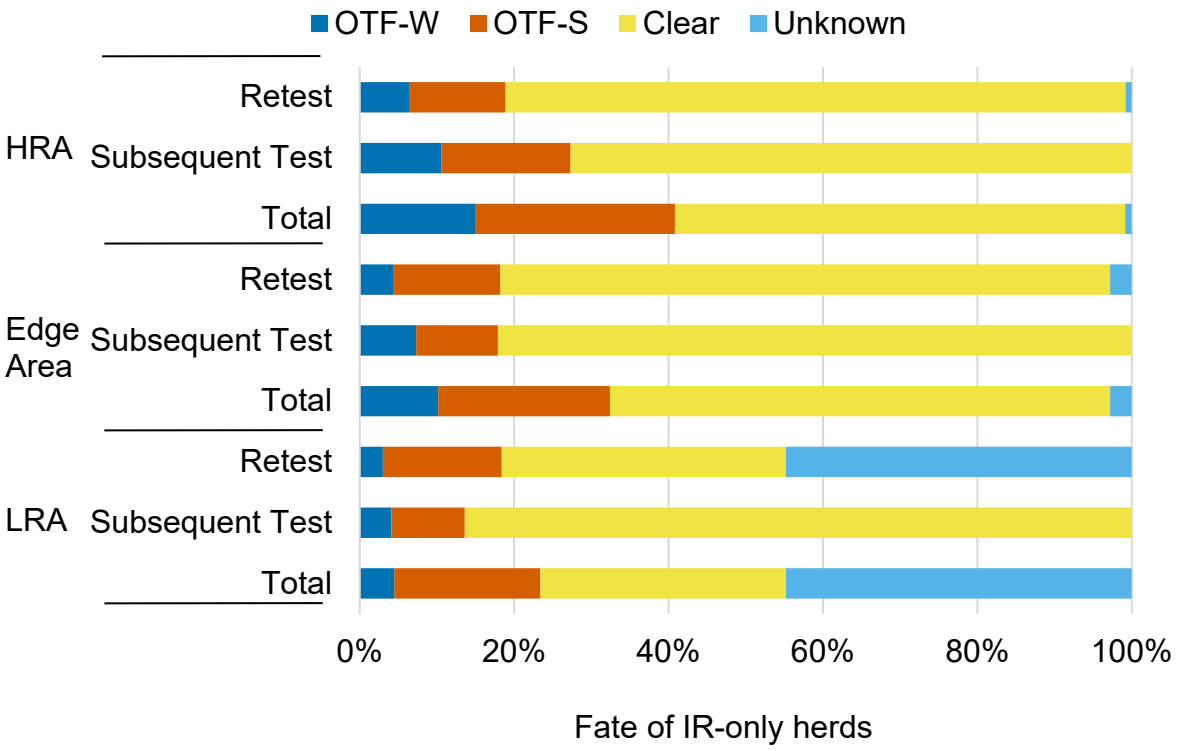
Area and HRA and decreased in the LRA (Table 3.3.6). More details on inconclusive reactors can be found in Chapter 3.4.

Table 3.3.6 Summary of number of IR-only herds and IRs disclosed in such herds, their percentages and percentage change between 2021 and 2022 by surveillance risk area.

Region	IR-only herds (% of all IR-only herds) (% change 2021-22)	IRs disclosed (% of all IRs disclosed) in IR only herds (% change 2021-22)
HRA	1,521 (66%) (-6%)	3,387 (70) (-5%)
Edge Area	571 (25%) (5%)	1,110 (23%) (5%)
LRA	201 (9%) (1%)	350 (7%) (1%)
England total	**2,315 (1%)**	**4,847 (-1%)**

In 2022, 41% of IR-only herds in the HRA went on to have a TB incident within the following 15 months in 2022. In the Edge Area the percentage was 32% and in the LRA 23% (Figure 3.3.6).

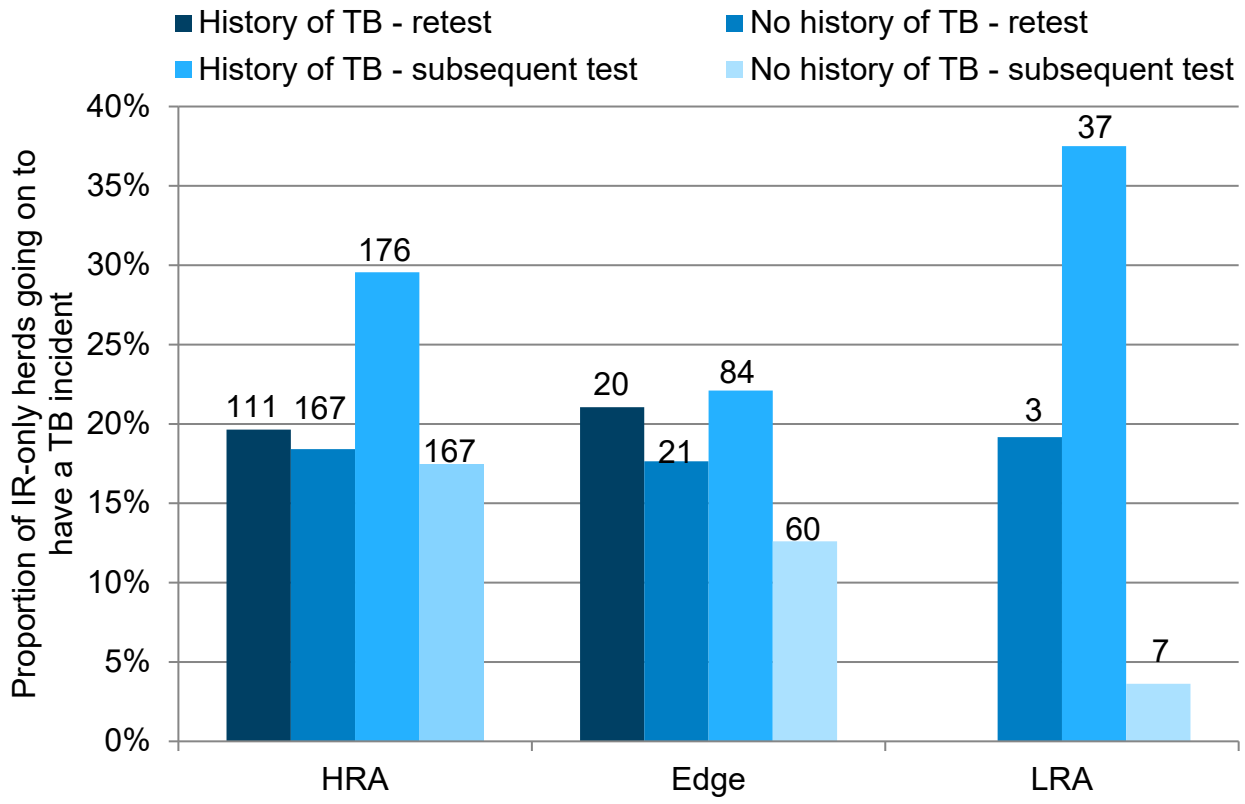
Figure 3.3.6 Fate of IR-only herds in the 15 months following disclosure of IRs in 2022, by risk area. The fate of some herds is recorded as unknown due to reasons such as ceasing trading and not having a retest.



In 2022, in the Edge Area and LRA, the majority of IR-only tests occurred in herds without a recent history of an OTF-W incident (83% and 96% respectively). The HRA had the lowest proportion of these herds at 63%. Just under half of the IRs in IR-only herds that went on develop TB (OTF-S or OTF-W) were detected by the IR retests in the HRA (46%) as opposed to the subsequent tests. In the LRA and Edge Area most IRs that developed TB were detected at an IR retest (79% and 56%, 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 2022 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 laboratory confirmed (OTF-W) TB incident herds.

Until the 11th of July 2021, all herds experiencing OTF-W incidents in the LRA and Edge Area, as well as in 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 testing policy was modified 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 OTF-W incident, qualified for a mandatory IFN-γ test. The test deployment policy was unchanged in the LRA and the annual surveillance testing part 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 was at APHA case vets' discretion.

Table 3.3.7 Animals (herds) receiving an IFN-γ test in 2022, by risk area and testing reason

Risk Area	Total	Miscellaneous	New OTF-W incident in BCP areas	OTF-W incident outside HRA	Persistent OTF-W incident	Persistent OTF-W incident in BCP areas	Recurrent incident
HRA	105,217 (754)	3,859 (72)	4,589 (33)	0 (0)	13,254 (73)	1,795 (11)	81,720 (565)
Edge Area	28,309 (211)	946 (21)	1,148 (3)	11,149 (111)	151 (2)	0 (0)	14,915 (74)
LRA	6,440 (74)	1 (1)	0 (0)	6,439 (73)	0 (0)	0 (0)	0 (0)
England	139,966 (1,039)	4,806 (94)	5,737 (36)	17,588 (184)	13,405 (75)	1,795 (11)	96,635 (639)

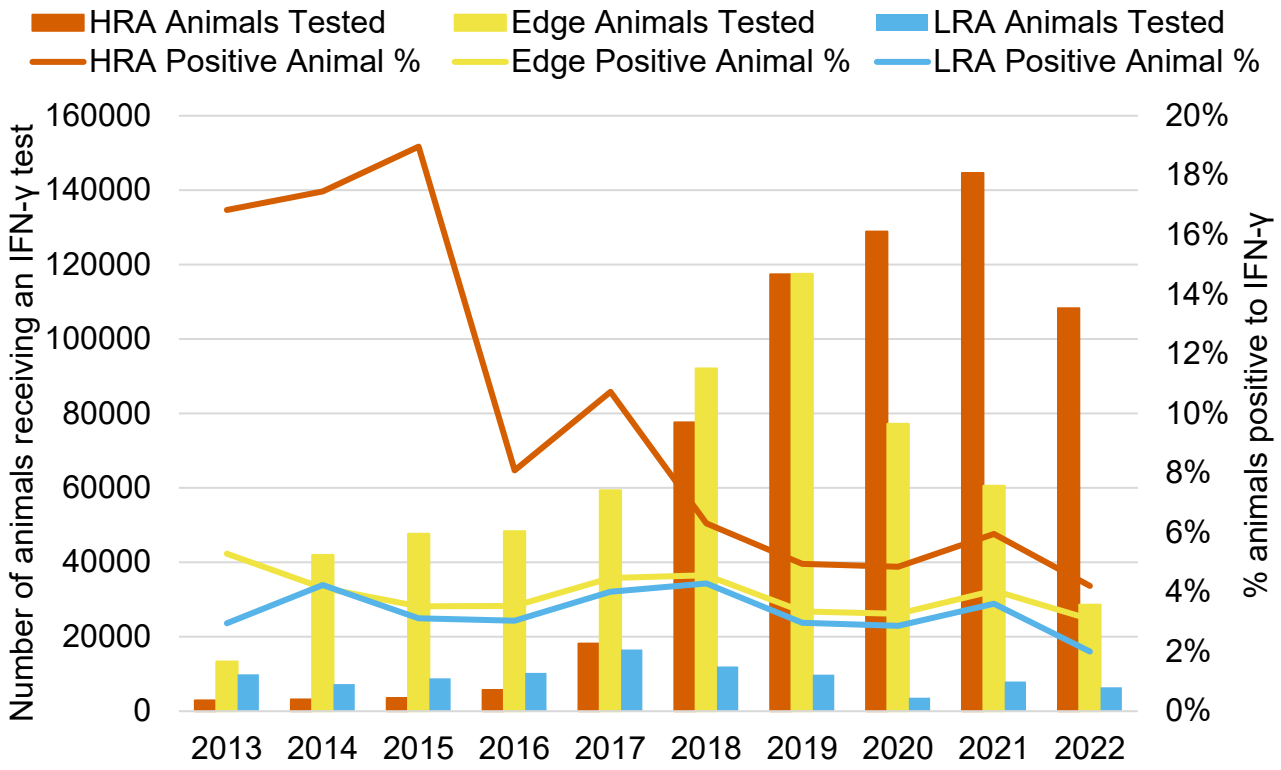
Note: Test types included Chronic breakdown management (VE-IFN_SLHERD), Miscellaneous (VE-IFN, VE-IFN_ANOM, VE-IFN_BOV_OTH, VE-IFN_FLEX, VE-IFN_NSR, VE-IFN_OTH_SP, VE-IFN_PRI), New OTF-W in BCP Areas (VE-IFN_NBCP), OTF-W outside HRA (VE-IFN_LOW_IN), Persistent OTF-W (VE-IFN_PERSI), Persistent OTF-W in BCP Areas (VE-IFN_PBCP), and Recurrent testing (VE-IFN_RECUR). Herds tested are in parentheses. In 2022, no cattle were tested under the Chronic Breakdown Management Policy in England, thus this data was excluded from the table.

A total of 143,310 cattle were IFN-γ tested in England in 2022 and 4% (5,567) of those were positive. A total of 1,066 herds were tested and 742 (70%) disclosed at least one IFN-γ test positive. Both the number of individual animals, and the number of herds receiving IFN-γ tests in 2022 fell compared to 2021 (213,173 animals and 1,970 herds).

Due to the serious epidemic of avian influenza affecting poultry farms and other captive birds during 2022, 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.

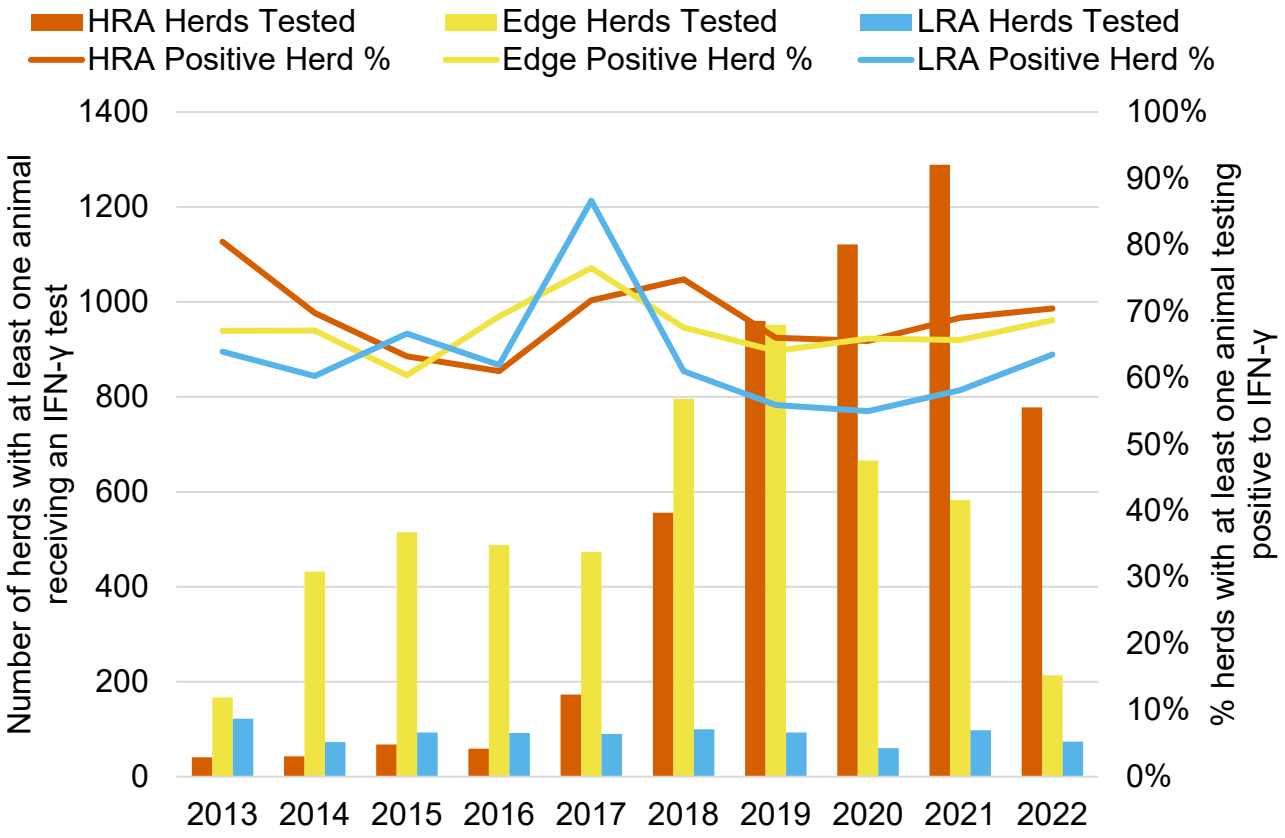
Since 2012, the overall IFN-γ test positive rate in animals has fluctuated between 4% and 6%. Historically there have been differences between risk areas, with higher rates in HRA herds (19% in 2015, 8% in 2016 and 11% in 2017). However, in 2021 and 2022, the rate fell in all risk areas. (Figure 3.3.8). 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, 2013 to 2022.



In the Edge Area, the proportion of herds which received an 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 an IFN-γ test with at least one positive animal by risk area, 2013 to 2022.



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

- During 2022, an average of 2,291 herds of cattle, water buffalo and farmed bison in England (5%) were under movement restrictions due to a TB incident, similar to previous years. In other words, about 95% of all those herds in England were Officially TB Free (OTF).
- The end-of-year point prevalence for England was 4.3%, with 2,035 (of 46,697) herds under restrictions on 31st December 2022.
- Most herds under restrictions were in the HRA. In 2022, the monthly average herd level prevalence in the HRA was 9.1%, a non-significant increase on 2021 (8.9%, z-test p=0.98.
- Herd prevalence in the Edge Area decreased non-significantly in 2022, falling back to levels last seen in 2017 and 2018 (z-test comparing 2021 and 2022 data, p=0.93). The end of the year prevalence in 2022 was highest in the counties of Oxfordshire (9%), Warwickshire (7%) and Berkshire (7%).
- Herd prevalence in the LRA remained very low and stable in 2022 (0.4% at the end of the year).
- TB infected herds remained under movement restrictions for a median of around six months in the HRA and Edge Area, and five months in the LRA. TB incident herds with more than 200 animals or with more than one reactor disclosed remained under movement restrictions for longer periods.
- In the HRA, the percentage of TB incidents classified as persistent, which were under restriction for more than 18 months, decreased slightly in 2022 (98 incidents, 7%), compared to 2021 (131 incidents, 9%), continuing a trend from 2015.
- The number of persistent incidents open at the end of the reporting year halved in the Edge Area in 2022 (11) relative to 2021 (24). There was only one persistent incident open at the end of the year in the LRA (in Lincolnshire) at the end of 2022, as in 2021.
- Overall, 162 persistent TB incidents were resolved in England during 2022, 82% of which were in the HRA.
- In 2022, 22,358 cattle were slaughtered for TB control reasons in England, with a median of three and an average (mean) of nine test reactors removed per TB incident that ended in 2022. The mean number of reactors removed has fluctuated over time and between risk areas. In 2022, an average of nine 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.

Herd prevalence

Herd prevalence is the proportion of cattle, water buffalo and farmed bison herds (henceforth termed ‘cattle herds’ for simplicity) 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 each TB incident herd remains under movement restrictions (incident duration).

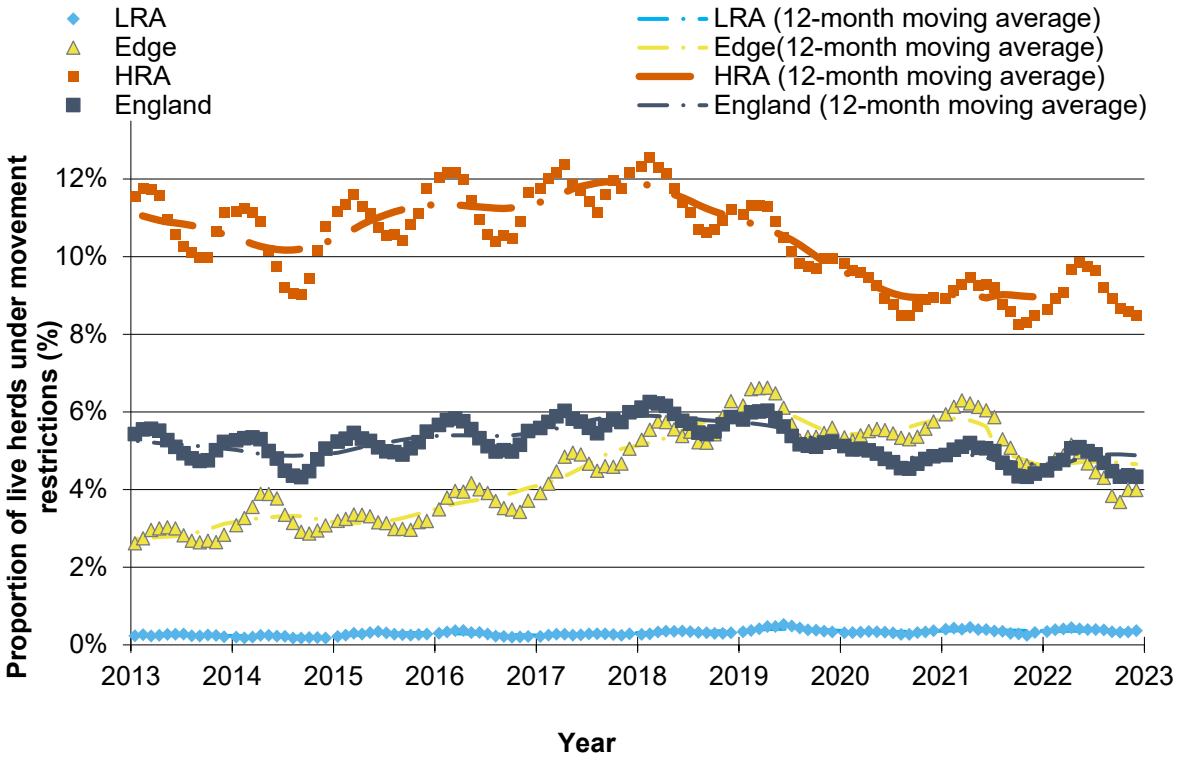
Stricter controls, in particular the number and types of tests with negative results needed for a TB incident herd to regain its OTF status, can increase the duration of restrictions. Less stringent controls may lead to a swifter resolution of the TB incident, but risks leaving undetected infection in 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 2022, an average of almost 5% of all cattle herds in England were kept under movement restrictions due to a TB incident, equating to around 2,191 herds. This was similar to the number of herds under restrictions in 2021 (5%, 2,291 herds). There was also a 6% reduction in the number of active cattle herds in England between 2021 (n=19,195) and 2022 (n=19,031).

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 in GB (i.e. October to April). Herd prevalence in the HRA increased non-significantly in 2022 (z-test p=0.82) compared to 2021, after a decreasing trend that started in 2018. In the Edge Area, while herd prevalence has risen steadily since 2007 with a marked upward trend since 2013 (when all herds in the area were placed on routine annual testing), it continued to plateau in 2022, as it has since 2020. The overall increase in prevalence since 2013 reflects both the earlier detection of (and the more stringent controls deployed in) infected herds. In the LRA, prevalence has remained consistently low for the past ten years.

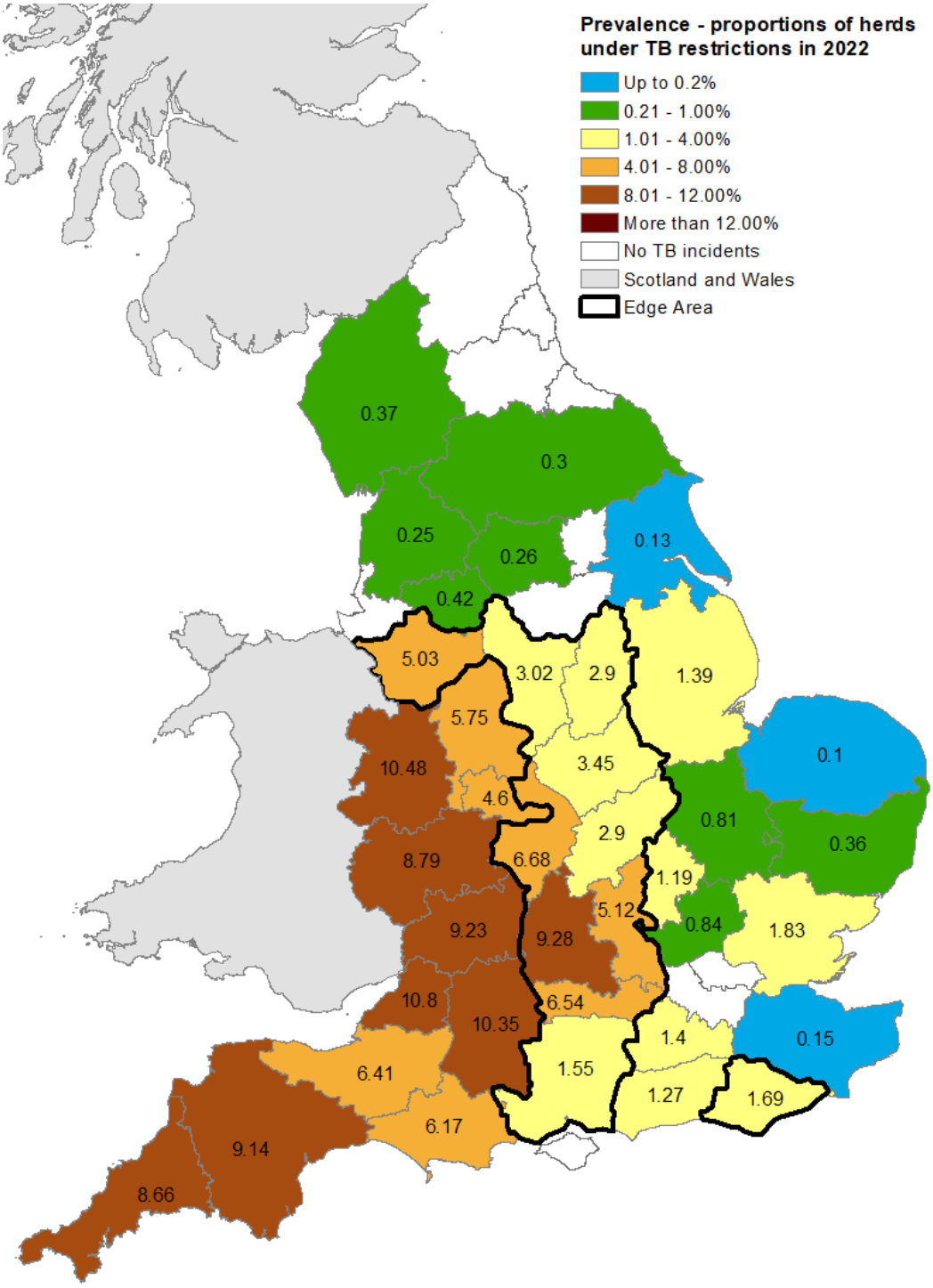
Figure 3.4.1 Proportion of live English herds under TB movement restrictions (prevalence) as a result of any TB incident, by month, between January 2013 and December 2022.



- Prevalence in the HRA spiked in mid-2022, however returned to the levels seen in previous years by the end of 2022. Prevalence in the HRA has been plateauing since 2011, with a tendency to decrease since 2018.
- In the Edge Area, prevalence peaked in between 2018 and 2019, but has been falling since, plateauing between 2020 and 2022.
- Prevalence has remained consistently low in the LRA.

In 2022, as in previous years, there was wide variation in the herd prevalence of TB across counties (Figure 3.4.2). The highest prevalence was seen in Avon (11%) (HRA), followed by Shropshire (10%) (HRA), Wiltshire (10%) (HRA) and Oxfordshire (9%) (Edge Area). The lowest prevalence was in the LRA counties. Further details about prevalence at county level are presented in Chapter 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 of England that were under restrictions due to a TB incident at the end of 2022 (31st December)



- Herd prevalence was generally greatest in the HRA counties (highest in Avon). However, as in previous years, Oxfordshire also sustained a high prevalence comparable to (or exceeding) that of HRA counties.

Duration of TB incidents

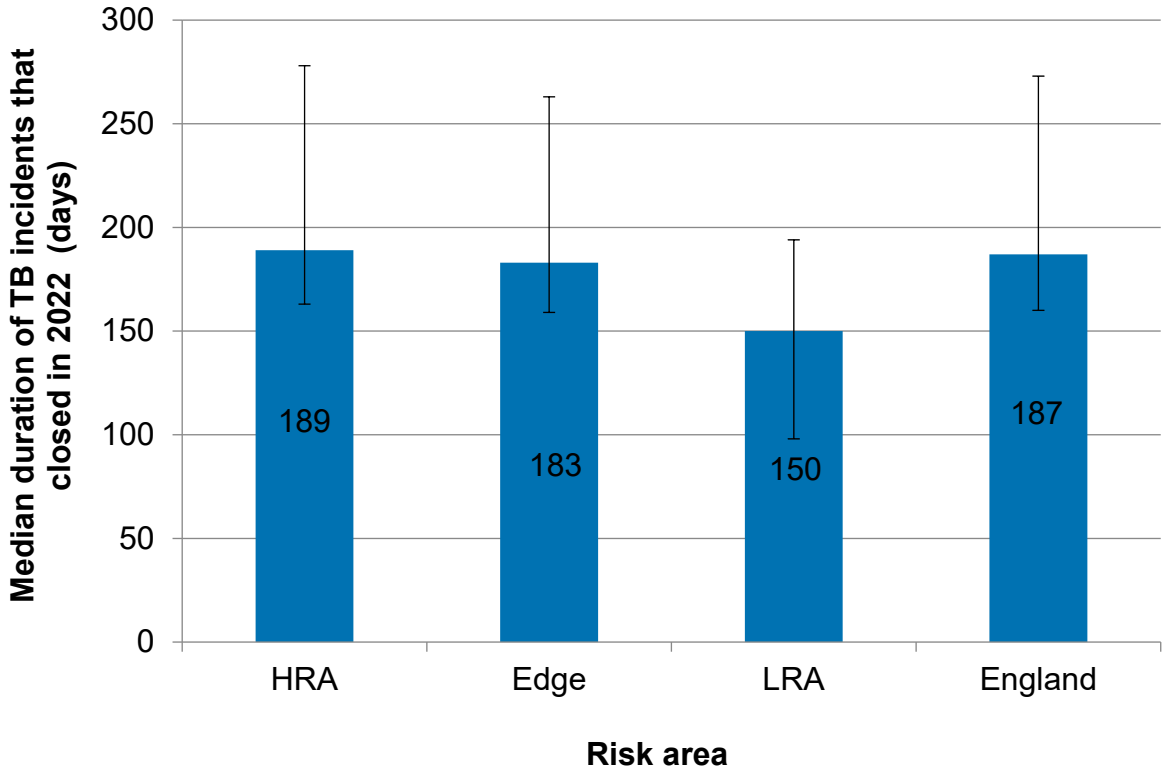
Herds affected by TB incidents lose their OTF status and are thus prevented from moving cattle to other herds while incident control measures are in place to limit the risk of spreading TB. Limited exceptions, including direct movements to slaughter, slaughter markets or finishing units approved by APHA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

TB incident duration affects the cost of TB to both farmers and taxpayers because movement restrictions upset the normal management of the herd and trigger more frequent herd testing. Longer TB 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 2,975 TB incident herds in England regained OTF status (i.e., had movement restrictions lifted) in 2022. Of those, 13 were non-grazing AFUs (nine in the HRA and four in the Edge Area). Due to differences in the management of TB in AFUs, which remain under permanent TB movement restrictions, they have been excluded from the following duration figures.

Herds with a TB incident were under restriction in the HRA and Edge Area for a median period of around six months. This was longer than in the LRA (median of five months), although this difference was not statistically significant (Figure 3.4.3). The lower duration in the LRA 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. The median and interquartile range (IQR) for herds in the HRA, Edge Area and LRA are shown in Figure 3.4.3. This is slightly higher than the median duration of incidents in the LRA in 2021, which was 137.5 days.

Figure 3.4.3 Median duration and interquartile range of all TB incidents that closed in 2022, by risk area

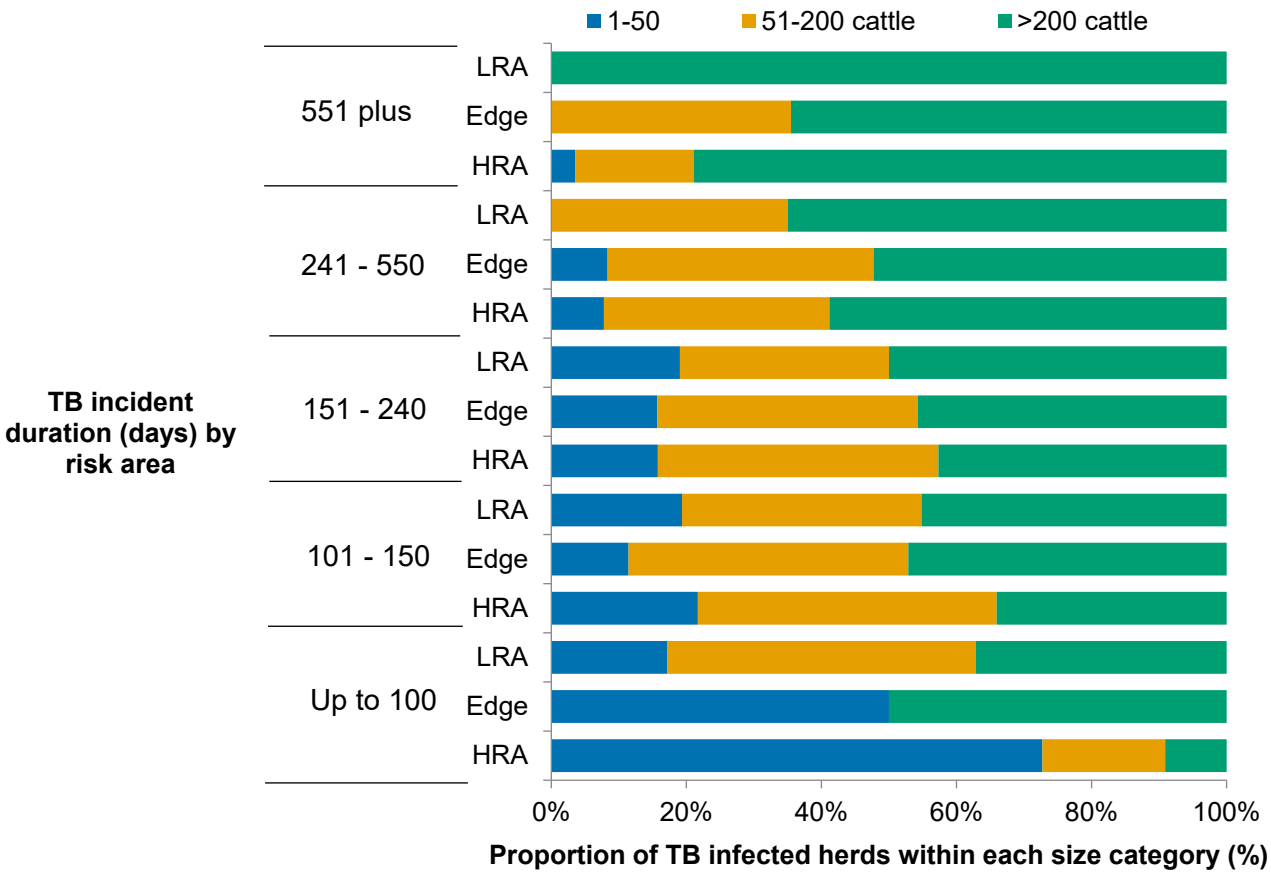


- Herds were under restriction due to TB for similar lengths of time (median) in the HRA and Edge Area, but the duration was shorter in the LRA. However, there is wide county-to-county variation within each risk area.

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 TB risk areas (Figure 3.4.4). Further details on the regression analysis used to look at the association between herd size, TB risk area and incident duration is available in the Great Britain surveillance data report (Tab D7).
In 2022, 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 50 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 ended in 2022, 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 eradicate infection from a herd, such as:

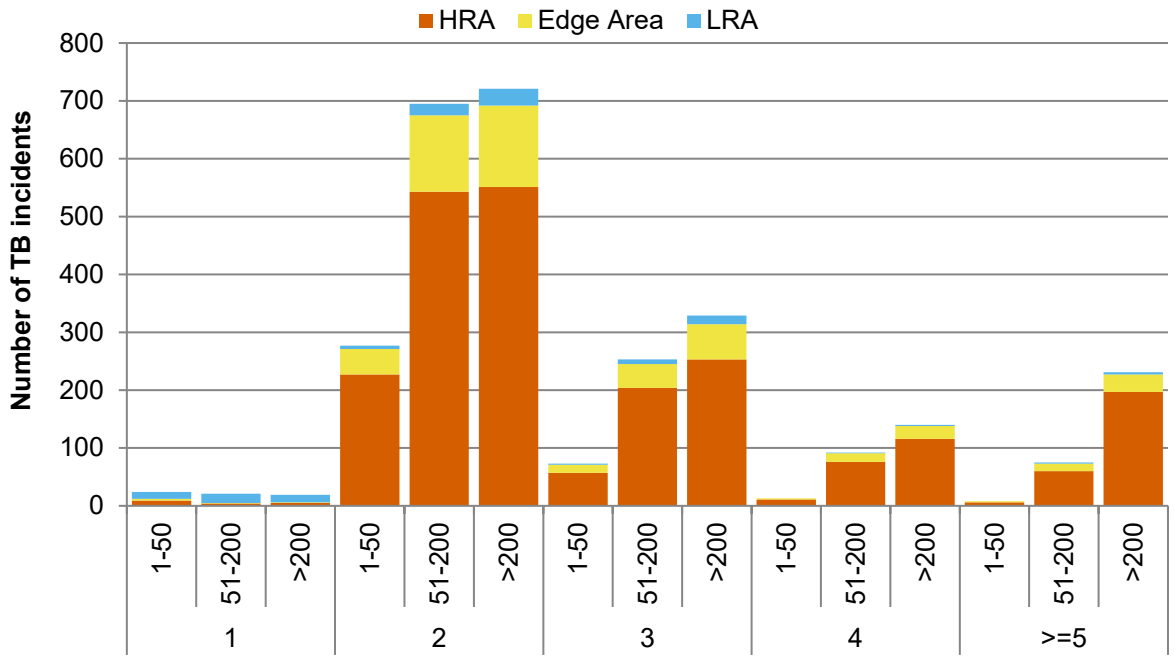
- The limitations of the existing ante-mortem diagnostic tests in finding all infected animals after one round of testing (imperfect sensitivity of the skin and IFN-tests) leading to false negative results and missed infected animals, some of which emerge as TB reactors in subsequent herd tests.
- Intense 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).
- Introduction of infected animals (herd replacements) under movement licence.
- Uninfected animals showing non-specific reactions, i.e. false positive test results (less common).

Figure 3.4.5 shows the number of short-interval skin tests (SITs) required to resolve a TB incident, comparing risk area and herd size.

In 2022, for all risk areas, most TB incidents required two SITs to restore OTF herd status, as in 2021. Herds in the HRA tended to have longer TB incidents, with 11% of herds (263) receiving five or more SITs in 2022. In the Edge Area, 9% of herds (45) received five or more SITs, and in the LRA just five per cent (six herds).

In the HRA, almost three-quarters of small herds (1-50 cattle) required two SITs to resolve a TB incident (73%), while 24% required three or more. Similarly, most medium size herds (51-200 cattle) ended their TB incident after two SITs (61%) and over a third required three or more SITs (38%). Large herds (>200 cattle) were split almost equally between needing two SITs (49%) or three or more SITs (50%).

Figure 3.4.5 Number of short interval tests (SITs) to resolve a TB incident, by risk area and herd size (for TB incidents ending in 2022)



Number of short interval tests (SITs) to resolve a TB incident, by herd size and risk area

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

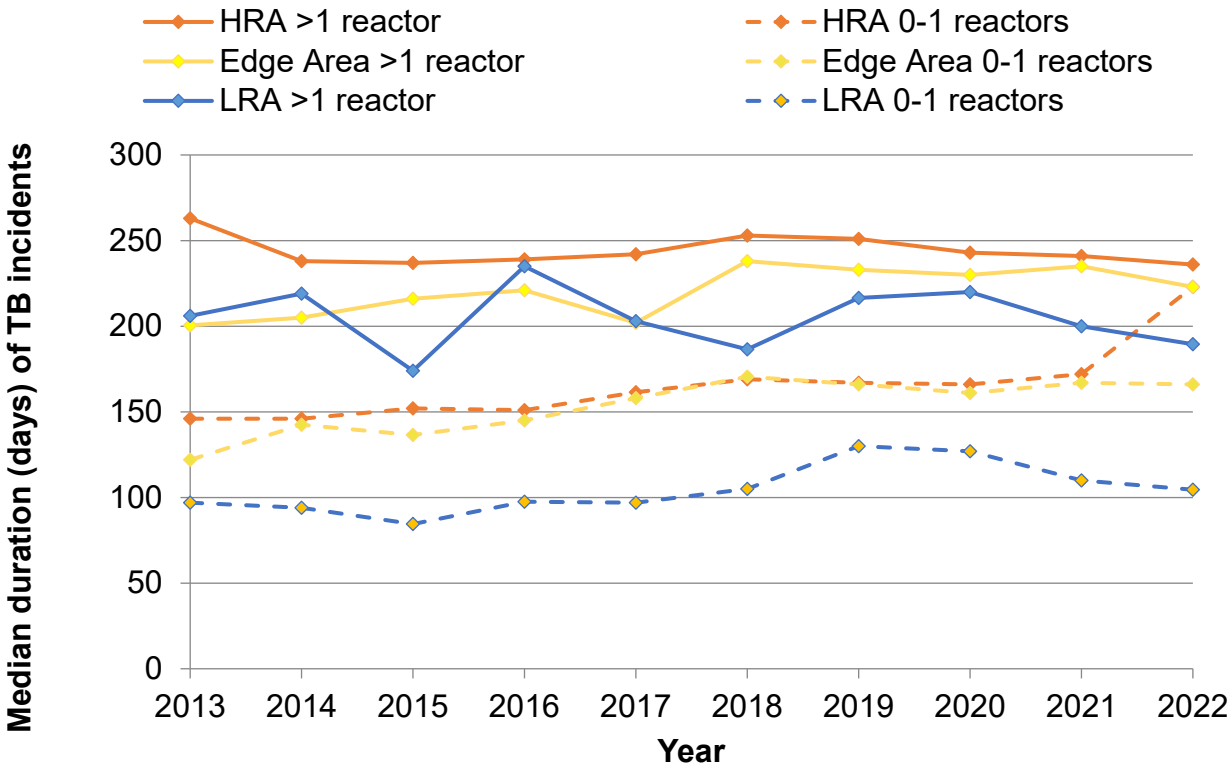
Changes in incident duration over time

Since 2013, 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). In 2022, this difference was statistically significant (Pearson's chi square test, $p<0.001$).

Additionally, 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 2022, herd incidents with more than one reactor in the Edge Area had the shortest median duration since 2017 (233 days in 2022, 202 days in 2017).

Previously, the duration of TB incidents with 0-1 reactors in the HRA and Edge Area had been similar to each other since 2014, increasing steadily each year. However, in 2022 this rose in the HRA to a median duration of 233 days (up from 172 in 2021), the highest seen. 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 most 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 ended in each year, between 2013 and 2022. Note: TB incidents triggered by no reactors were TB incidents initiated by a slaughterhouse case, or by two or more IRs per TB incident, where subsequent testing in the herd revealed no reactors



- TB incidents that ended in 2022 in the HRA and Edge Area with more than one reactor were under restriction for a similar duration.
- In 2022, the median duration of single reactor herds in the HRA was substantially greater than the Edge Area for the first time since 2013.
- 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

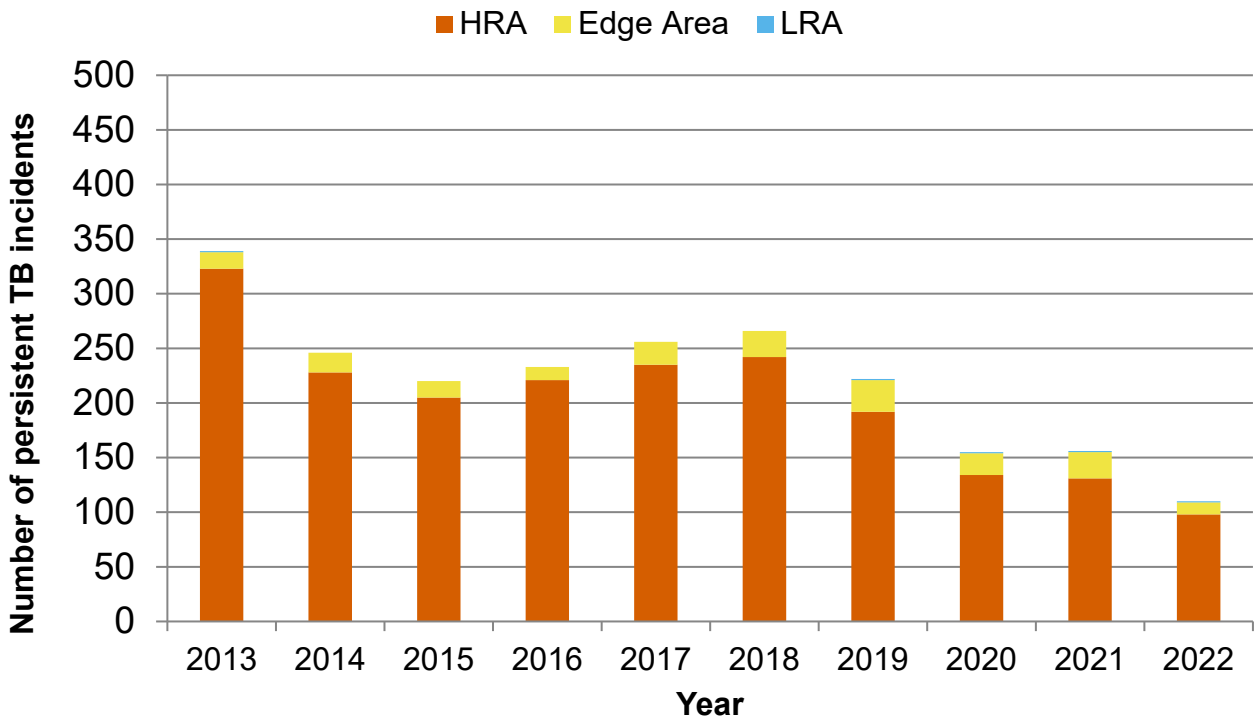
Once a TB infected herd has been under movement restrictions for over 550 days (about 18 months), APHA considers the incident to be ‘persistent’. The affected herds are then eligible for enhanced management procedures, based on a series of prioritisation criteria. The causes of persistent TB incidents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

Figure 3.4.7 shows the number of persistent TB incidents that remained unresolved at the end of each year since 2013, by risk area. The vast majority of those (89%) were in the HRA.

The number of persistent incidents still open at the end of 2022 in England (n=110) was the lowest in the past 10 years. In the Edge Area, the number of persistent incidents more than halved, from 24 in 2021 to 11 in 2022, falling back to levels last seen in 2016. In the HRA the number of persistent TB incidents increased by a fifth between 2015 to 2018, but have been falling since, dropping by a quarter between 2021 (n=131) and 2022 (n=98) (Figure 3.4.7). Only one persistent incident remained open in the LRA (Lincolnshire) at the end of 2022 (Figure 3.4.8).

The fall in the number of persistent incidents at the end of each year in the HRA since 2019 is an encouraging trend. Despite the non-significant increase in the number of TB incidents in the HRA in 2022 relative to 2021, the decrease in persistent incidents continued, with 7% of all TB incidents still open at the end of the year being persistent, down from 9% in 2021.

Figure 3.4.7 Number of persistent TB incidents still open at the end of each year that had lasted more than 550 days.



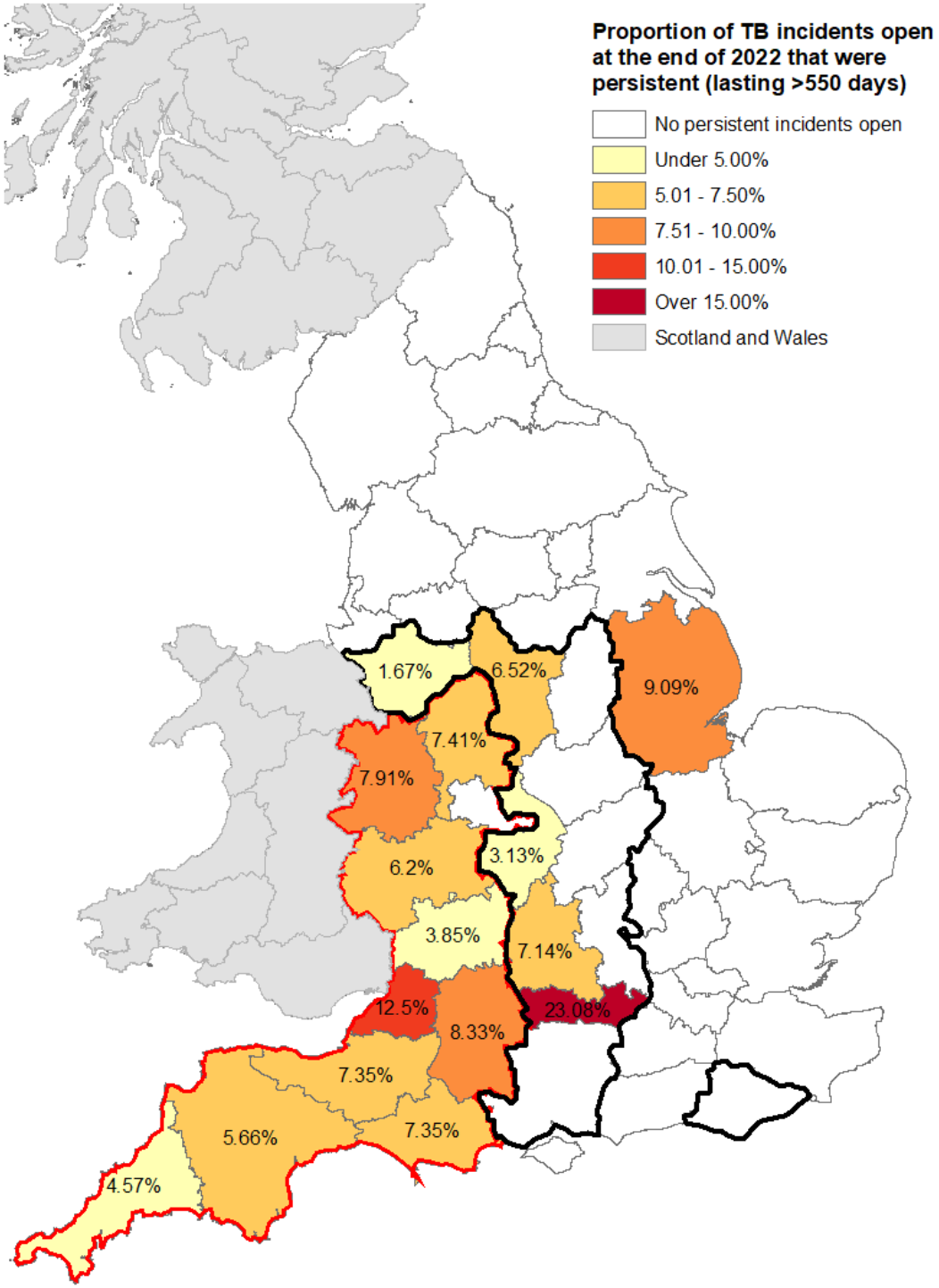
- During 2022, there were 110 persistent TB incidents in England overall (98 in the HRA, 11 in the Edge Area and one in the LRA).

There was variation across counties in the proportion of persistent incidents at the end of 2022 that were classified as persistent (Figure 3.4.8), with sixteen counties having persistent incidents in 2022 (n=17 in 2021). Within each county, the highest proportion of persistent TB incidents open at the end of 2022 was found in Berkshire in the Edge Area (23%) and Avon in the HRA (13%) –the only two counties in 2022 in which this proportion exceeded 10%, compared to six in 2021.

Despite having the highest proportion of persistent incidents in England, this proportion of incidents in Berkshire fell compared to 2021 (n=23% in 2022, n=27% in 2021). This is in line with the decreasing trend in persistent incidents in England observed over the previous decade. The proportion of persistent incidents open at the end of the reporting year had previously been increasing in Berkshire, where it rose from 14% in 2018 to 27% in 2021.

In Avon, the proportion of persistent incidents has fluctuated in recent years – it was 13% in 2022, as in 2021, however had been under 10% in both 2020 and 2019. The proportion in 2022 for Avon was still lower than its previous highpoint of 19% in 2013. All other counties had a proportion under 10% of persistent incidents.

Figure 3.4.8 Proportion of persistent TB incidents in each county, open at the end of 2022, that had lasted more than 550 days



- The highest proportion of persistent TB incidents open at the end of 2022 was in the HRA.
- The counties with the highest proportion of persistent TB incidents open at the end of 2022 were Berkshire (23%) and Avon (13%).

Number of animals removed from TB incident herds

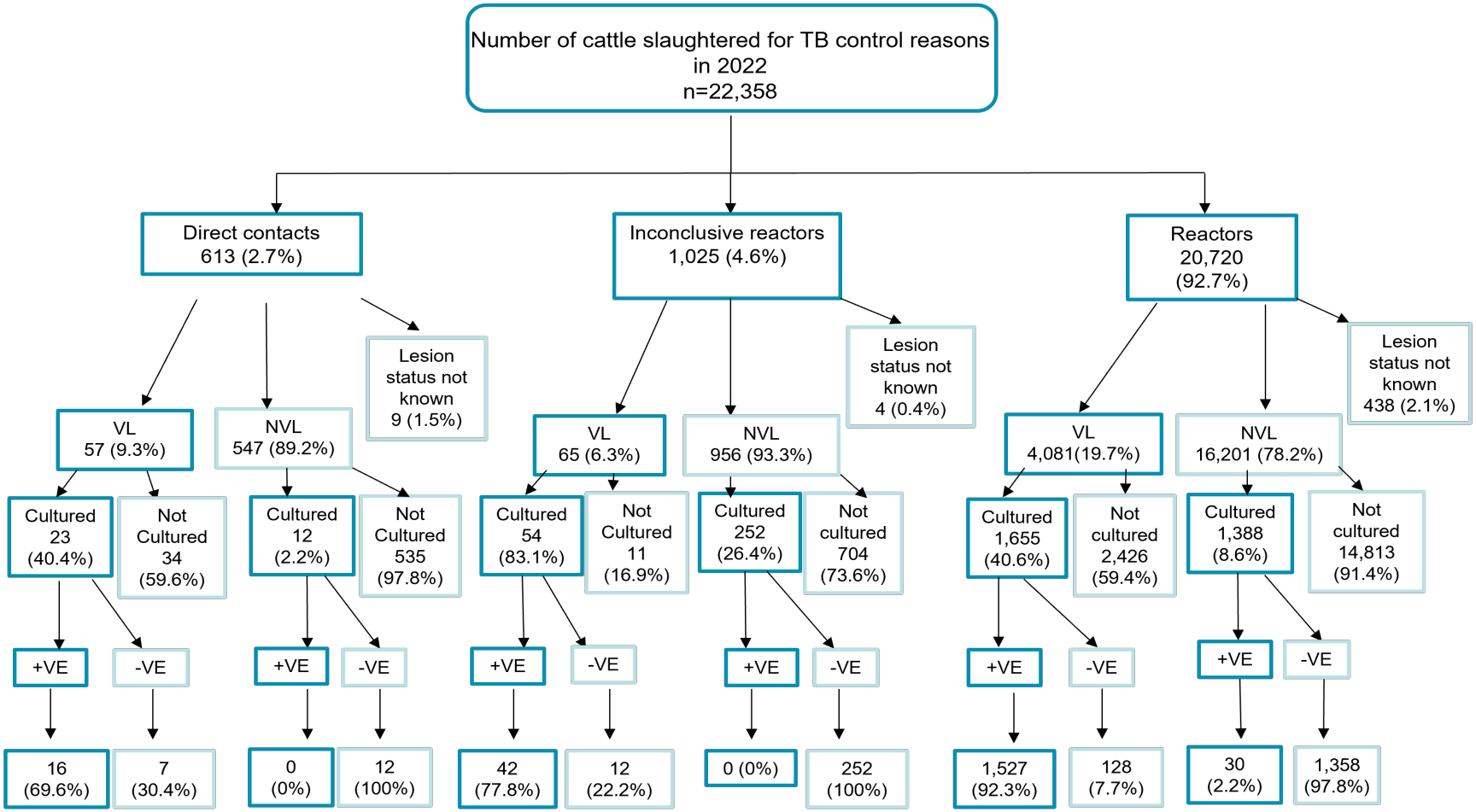
Cattle that test positive for TB must be isolated from the rest of the herd and are rapidly removed. In 2022, a total of 22,358 cattle were slaughtered for TB disease control purposes in England. This was a quarter less than in 2021 (n=27,855). The vast majority of these animals were skin or IFN-γ blood test reactors, or both (93%). The remaining 7% 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 at slaughter for laboratory culture and whole-genome sequencing (WGS) of *M. bovis*. For incident control purposes, confirmation of infection with *M. bovis* entails the detection of typical visible lesions of TB at PMMI in at least one slaughtered test reactor ('VL reactors'), or the identification of *M. bovis* by bacteriological culture (or, more recently, by PCR testing) in at least one animal in the affected herd.

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 less than 2% of animals with non-visible lesions (NVL) (Figure 3.4.9a).

The results of the single intradermal comparative cervical tuberculin (SICCT) 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 and is then also retrospectively applied to the results of the test that disclosed the TB incident. It is designed to identify more positive animals, thus reducing the risk of leaving undisclosed infection in the herd.

Figure 3.4.9a Diagram showing the number of different categories of cattle that were slaughtered for TB control reasons in 2022, and the number (and percentage) of those in which infection with *M. bovis* was confirmed post-mortem.



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

In England, most test reactors in 2022 (51%) were removed under the standard-interpretation of the skin test (10,652 animals). This was followed by supplementary IFN-γ blood tests with a positive result (5,567 animals, 27%), which fell by more than half in 2022 (11,185 animals in 2021). This decrease in the number of reactors removed after supplementary IFN-γ blood tests is due to several reasons. This includes fewer cattle herds being eligible for IFN-γ testing due to changes in the policy in 2021; fewer OTF-W incidents disclosed due to decreasing incidence and prevalence in England; and a proportion of tests which were not booked due to diversion of APHA resources because of the avian influenza outbreak.

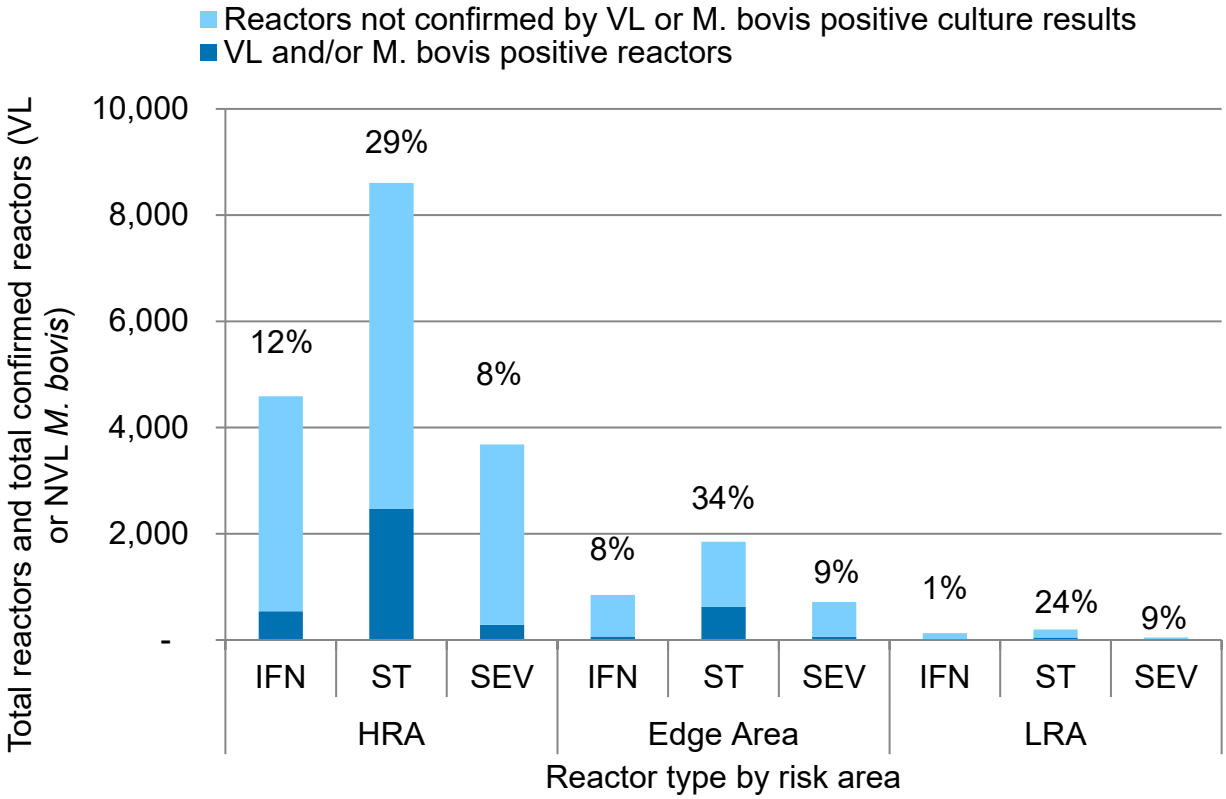
Finally, 21% (4,443 animals) were severe-interpretation reactors. Before 2021, IFN-γ tests were compulsory in OTF-W incidents in the Edge Area and the LRA, and in parts of the HRA where badger control had been in operation for at least two years. On 12th July 2021, a new policy was introduced in the HRA and in the six-monthly testing zones of the Edge Area whereby only herds with OTFW incidents occurring within 18 months of regaining officially TB free (OTF) status following a previous OTFW incident, and herds sustaining a persistent TB incident, require a mandatory IFN-γ test. The test deployment policy was unchanged in the LRA and the annual surveillance testing part of the Edge Area.

The pattern of slaughtered reactor cattle in the HRA was similar to England overall, with over half the cattle slaughtered under a standard interpretation of the skin-test (8,608 animals, 51%). Around a quarter (27%) of animals in the HRA were removed because of a positive IFN-γ test (4,589 animals). Similarly, most animals were also removed under a standard interpretation of the skin test in 2022 in the Edge Area and LRA (53% for both risk areas, 1,848 animals in Edge Area and 196 in the LRA). Animals removed after a positive IFN-γ test represented 24% (849 animals) and 34% (126 animals) in the Edge and LRA 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, 77% were removed as standard-interpretation reactors.

In England, 30% of standard-interpretation reactors had visible lesions of TB, *M. bovis* positive culture results, or both. For IFN-γ test-positive animals, the equivalent proportion was 11%, and was 8% for severe-interpretation reactors. The proportion for IFN-γ test-positive animals increased in 2022 compared to 2021 (8%).
As expected, these percentages varied by TB risk area (highest in the HRA and Edge Area, and lowest in the LRA). In the HRA, the percentage of IFN-γ test confirmed cases increased from 8% in 2021 to 12% in 2022. Standard-interpretation reactors dropped from 34% to 29%, as did severe-interpretation reactors (12% to 8%) (Figure 3.4.9b).

Figure 3.4.9b Number of reactors and other animals removed for TB control reasons in 2022 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.



The majority of the 22,358 cattle removed from herds were reactors taken from the HRA (n=18,148, 81%), which has been the pattern over the last ten years (Figure 3.4.10a). However, substantial numbers were also taken as 1xIRs or DCs (655 in the HRA) and 2xIRs (614 in the HRA).

After a steep increase in the number of reactors removed from herds in the Edge Area between 2013 and 2019, the number of reactors has been decreasing since 2020, falling by 30% in 2022 to 3,473 reactors removed (Figure 3.4.10b). Increases seen since 2013 were due to the adoption of more frequent routine herd testing and more stringent TB incident control protocols in the Edge Area.

In the LRA, the number of reactors and 1xIR or direct contacts has fluctuated over the years but remains a tenth of the value seen in the HRA and Edge Area. The number of 2xIRs has been stable, hovering around 50 since 2016.

Two consecutive skin herd tests with negative results at severe interpretation are required before restrictions can be lifted from any TB 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 2013 and 2022, in the HRA.

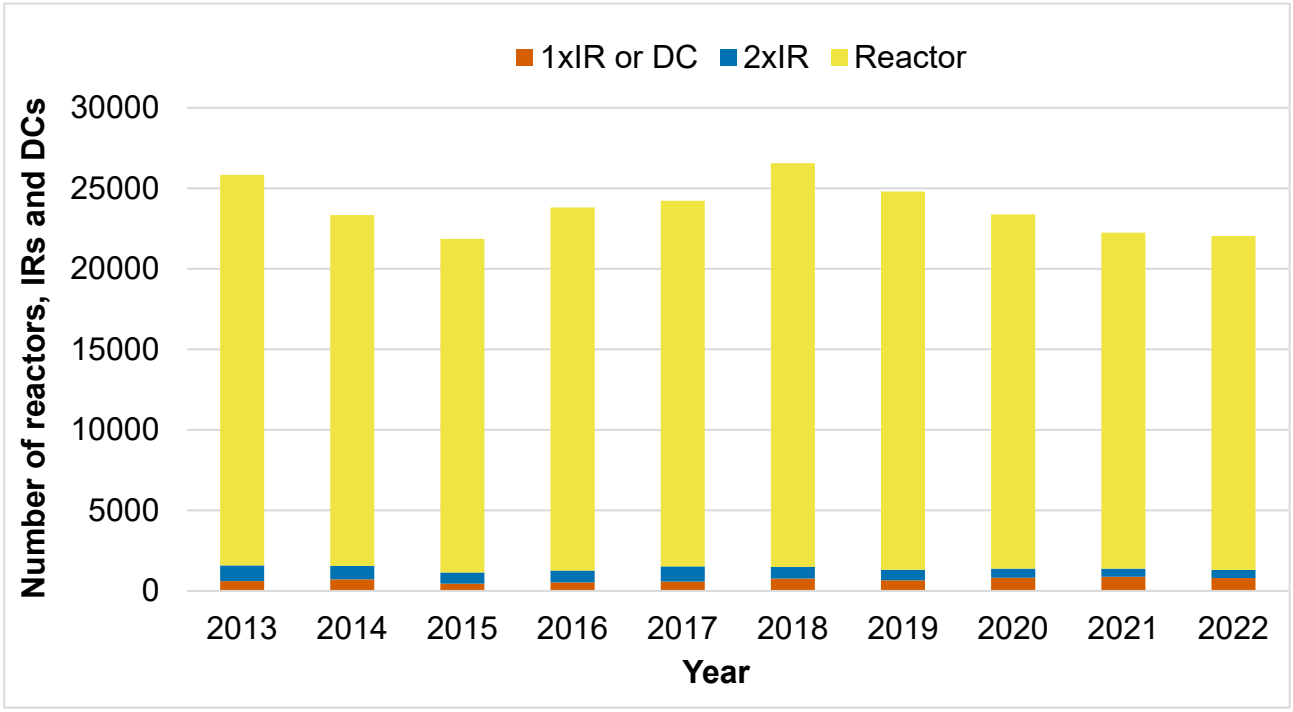


Figure 3.4.10b Number of reactors, inconclusive reactors and direct contacts removed from herds between 2013 and 2022, in the Edge Area.

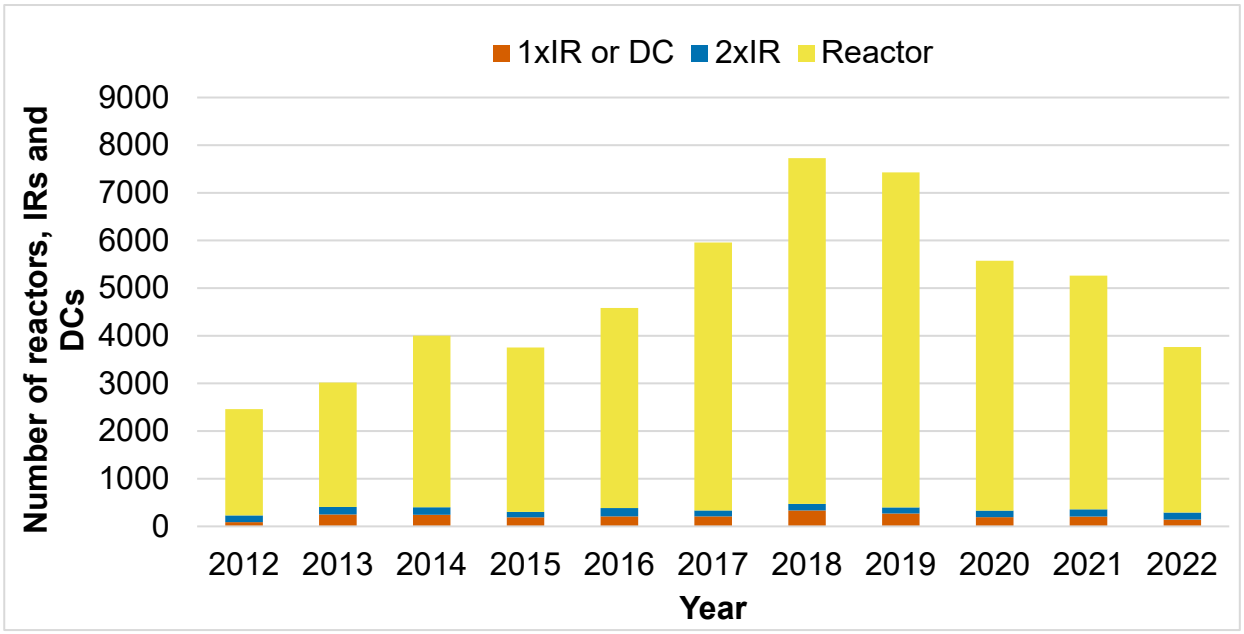
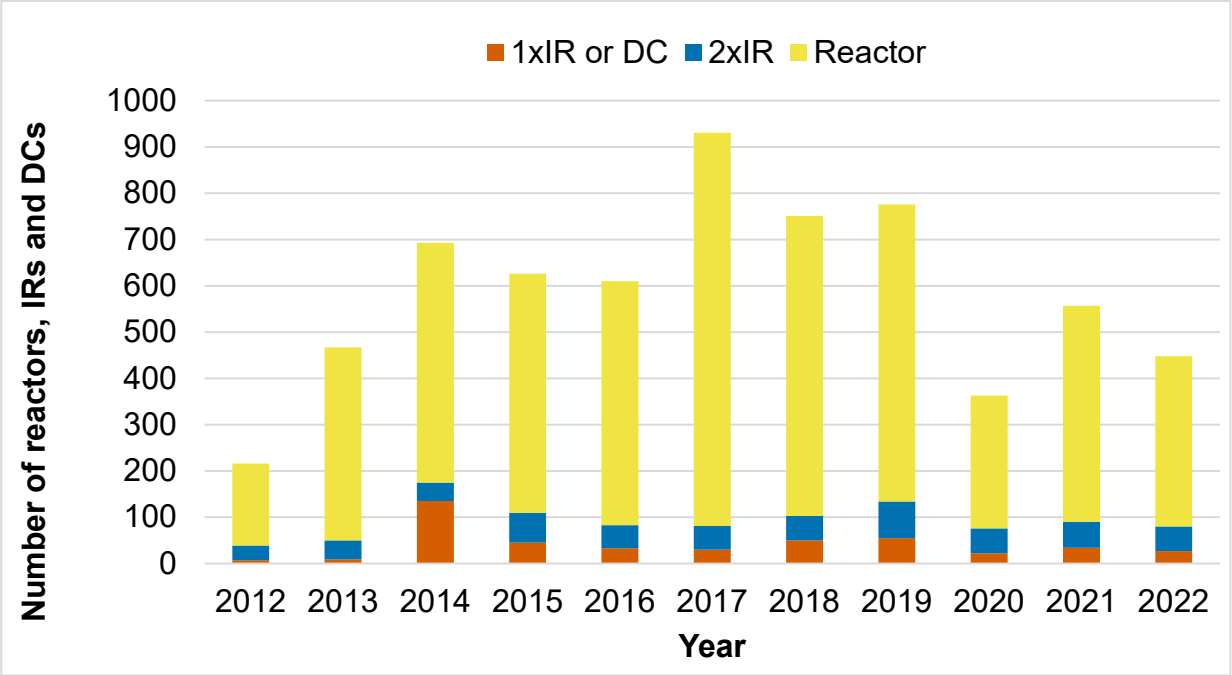


Figure 3.4.10c Number of reactors, inconclusive reactors and direct contacts removed from herds between 2013 and 2022, in the LRA.



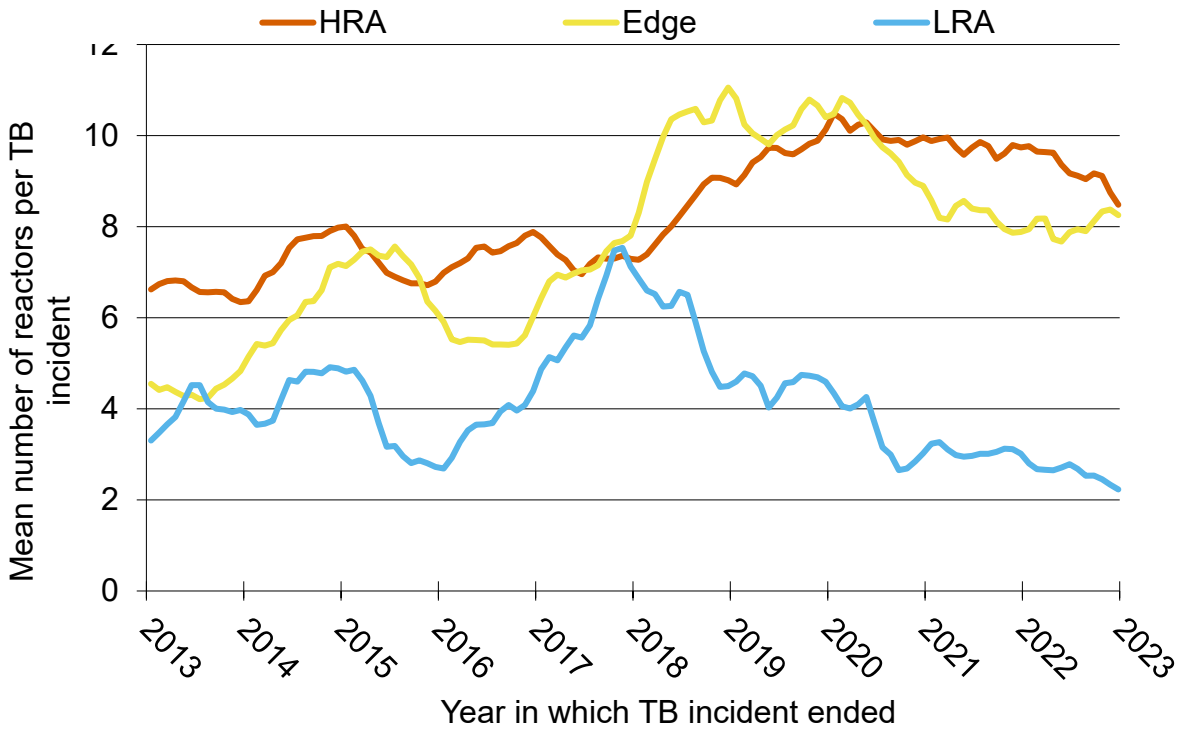
- Most cattle removed over the past ten years are reactors taken from the HRA, with substantial numbers also removed as DCs or IRs.
- The number of cattle removed as reactors in the Edge Area has increased substantially since 2013, when more stringent controls were introduced, but has been falling since 2020.

In 2022, the *median* number of reactors removed per incident (including IFN-γ test positive animals) was three, consistent with previous years. The *mean* number of test reactors removed in the HRA per TB incident was around six from 2009 to 2014. It then increased to almost 10, by the end of 2020, and has since dropped to 8.73 in 2022. 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 2022.

The fall in the number of reactors in the HRA and Edge Area may have been associated with changes in the use of the IFN-γ test in recent years. The number of IFN-γ tests used in England fell by 14% during the COVID-19 pandemic in 2020 compared to 2019, and specifically by over a third (34%) in the Edge Area. In 2021, changes to eligibility criteria to use IFN-γ tests in herds in the HRA and LRA meant that 12% more IFN-γ tests were conducted in the HRA, whereas these same tests decreased by a fifth in the Edge Area. In 2022, IFN-γ tests halved in the Edge Area to 28,622 compared to 2021, and fell by a quarter in the HRA, to 108,248. There are very few TB incidents in the LRA, so the equivalent mean shows greater variability.

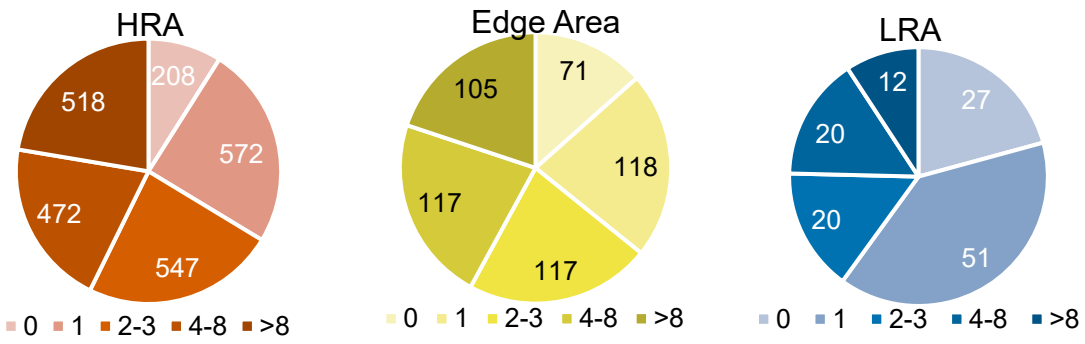
Of the TB incidents that closed in 2022, 306 had no reactors (Figure 3.4.11b). These were either incidents initiated by a slaughterhouse case, or by two or more IRs per TB incident, where subsequent testing in the herd revealed no reactors. Sixty-five percent of TB incidents in England had two or more reactors, largely driven by the Edge Area and the HRA (64% and 66% respectively). In the LRA, the proportion was 40% (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 2013 and December 2022, 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, rose to close to 10 reactors in 2020 and in 2021, and has fallen in 2022 to around 9 per incident.
- 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 2022.
- There are few incidents in the LRA, so the mean shows greater variability, with a peak of almost 8 reactors in 2018.

Figure 3.4.11b Number of reactors per TB incident that finished in 2022, 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 were spread evenly between all reactor number categories, except for incidents with no reactors, which were the least common.
- In the LRA, incidents with just one reactor were most common.

4. The TB epidemic in England's risk areas

4.1 Epidemiology of TB in the High Risk Area

- In 2022, the High Risk Area (HRA) accounted for 78% of all new TB incidents declared in England in 2022. The total number of new TB incidents detected in the HRA in 2022 (n=2,294) increased significantly by 6.5% compared to 2021 (n=2,155) ($p<0.001$), following the effective rollout of six-monthly TB surveillance testing of herds across most counties of the HRA from September 2020 (Staffordshire and Shropshire) and July 2021 (the remaining nine HRA counties). The change in policy is likely to lead to an increase in the detection of TB incidents.
- However, the TB herd incidence rate in the HRA was 14.4 TB incidents per 100 herd years at risk (HYR), the same as 2021. This was the lowest annual herd incidence rate recorded in the HRA since 2007.
- In 2022, TB incidence per 100 HYR decreased in six HRA counties, and increased in the remaining five counties, compared to a reduction in almost all HRA counties in the previous year.
- The only counties which saw a statistically significant change in incidence in 2022 compared to 2021 were Cornwall (24% increase, $p=0.01$) and Staffordshire (20% decrease, $p=0.02$). The lowest incidence rates were observed in Staffordshire (11.5 TB incidents per 100 HYR), Somerset (11.5) and the West Midlands (7.9). The highest rates in 2022 were observed in Shropshire (16.7), Hereford and Worcester (16.3) and Gloucestershire (15.6).
- The overall average monthly herd prevalence for the HRA increased non-significantly from 8.9% in 2021 to 9.1% in 2022 ($p=0.816$). However, the end of year herd prevalence had a non-significant decrease between 2021 and 2022 (8.5% and 8.4% respectively, $p=0.948$).
- As with the incidence rate, prevalence varied between counties. The highest end-of-year county herd prevalence's in 2022 were seen in Avon (10.8%), Shropshire (10.5%) and Wiltshire (10.4%). The West Midlands had the lowest prevalence in 2022, though there was a 35% increase from 2021 (from 3.4% in 2021 to 4.6% in 2022). However, the West Midlands contains very few herds, so estimates of prevalence can vary widely due to sampling variability.
- Devon had both the highest number of herds in the HRA in 2022 (24%) and accounted for the highest percentage of all new TB incidents in the HRA in 2022 (26%). This was followed by Cornwall, which had 15% of new TB incidents, and 14% of HRA herds.
- The median duration of TB herd incidents was 189 days in the HRA overall in 2022, which was a statistically significant decrease from 202 days in 2021 ($p<0.001$). Counties experiencing the longest TB incidents on average (for incidents ending in 2022) included Avon (211.5 days), Dorset (196 days), and Gloucestershire (193).

- Overall, most counties in the HRA saw a decrease in the percentage of persistent TB incidents (those lasting more than 550 days) that were still ongoing at the end of 2022 compared to 2021. The exceptions to this were Shropshire, which saw an increase, and Avon which remained stable. Counties with the highest percentage of persistent TB incidents were Avon (12.5%), Wiltshire (8.3%) and Shropshire (7.9%).
- The HRA accounted for 75% (n=108,248) of all IFN-γ tests carried out in England in 2022. The number of tests carried out in the HRA decreased by 25% from 2021 (n=144,621) and by 16% compared to 2020 (n=128,858). The HRA county where the highest number of IFN-γ tests were carried out in 2022 was Shropshire (n=19,055; 18% of HRA tests). The number of tests carried out in Shropshire increased by 107% in 2022 compared to 2021.

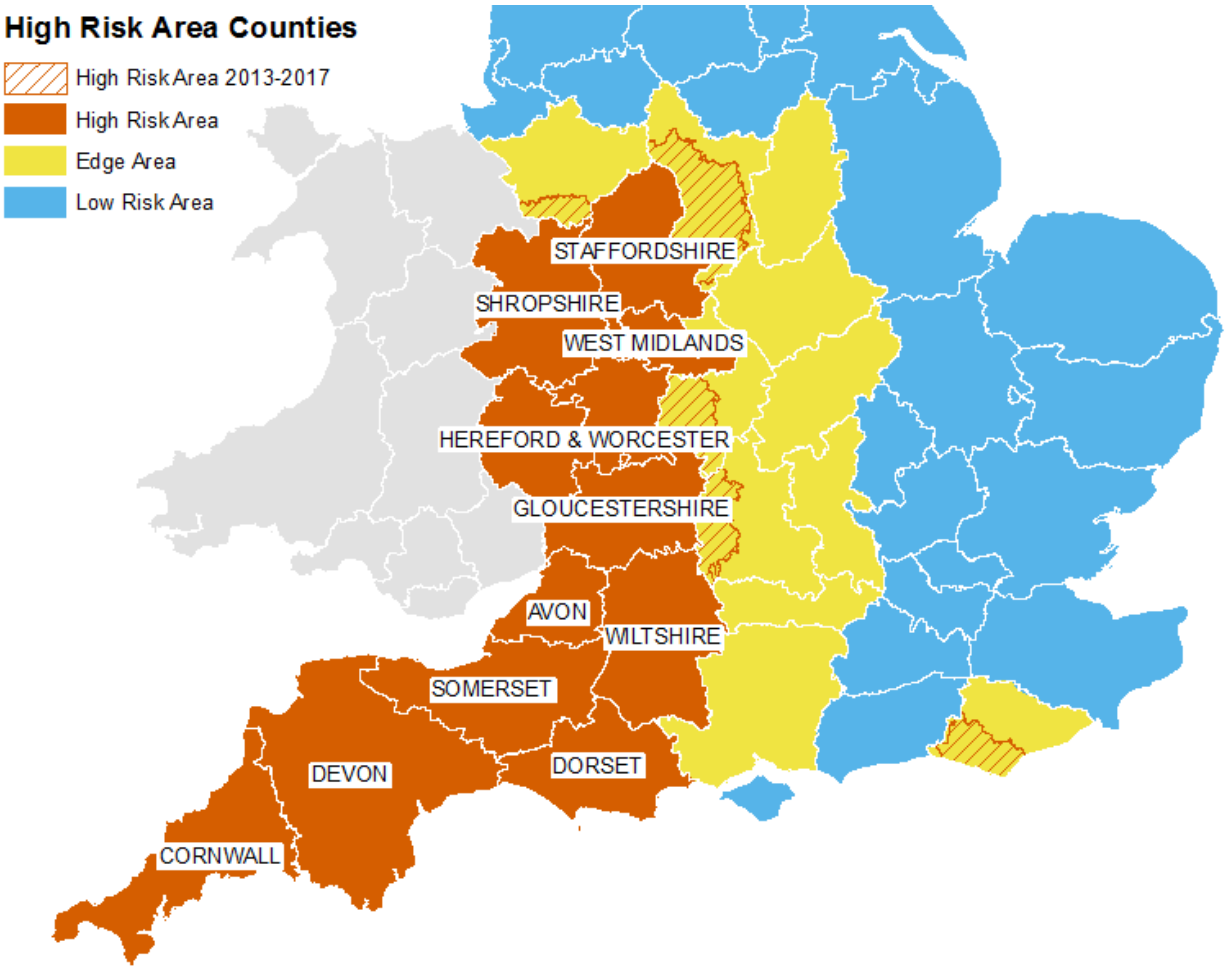
Geographical coverage of the HRA

The High Risk Area (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 (and number of cattle herds in) the HRA. Data reported in this chapter are for the 11 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.

From July 2021, default six monthly testing was rolled out across the HRA, having been first introduced in Staffordshire and Shropshire in September 2020. Prior to this policy change, all herds in the HRA received annual surveillance tests. 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. For more information please refer to the TBhub (Six-monthly surveillance testing of cattle herds in the High Risk Area - Bovine TB | TB Hub).

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 2022, 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 (i.e. lesion and/or culture-positive ones (OTF-W), or lesion and/or culture-negative but strongly suspected ones (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 2022 was 14.4 TB incidents per 100 HYR, the same as 2021 (Table 4.1.1).

Table 4.1.1 Table of headline TB epidemiological parameters for the High Risk Area of England in 2022

Year	Total number of new TB infected herds (TB incidents)	Herd incidence rate	Median duration of TB incident (days) (interquartile range)	Herd prevalence (average monthly)
2022	2,294	14.4	189 (163 to 278)	9.1
2021	2,155	14.4	202 (167 to 291)	8.9
Change (%)	6.5	0	-6.4	2.2
Statistical significance	(p<0.001)	(p=0.952)	(p<0.001)	(p=0.816)

Note: The change in total number of new TB 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 2022 and 2021 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 2021 and 2022 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. During 2022, most herds in the HRA received two routine herd tests, compared to one in the previous years, due to the change in policy implemented from July 2021. The exceptions to this were Staffordshire and Shropshire, where herds moved from annual to six monthly testing following the rollout of the policy in September 2020. Increasing the default testing frequency of cattle herds in the HRA from annual to six monthly enables TB infected herds to be identified sooner.

The number of new TB incidents increased in seven of the eleven HRA counties in 2022 compared to 2021, however the increase was only statistically significant in three counties (Devon p<0.001, Somerset p=0.003, and Wiltshire p=0.001). The change in total number of new TB incidents for each county was compared using a chi-squared test. TB incidents decreased significantly in four HRA counties in 2022 compared to 2021: Staffordshire (172 vs 241 TB incidents, p<0.001), Shropshire (231 vs 275 TB incidents, p=0.006), Avon (92 vs 99 TB incidents, p=0.001) and Hereford & Worcester (239 vs 242 TB incidents, p<0.001).

Despite fluctuations at individual county level, all counties have seen decreases in the number of new TB incidents in 2022 compared to five years ago, except the West Midlands (five TB incidents in 2018, six in 2022). However, the West Midlands contains very few herds and cattle compared to the other counties (see Figure 4.1.6). The greatest relative reduction in new TB incidents between 2018 and 2022 was seen in Staffordshire and Shropshire (43% and 23% reduction, respectively). Over a quarter (26%) of all HRA

TB incidents were detected in Devon in 2022, although the number of new TB incidents in this county fell by 12% between 2018 and 2022 (692 incidents vs 607).

Figure 4.1.3 shows the percentage of new TB incidents that were OTF-W in each county. In 2022, the highest percentage of OTF-W TB incidents were disclosed in the West Midlands (83%), Avon (63%) and Gloucestershire (57%). In 2021, 64% of TB incidents in Shropshire were OTF-W, however this percentage fell to 51% in 2022. In Devon, Gloucestershire and Somerset, the percentage of OTF-W TB incidents fell for four or more consecutive years (Figure 4.1.3).

Figure 4.1.2 Annual total number of new TB incidents (OTF-W and OTF-S) by HRA county 2018 to 2022. Counties ranked by total TB incidents. Number of TB incidents in 2022 labelled on chart.

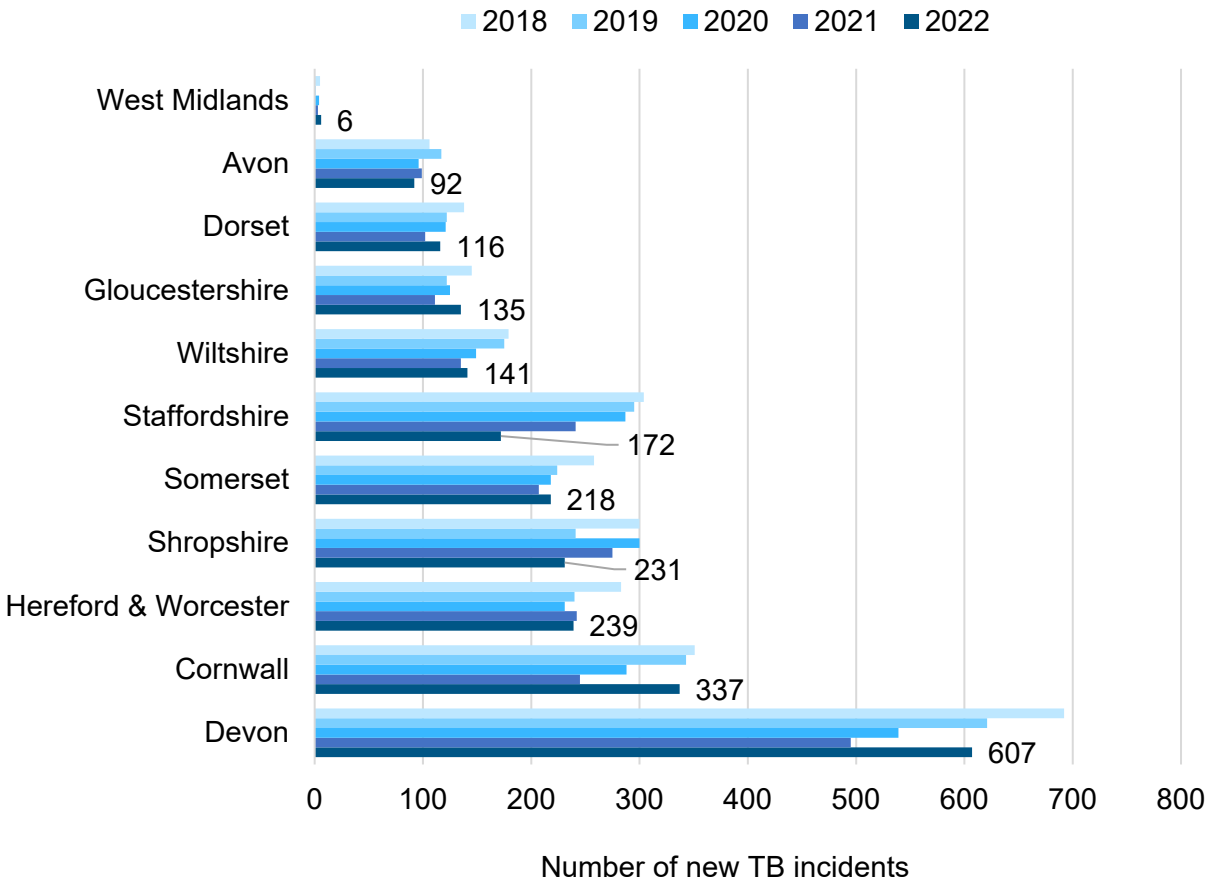
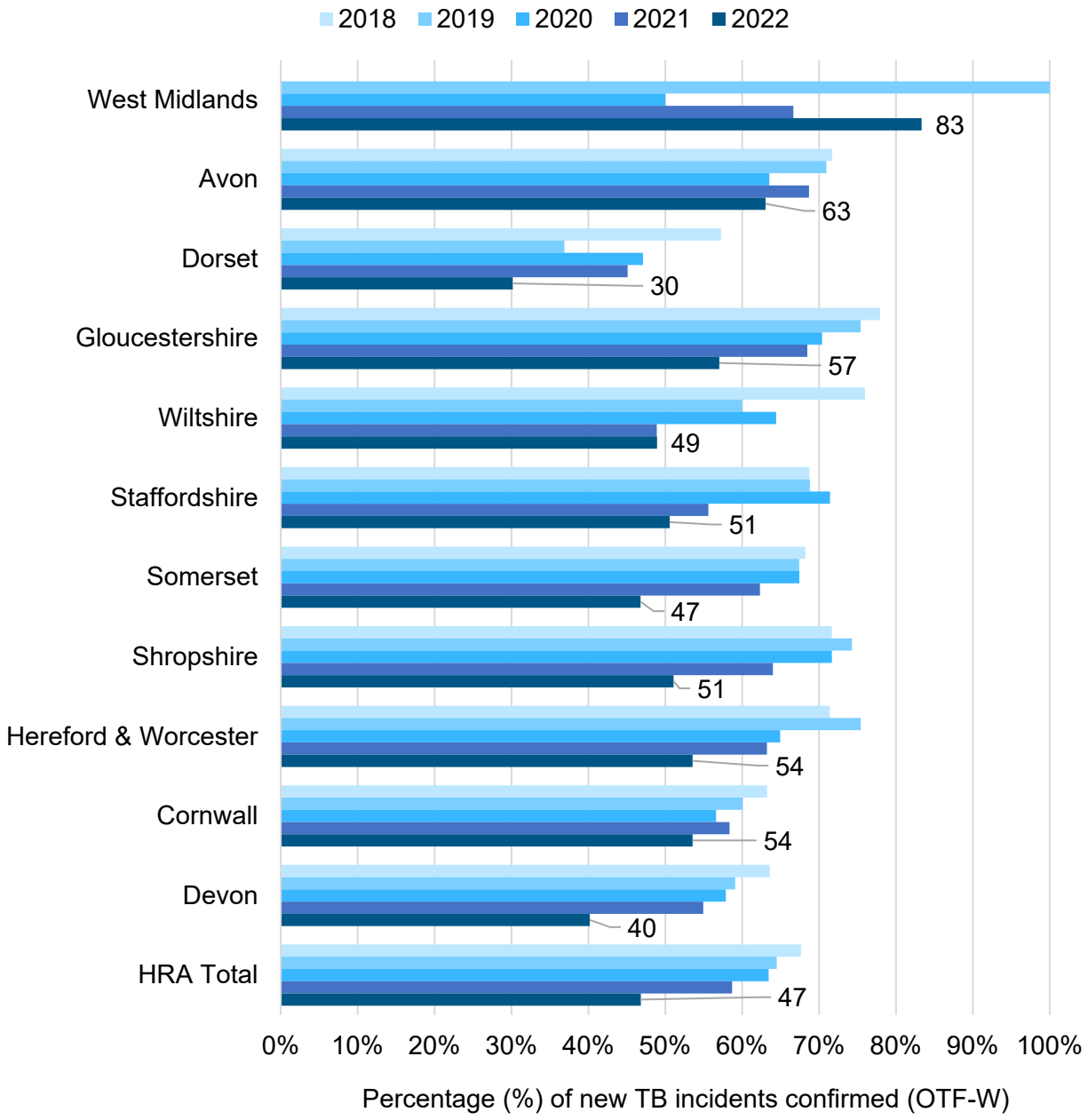


Figure 4.1.3 Percentage of new OTF-W TB incidents in HRA counties, 2018 to 2022. Counties ranked by total TB incidents in 2022. Percentage of OTF-W in 2022 labelled on chart.



County level TB incidence rate

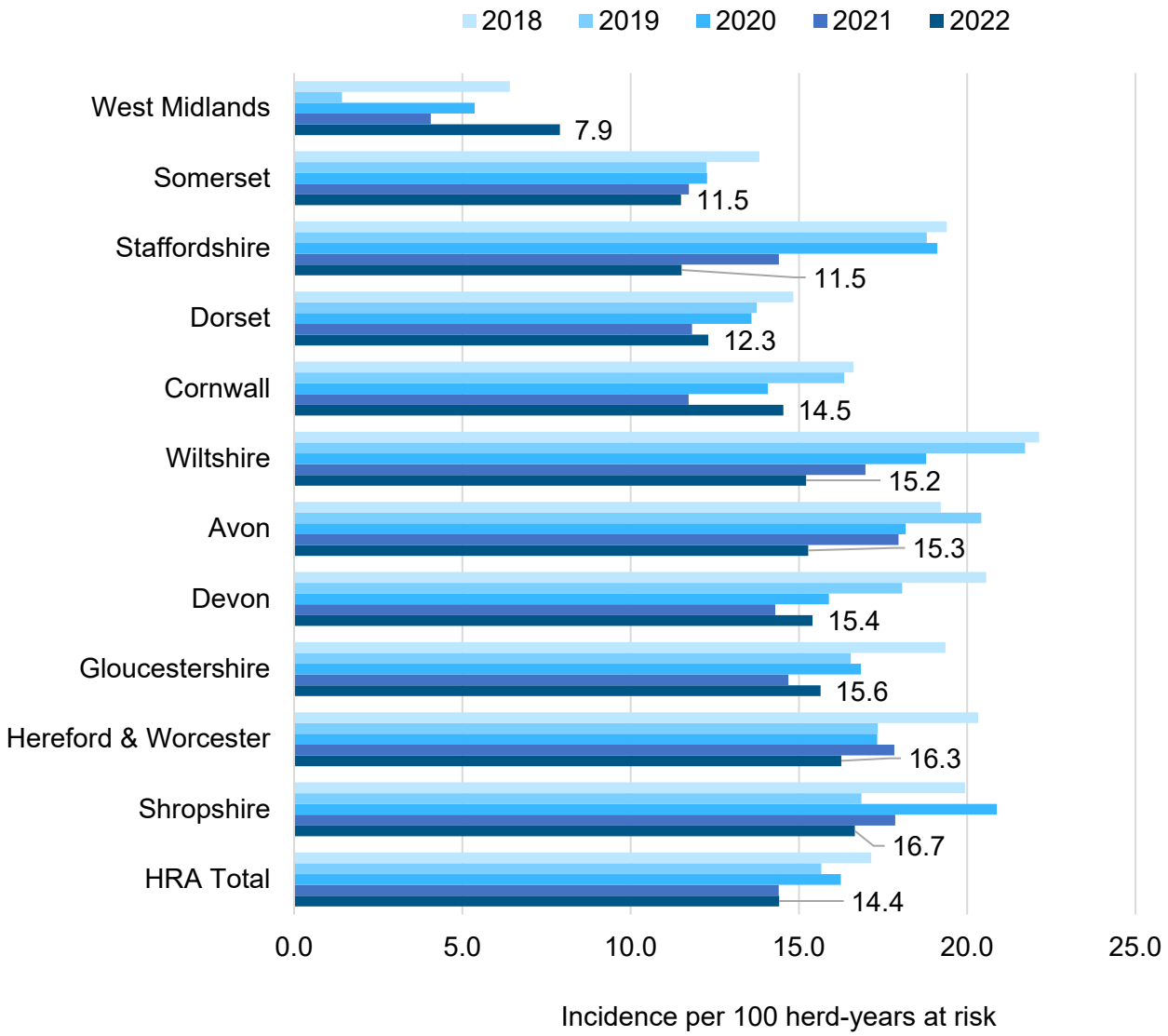
The preferred measure of disease occurrence is TB incidents per 100 HYR, i.e. the rate at which new TB incidents are occurring in the population of herds at risk. Figure 4.1.4 ranks counties in the HRA by their incidence rate since 2018.

TB incidence decreased in 2022 compared to 2021 in six of the eleven HRA counties, although most county-level reductions were non-significant. A significant decline in incidence only occurred in Staffordshire (14.4 TB incidents per 100 HYR in 2021 to 11.5 in 2022, 20% reduction, p=0.02). Similarly, four of the five county-level increases in incidence were non-significant, except Cornwall (11.7 TB incidents per 100 HYR in 2021 to 14.5 in 2022, 24% increase, p=0.01), as expected given the increase in the number of TB incidents in 2022.

The highest incidence rates in 2022 were observed in Shropshire, Hereford and Worcester and Gloucestershire (16.7, 16.3 and 15.6 TB incidents per 100 HYR, respectively). Notably, the highest incidence in 2022 (Shropshire, 16.7 TB incidents per 100 HYR) was lower than the highest incidence in 2021 (Avon, 18.0 TB incidents per 100 HYR).

Overall, the incidence rate in the HRA was stable in 2022 compared to 2021 (14.4 TB incidents per 100 HYR) (Figure 4.1.4), which was the lowest recorded since 2007.

Figure 4.1.4 TB Incidence rate per 100 herd-years at risk from 2018-2022, by HRA county. Counties ranked by incidence in 2022.



- The incidence rate continued to fall in Shropshire, Avon, Wiltshire, Staffordshire and Somerset in 2022, compared to 2021, although the decrease was only statistically significant in Staffordshire (p=0.02). Wiltshire, Somerset, and Avon have been showing a decreasing trend in incidence for the past four years or more. A decrease was also observed in Hereford and Worcester, which had increased non-significantly in 2021 compared to 2020.
- Gloucestershire, Devon, Cornwall, Dorset and the West Midlands all had increased incidence in 2022, compared to 2021. However, the increase in incidence was only significant in Cornwall (p=0.01).

County level prevalence

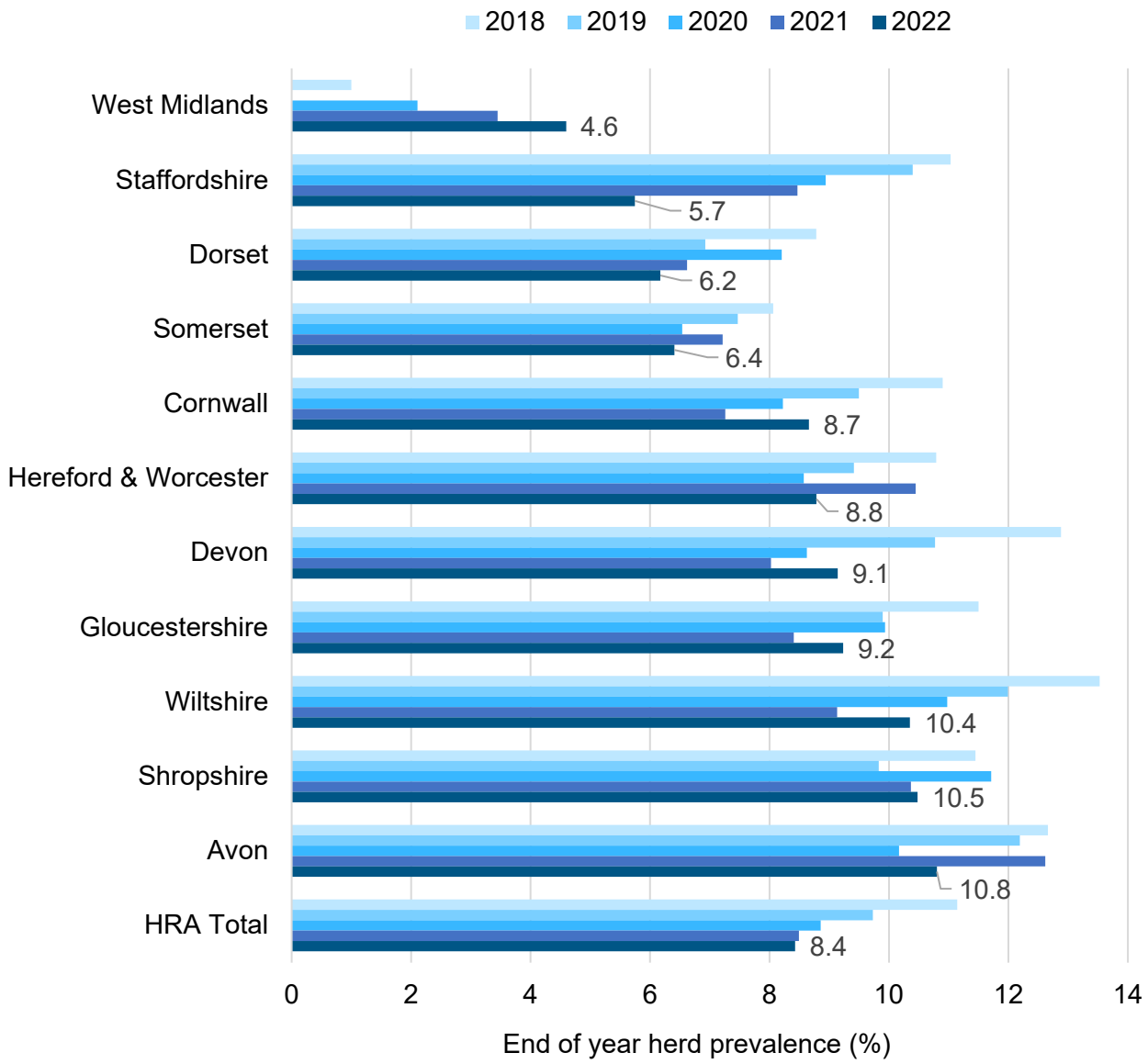
Prevalence reflects the percentage of herds that are restricted due to TB at a given point in time. Average monthly prevalence is measured by counting the number of herds under restriction due to a TB incident at the mid-point of each month, divided by the number of active herds in a geographical area. Whereas end of year prevalence is a point prevalence reported here on the 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.

In 2022, the average monthly prevalence increased compared to 2021 (9.1% in 2022, 8.9% in 2021, p=0.816). However the end of year prevalence had a non-significant decrease (8.4% in 2022, 8.5% in 2021, p=0.948). End of year herd prevalence figures for 2022 are provided in Figure 4.1.5.

End of year herd prevalence dropped in the HRA overall for the fifth year in a row. This decrease from 2021 to 2022 occurred in five of the eleven HRA counties, however all decreases were not statistically significant. A non-significant increase in prevalence relative to 2021 was seen in Shropshire (10.4% in 2021 to 10.5% in 2022), Wiltshire (9.1% to 10.4%), Gloucestershire (8.4% to 9.2%), Devon (8.0% to 9.1%), Cornwall (7.3% to 8.7%) and the West Midlands (3.4% to 4.6%) (Fig 4.1.5).

As in 2021, Avon had the highest prevalence in 2022 (10.8%). The lowest prevalence in 2022 was seen in Staffordshire (5.7%) and the West Midlands (4.6%) (Figure 4.1.5), compared to Dorset (6.6%) and the West Midlands (3.4%) in 2021.

Figure 4.1.5 End of year herd prevalence from 2018-2022, by HRA county. Counties ranked by order of prevalence in 2022.

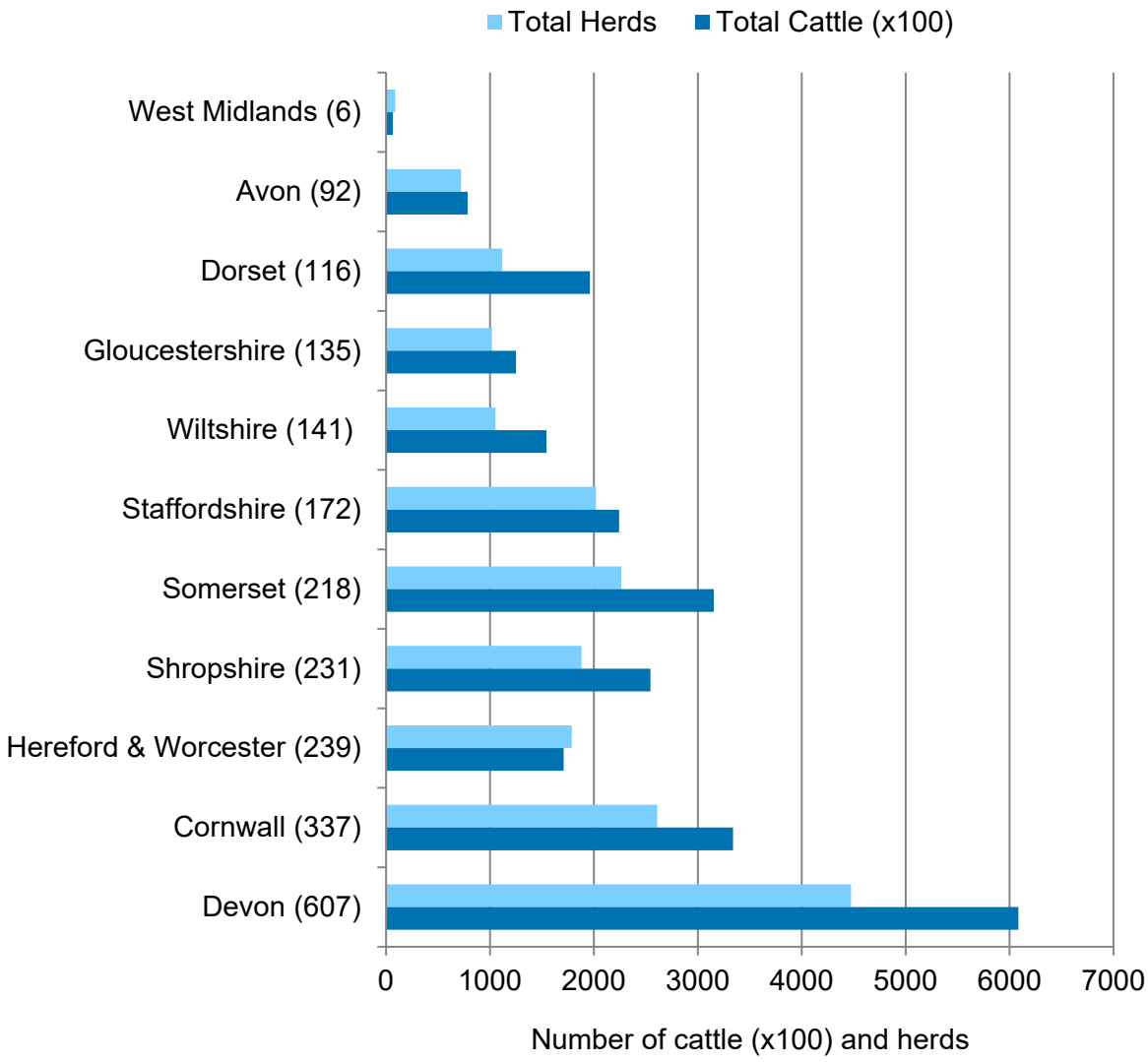


Demographics and influence on TB

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 land fragmentation on farms (Broughan et al., 2016). The total number of cattle (i.e., the cattle population) 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 Figures 3.2.1a and b, Chapter 3.2 Characteristics of herds found infected with TB).

Devon incurred 26% of all new TB incidents in the HRA in 2022, containing 24% of herds and 25% of all HRA cattle. Cornwall was the county with the second highest percentage, with 15% of all HRA TB incidents, 14% of herds and 14% of cattle (Figure 4.1.6).

Figure 4.1.6 Total Number of cattle (x100) and herds in HRA counties in 2022. Counties ranked by new TB incident totals (in parenthesis next to county name)

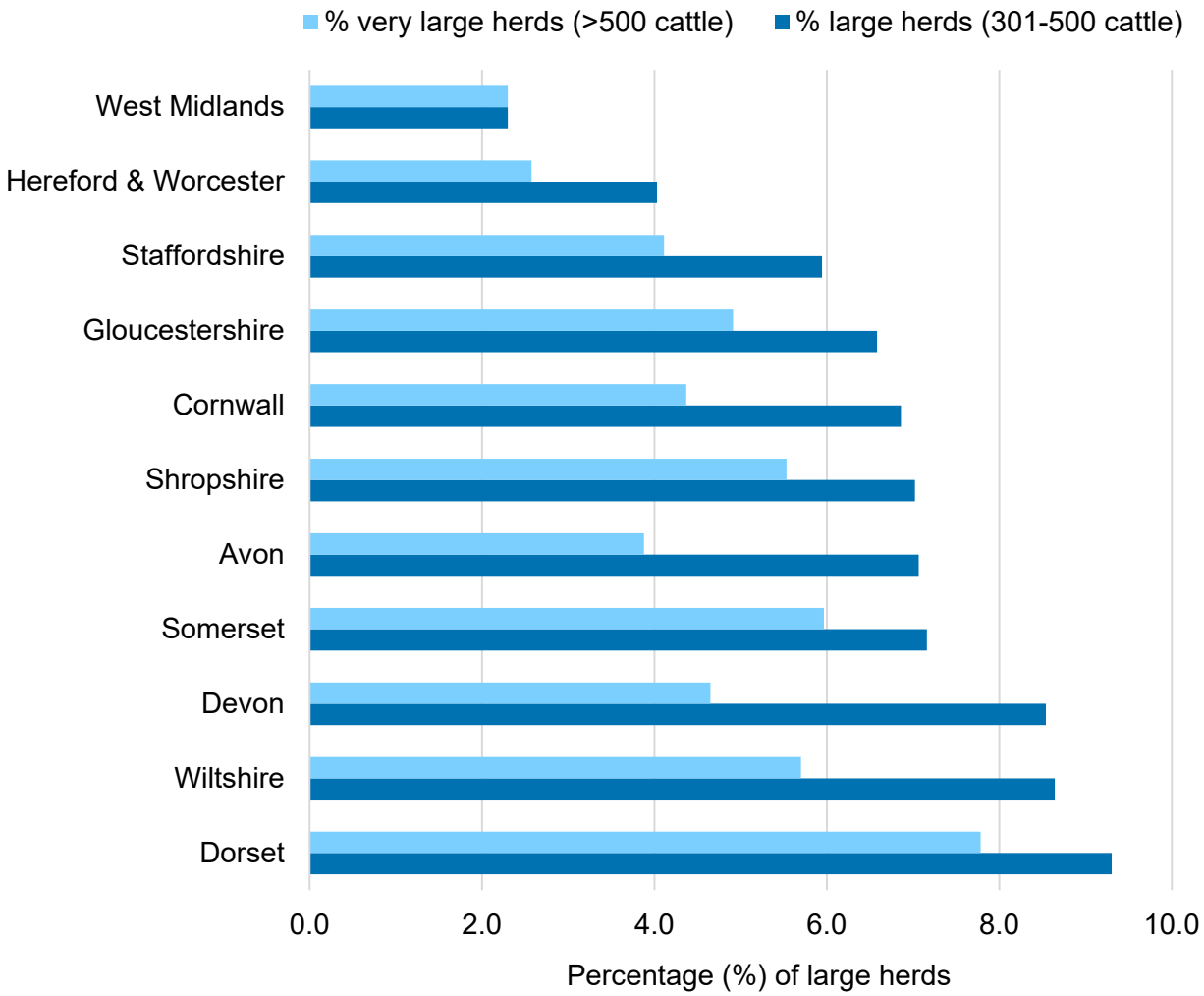


- As expected, counties with larger numbers of cattle and herds tended to have a greater number of TB incidents.
- Hereford and Worcester had more TB incidents in 2022 than would be expected when considering the number of herds and cattle in the county. By contrast, Dorset and Somerset appear to have had fewer TB incidents than may have been expected.

Figure 4.1.7 shows the percentage of large and very large herds in the different counties of the HRA in 2022, ranked by the percentage of large herds (301-500 cattle). In 2022, 7.2%

of herds in the HRA were large, and 4.8% were very large herds. These are very similar to the percentages seen in 2021 (7.0% large and 4.6% very large herds). 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 percentage of large herds had a relatively low incidence rate; for example, Dorset, had the highest percentage of large and very large herds, but was ranked 8th for incidence per 100 HYR in the HRA in 2022 (Figure 4.1.4).

Figure 4.1.7 Percentage of large (301-500 animals) and very large (>500 animals) herds, by HRA county, in 2022. Counties ranked by percentage of large herds.



- As in 2021, Dorset had the highest percentage of herds with more than 300 cattle in 2022 (17%, 191 herds), followed by Wiltshire (14%, 151 herds).
- Also consistent with 2021, Hereford and Worcester (7%, 118 herds) and West Midlands (5%, 4 herds) had the lowest percentage of herds with more than 300 animals in 2022.

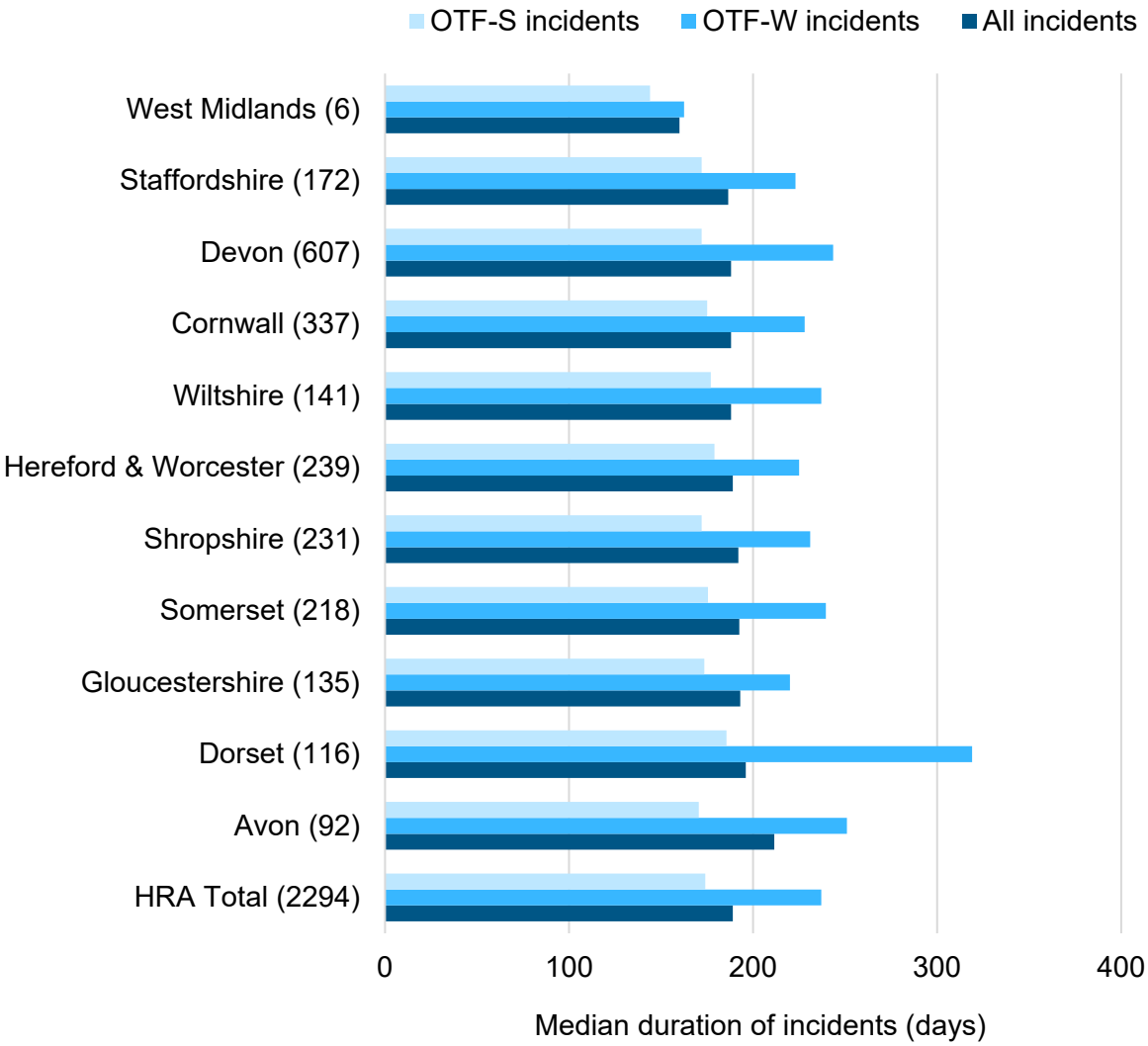
TB incident duration and persistent TB incidents

A total of 2,317 TB incidents ended in the HRA in 2022. Figure 4.1.8a shows the median duration of all those incidents, and OTF-W and OTF-S TB incidents, by HRA county. Nine of the 2,317 TB incidents involved approved 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.

For all TB incidents ending in 2022, the median duration was 189 days for all counties in the HRA. The county with the longest median duration for all TB incidents was Avon (211.5 days), followed by Dorset (196 days), and Gloucestershire (193 days) (Figure 4.1.8a). Despite these counties also having the longest median duration in 2021, all three have had a decrease in 2022 compared to 2021.

The median duration of lesion or culture-positive (OTF-W) TB incidents was longer than the median for OTF-S TB incidents, across all HRA counties in 2022 (Figure 4.1.8a), the same as in 2021 and 2020.

Figure 4.1.8a Median duration (days) of all TB incidents that ended in 2022, for all TB incidents, OTF-W TB incidents and OTF-S TB incidents, by HRA county. Counties ranked by the duration of all TB incidents (number of incidents in parenthesis)



- In all counties, the median duration of TB incidents was higher in OTF-W TB incidents compared to total TB incidents.
- Median duration was highest in Avon (211.5 days for all TB incidents).

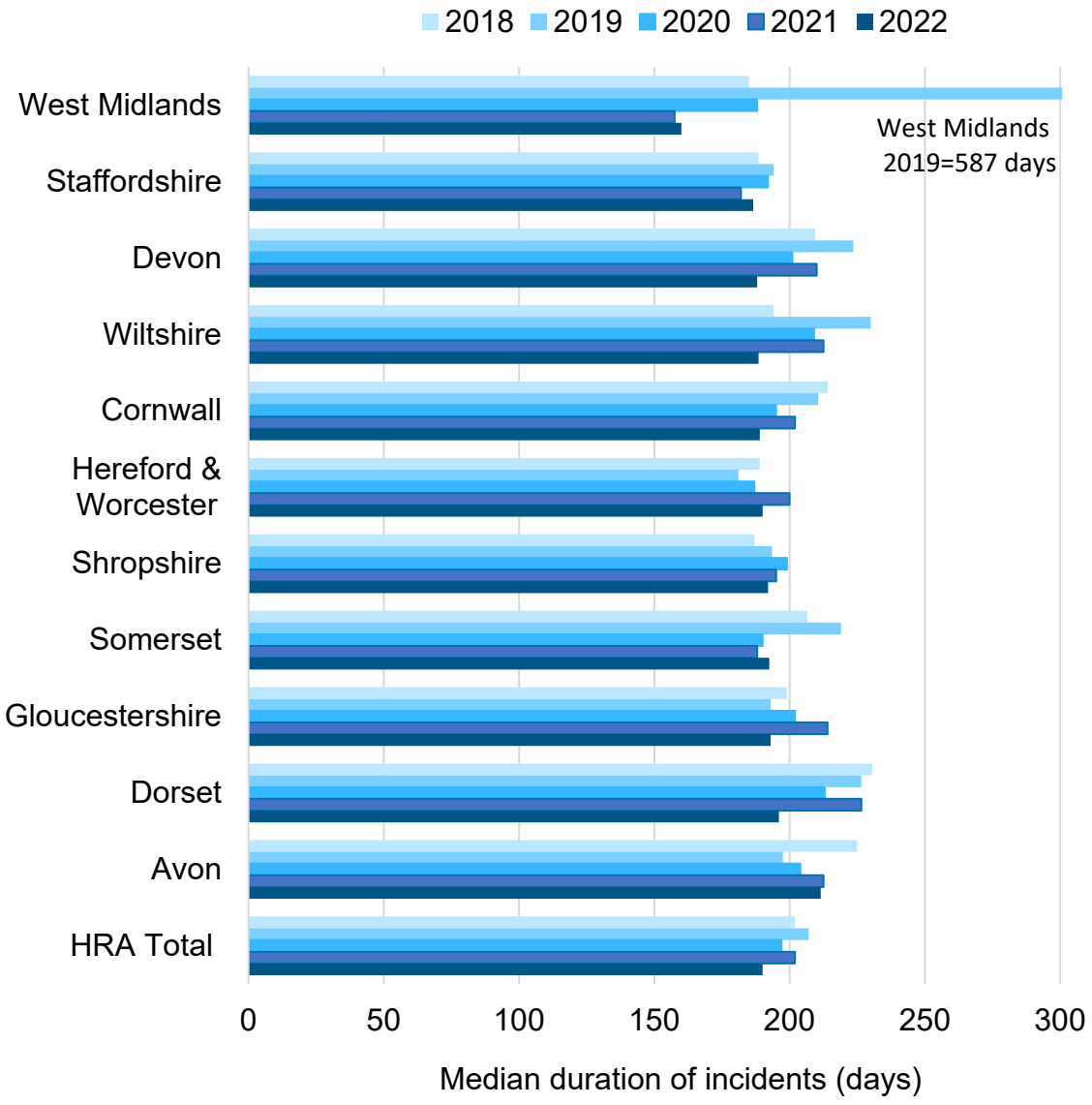
Figure 4.1.8b shows the median duration of all TB incidents (including AFUs) that ended in each year from 2018 to 2022. For most counties, duration has varied around 200 days between 2018 and 2022. The difference in median duration between counties was significant in 2022 compared to 2021 ($p<0.001$; 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 percentage of large and very large herds in the county (>300 animals) (Figure 4.1.7).

Overall, most counties saw a decrease in median duration between 2021 and 2022, which

is likely to be due to the reduction in the percentage of new OTF-W TB incidents in most HRA counties in 2022 (Figure 4.1.3). The largest decreases were seen in Dorset (30.5 days), Wiltshire (24 days) and Devon (22 days). The only counties which saw an increase in median duration of all TB incidents between 2021 and 2022 were Somerset and Staffordshire (both saw an increase of 4.5 days) and the West Midlands (2.5 days).

Avon and Hereford and Worcester also saw an increase in median duration over the same three year period. This was three days for Hereford and Worcester and seven and a half days for Avon (Figure 4.1.8b).

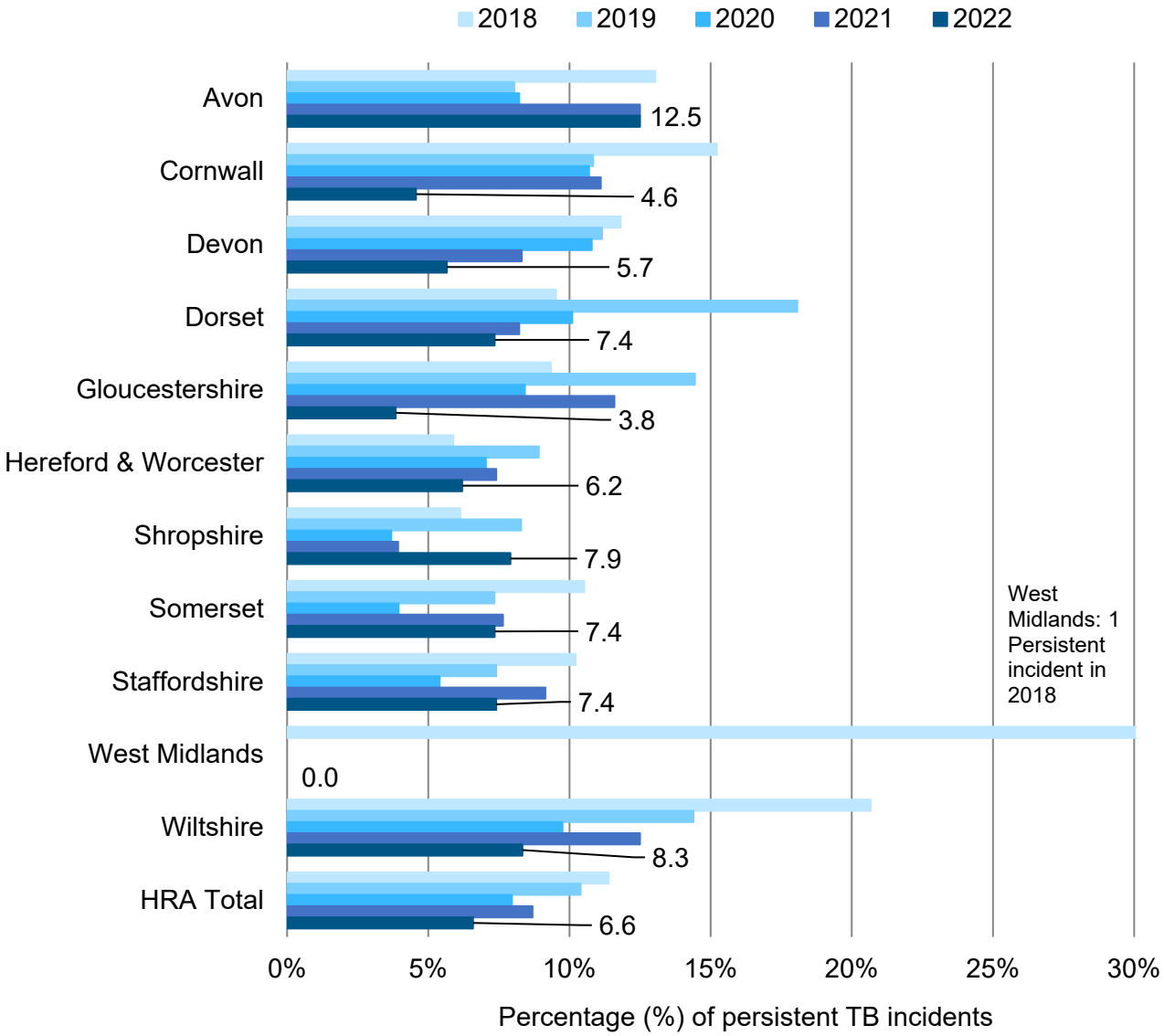
Figure 4.1.8b Median duration (days) of all TB incidents that ended in each year between 2018 and 2022, by HRA county. Counties ranked by 2022 duration)



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

TB 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 2022, 142 persistent TB incidents were resolved in the HRA, however 98 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 2022, out of all TB incidents in each of the counties in the HRA.



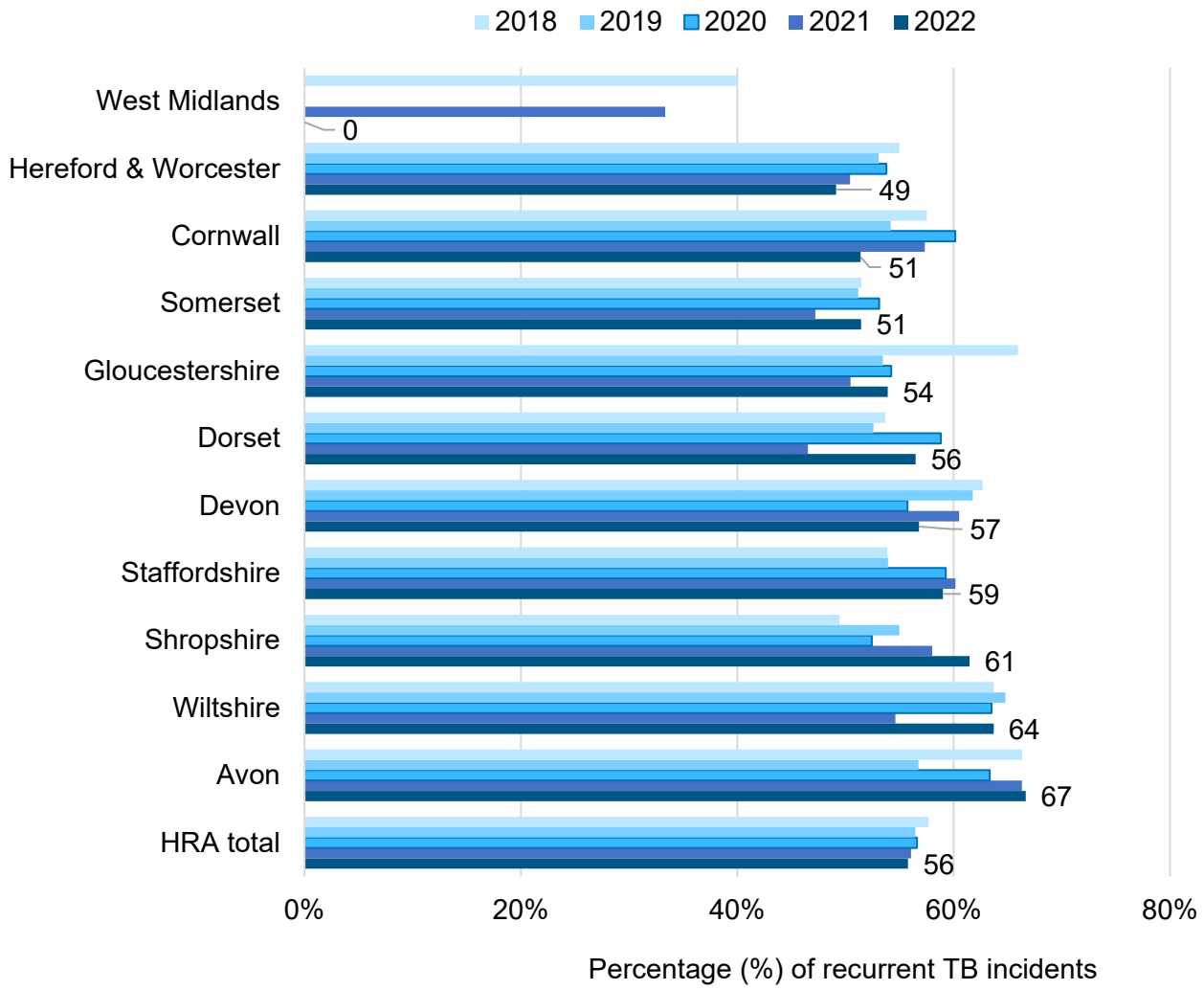
- The percentage of persistent TB incidents was highest in Avon, Wiltshire and Shropshire.
- Overall, most counties saw a decrease in the percentage of persistent TB incidents in 2022 compared to 2021. The exceptions to this were Shropshire(which saw an increase from 3.9% in 2021 to 7.9% in 2022) and Avon (which remained stable at 12.5%).

Recurrence of TB infection

In 2022, 56% of new TB incidents in the HRA occurred in herds that had experienced at least one TB incident in the previous three years, the same as in 2021. This percentage of recurrent TB incidents was higher than in the Edge Area (48%) and LRA (15%), the same as in 2021. Within the HRA, recurrence was highest in Avon (67%), Wiltshire (64%) and Shropshire (61%), and lowest in Hereford and Worcester (49%) and the West Midlands (0%, none of six incidents) (Figure 4.1.10).

Six out of eleven counties in the HRA saw an increase in the percentage of recurrent TB incidents in 2022 relative to 2021; the exceptions were Devon, Cornwall, Staffordshire, Hereford and Worcester and the West Midlands, which experienced decreases (Fig 4.1.10).

Figure 4.1.10 Annual percentage of TB incidents in herds that had experienced any TB incident in the previous three years, by HRA county (2018 to 2022). Counties ranked by recurrence percentage in 2022.



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 OTFW TB incidents 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 help reduce incident recurrence include the provision of bespoke farm biosecurity advice and control of the reservoir of infection in badgers through licensed culling and, to a lesser degree, vaccination.

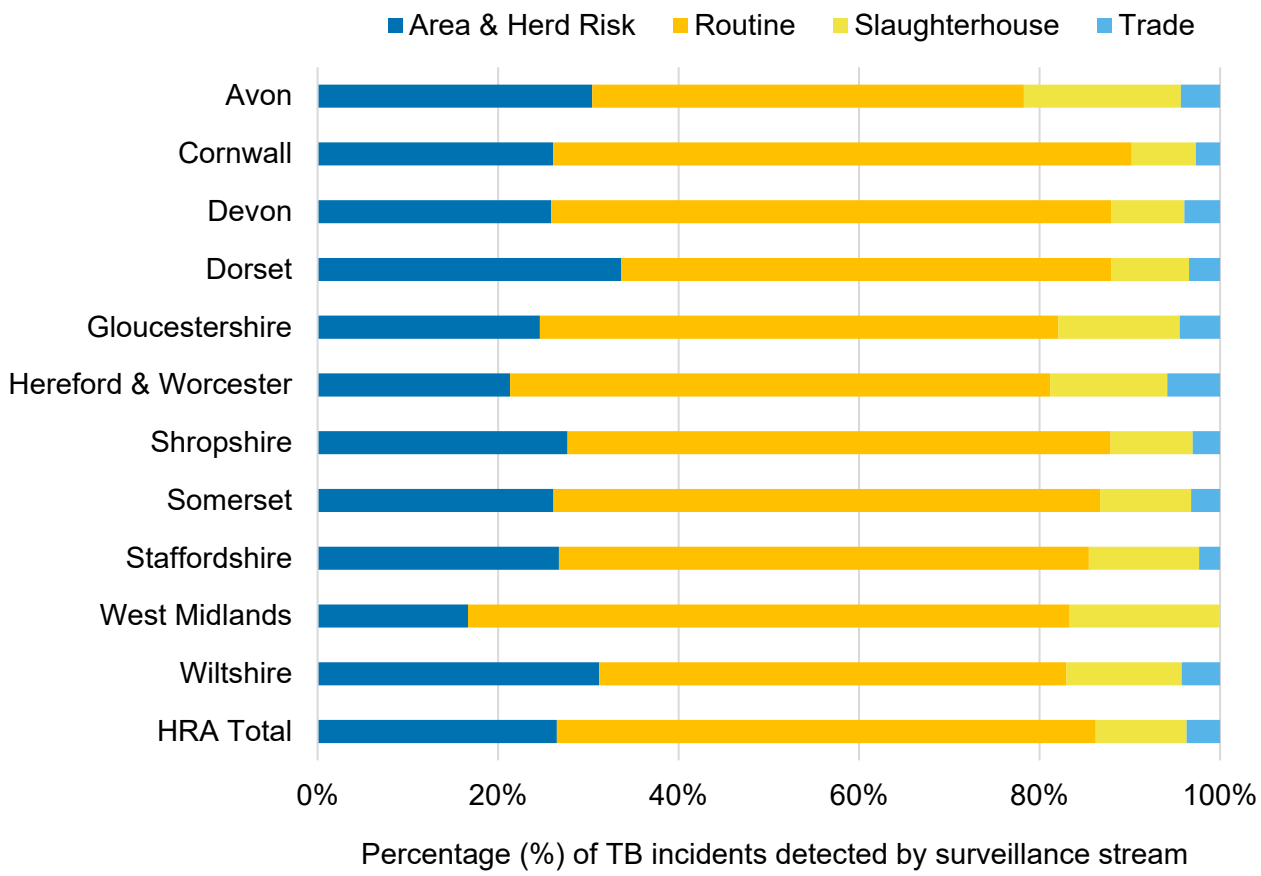
TB surveillance and incident detection

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 percentage of TB infected herds disclosed by each surveillance stream and county. In the HRA overall, the highest percentage of TB incidents were disclosed by Routine herd tests (59.7%). Routine herd testing (performed every six or 12 months) was also the leading disclosing surveillance stream in all counties in the HRA in 2022, where it triggered over half of all TB incidents except in Avon (47.8%).

Overall, Area and Herd Risk surveillance tests detected the second highest percentage of TB incidents in the HRA (26.5%), with the highest percentage of TB incidents disclosed in Dorset (33.6%), followed by Wiltshire (31.2%). Trade and other surveillance tests led to the fewest detections of TB in the HRA in 2022 (3.7%), with Hereford & Worcester finding the highest percentage of TB incidents (5.9%) (Figure 4.1.11).

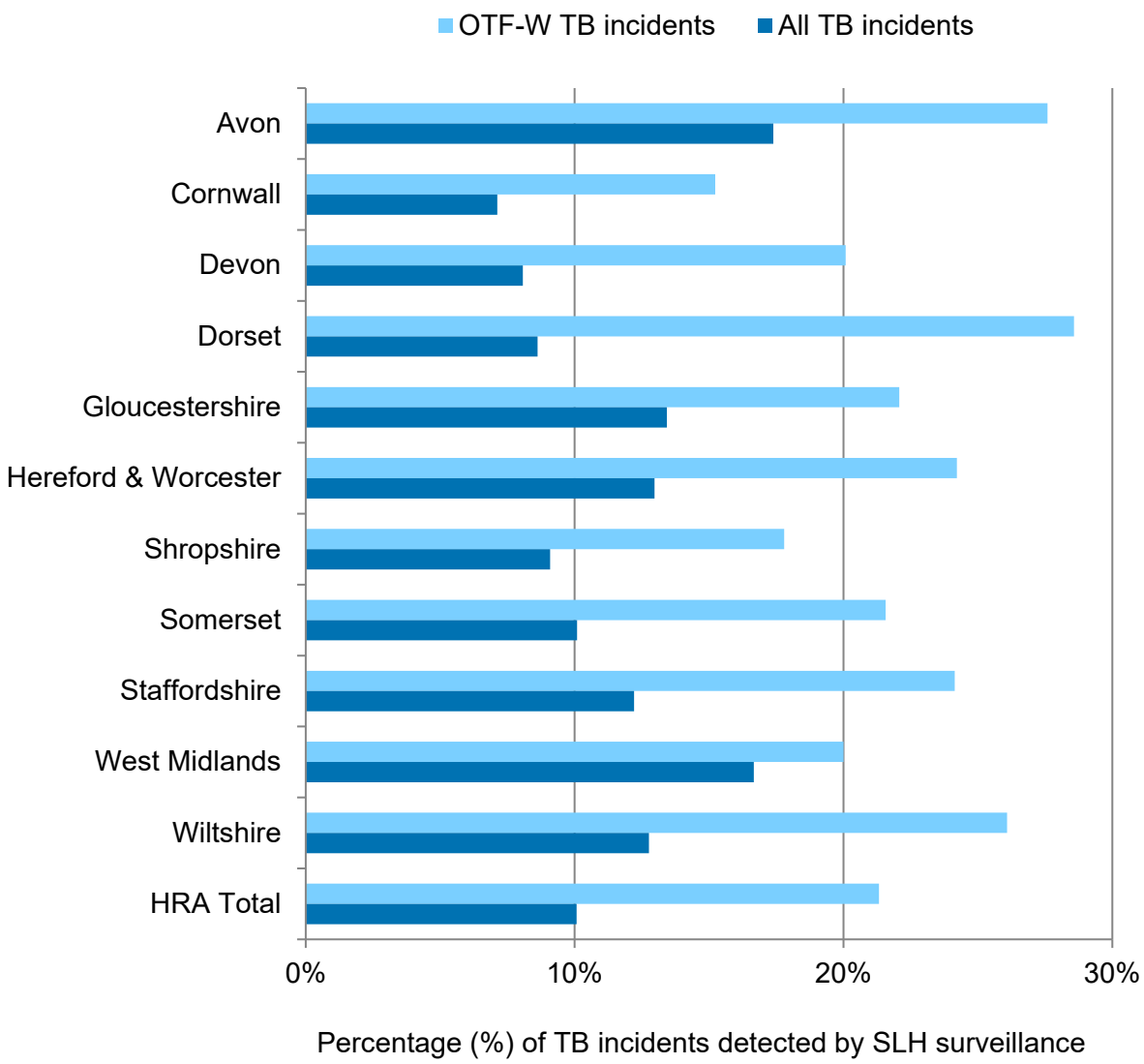
The Area and Herd Risk surveillance stream had the test types which were the most efficient at detecting TB incidents within the HRA in 2022. Source tracing herd tests were the most efficient test types within the HRA overall (20 TB incidents per 100 herd tests) in 2022. This was followed by post-incident 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 2022 (Table 3.3.3.a, Chapter 3.3 Finding Infected herds).

Figure 4.1.11 Percentage of TB incidents detected by each surveillance stream, by HRA county in 2022.



In the HRA overall, 10.1% of all TB incidents and 21.3% of OTF-W TB incidents were disclosed through routine post-mortem meat inspection of non-TB test reactor cattle in slaughterhouses in 2022, similar to the situation in 2021. Variation between counties can be seen in Figure 4.1.12. Dorset (28.6%), Avon (27.6%), and Wiltshire (26.1%) had the highest percentage of OTF-W TB incidents disclosed by slaughterhouse surveillance in 2022. The lowest rates of OTF-W detection by slaughterhouse surveillance were reported in Cornwall (15.2%) and Shropshire (17.8%).

Figure 4.1.12 Percentage of TB incidents disclosed by slaughterhouse (SLH) surveillance (routine post-mortem meat inspection) in 2022, for all TB incidents and OTF-W incidents, by HRA county.

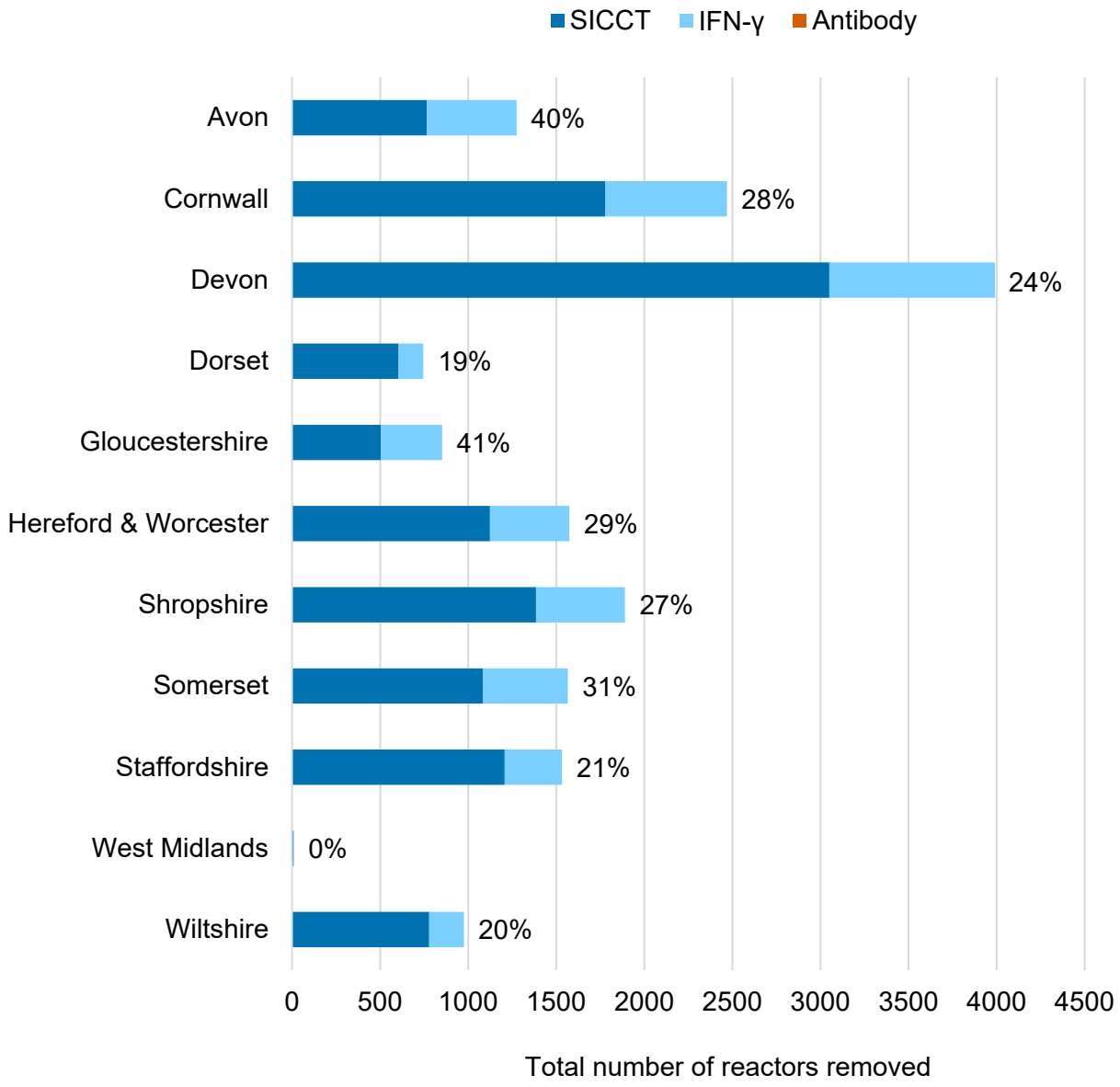


Number of reactors removed

Overall, 16,879 cattle were slaughtered for TB control purposes in the HRA in 2022. These comprised 12,290 skin (SICCT) test reactors (72.8%), 4,589 IFN-γ blood test-positive animals (27.2%) and zero antibody test positives. The total number of animals removed, and the percentage that were detected by IFN-γ testing, varied by county. Most cattle were removed from herds in Devon (3,991 animals), where 24% of the animals removed were detected by IFN-γ testing.

In 2022, Gloucestershire had the highest percentage of cattle removed as IFN-γ test positives (41%), followed by Avon (40%), and Somerset (31%) (Figure 4.1.13). No IFN-γ test positives were detected in the West Midlands in 2022.

Figure 4.1.13 Number of reactors removed in 2022 due to SICCT, IFN-γ and antibody testing, by HRA county. Percentage of reactors removed due to IFN-γ testing next to bars.



Use of the IFN-γ test in the HRA

As from July 2021, and throughout 2022, the policy for mandatory IFN-γ testing of TB incident herds in the HRA was as follows:

(1) *any new breakdowns (incidents) with lesion and/or culture positive animals which meet the following criterion: the breakdown occurred within 18 months of the herd regaining OTF status following a previous breakdown with OTF-W animals.*
(2) *chronic or persistent breakdowns with lesion and/or culture positive animals.*

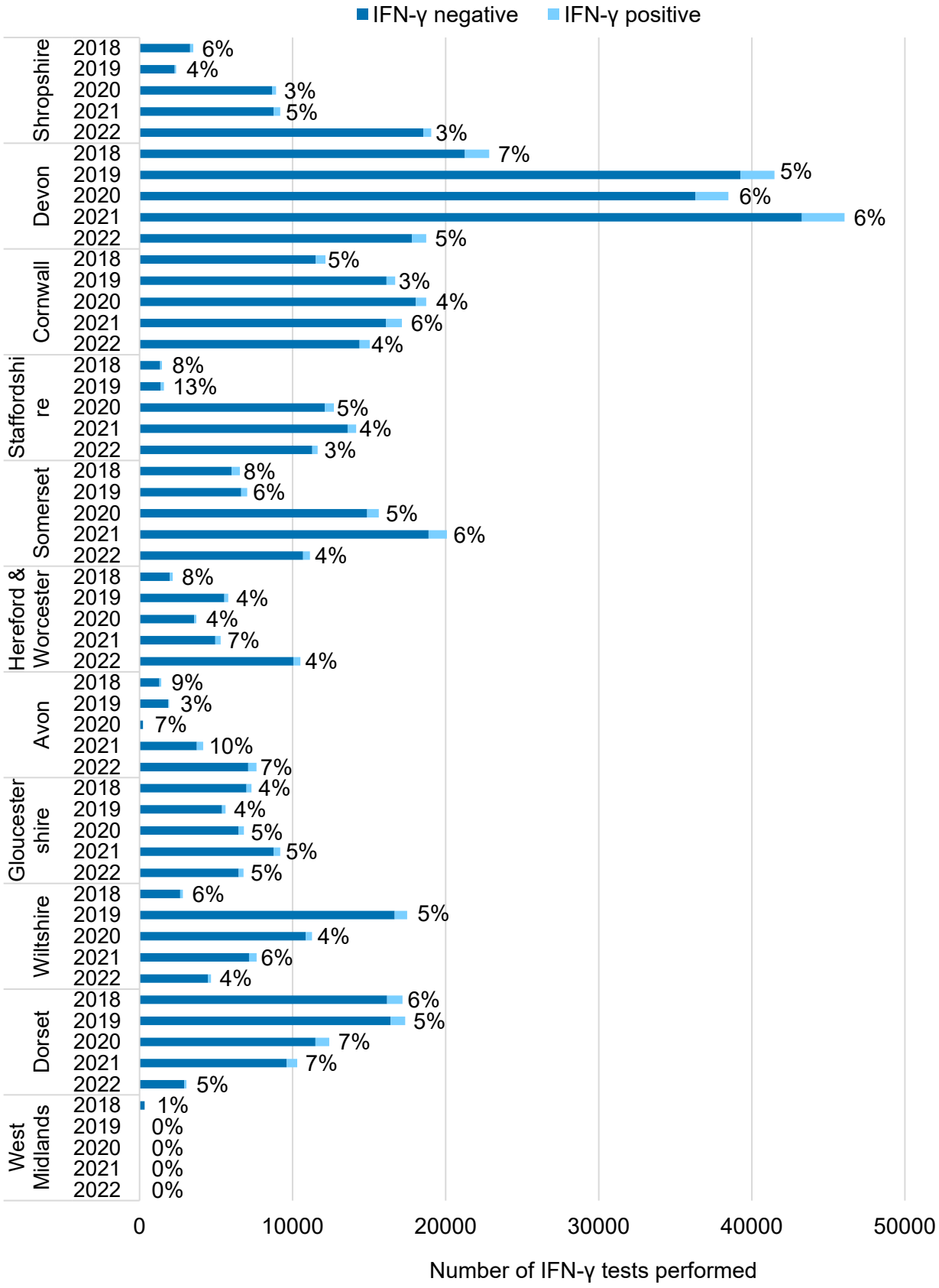
As previously, additional deployment of the IFN-γ blood test took place at APHA's discretion in other situations. This included the application of a flexible extended version of IFN-γ in cases where co-infection with *Mycobacterium avium* subspecies *paratuberculosis* (Johne's disease) infection was 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 2022, 108,248 animals received an IFN-γ test in the HRA, with 4.2% identified as positive. This is a 25% decrease on the number of HRA IFN-γ tests performed in 2021 (144,621) and a 16% decrease compared to 2020 (128,858). There may be several reasons for this decrease, including but not limited to, the change in IFN-γ testing policy which took place in 2021, the diversion of APHA resources towards the highly pathogenic avian influenza outbreak, and the decrease in the number of new OTF-W incidents in most HRA counties in 2022 (see Figure 4.1.3).

As in previous years, the percentage of animals testing positive to the IFN-γ test varied by HRA county: from 3% in Shropshire and Staffordshire, to 7% in Avon.

Most tests were conducted in Shropshire (18%), where there was a 107% increase in tests conducted in this county in 2022 compared to 2021. The number of tests conducted also increased in Avon and Hereford and Worcester in 2022, by 84%, and 98% respectively. A decrease in the number of tests performed was seen in seven of the eleven HRA counties (Figure 4.1.14). The greatest decreases in the number of tests in 2022 compared to 2021 were in Dorset (-70%), Devon (-59%) and Somerset (-45%).

Figure 4.1.14 Number of IFN-γ animal tests performed in HRA counties, 2018-2022. The percentage of tests with a positive result are labelled on the chart. Counties ranked by decreasing total number of IFN-γ tests performed in 2022.



Sources of infection

Due to the impact of the avian influenza outbreaks in 2021 and 2022 on veterinary investigation into the source of infection for new TB incidents, novel data driven methods to quantify the likelihood of risk pathways for TB infection were developed by APHA. This new method combines cattle movement data with whole genome sequencing (WGS) data from M. bovis isolates in cattle to provide insights into possible risk pathways for new incidents. More details on the methodology for determining the risk pathways for the sources of infection can be found in Chapter 3.2 Characteristics of herds found infected with TB and the Explanatory Supplement.

All new incidents in the HRA (n=2,294) are evaluated for cattle movements with a high likelihood of infection and WGS data used to assess for evidence of a local reservoir. Overall, most incidents in the HRA (56%) did not have any WGS data associated with the TB incident, and no evidence of cattle movements with a high likelihood of having an undetected TB infection during movement.

A total of 522 incidents (23%) did have a local reservoir identified from the WGS data. Counties with the highest number of incidents associated with a local reservoir were West Midlands (3 incidents, 50%), Avon (37 incidents, 40%), Shropshire (75 incidents, 32%), and Staffordshire (53 incidents, 31%). In the West Midlands, all 3 incidents associated with a local reservoir also had no evidence of cattle movements onto the herd with a high likelihood of infection. Avon, Shropshire and Staffordshire also had a high proportion of incidents associated with a local reservoir without cattle movements with a high likelihood of infection onto the herd (33%, 29% and 26% respectively).

The proportion of incidents that were associated with **any** cattle movements with a high likelihood of infection were identified regardless of the availability of WGS data to detect a local reservoir represented 14% of all TB incidents in the HRA (332 incidents in total). The proportion was stable across all counties in the HRA, between 13% and 17% of all TB incidents within each county (Table 3.2.1a).

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 regions of the Edge Area in 2022, 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 of herds located within 3km of any OTF-W incident – this was changed to contiguous testing at the end of 2022.
- The number of new TB incidents disclosed in the Edge Area in 2022 (n=490) decreased by 14.5% compared to 2021 (n=573), with the highest proportional falls seen in Northamptonshire (46%), Derbyshire (26%) and Cheshire (19%). Decreases were seen in 9 of 11 Edge Area counties, with marginal increases in Buckinghamshire (13%) and Hampshire (5%). In 2022, the greatest number of incidents were detected in Cheshire (n=114), the least in Berkshire and Nottinghamshire (n=18 in both).
- Overall, there was a statistically significant decline in TB incidence per 100 herd years at risk (HYR) in the Edge Area in 2022 compared to 2021 (7.7 vs 8.9, p=0.018). This was the second consecutive year that the incidence rate per 100 HYR decreased in the Edge Area, from 10.0 in 2020. Additionally, incidence per 100 unrestricted herds tested decreased in 2022 (7.0) compared to 2021 (8.0).
- The end-of-year herd prevalence in the Edge Area also dropped in 2022 (4.0%) compared to 2021 (4.7%). This was the second consecutive year that the end-of-year prevalence for the Edge Area decreased since 2020 (5.7%). A decrease was seen in most of the 11 counties, except for Buckinghamshire and Warwickshire.
- The median duration of TB incidents varied between counties. The longest median duration of TB incidents (that ended in 2022) were in Oxfordshire (230 days), Nottinghamshire (197 days), and Buckinghamshire (190.5 days), all of which lasted longer than the median duration of all incidents in the Edge Area (185 days).
- Forty-eight percent of new TB incidents in the Edge Area in 2022 occurred in herds that had experienced at least one TB incident in the previous three years (recurrent breakdowns). Recurrence was highest in Berkshire (67%), East Sussex (67%) and Warwickshire (59%).
- There was no evidence of cattle movements associated with a high likelihood of infection and there was no WGS data available to explore the presence of a local reservoir for most incidents in the Edge Area (52%). However, 20% of incidents had WGS data supporting the presence of a local reservoir, and no cattle movements associated with a high likelihood of infection.

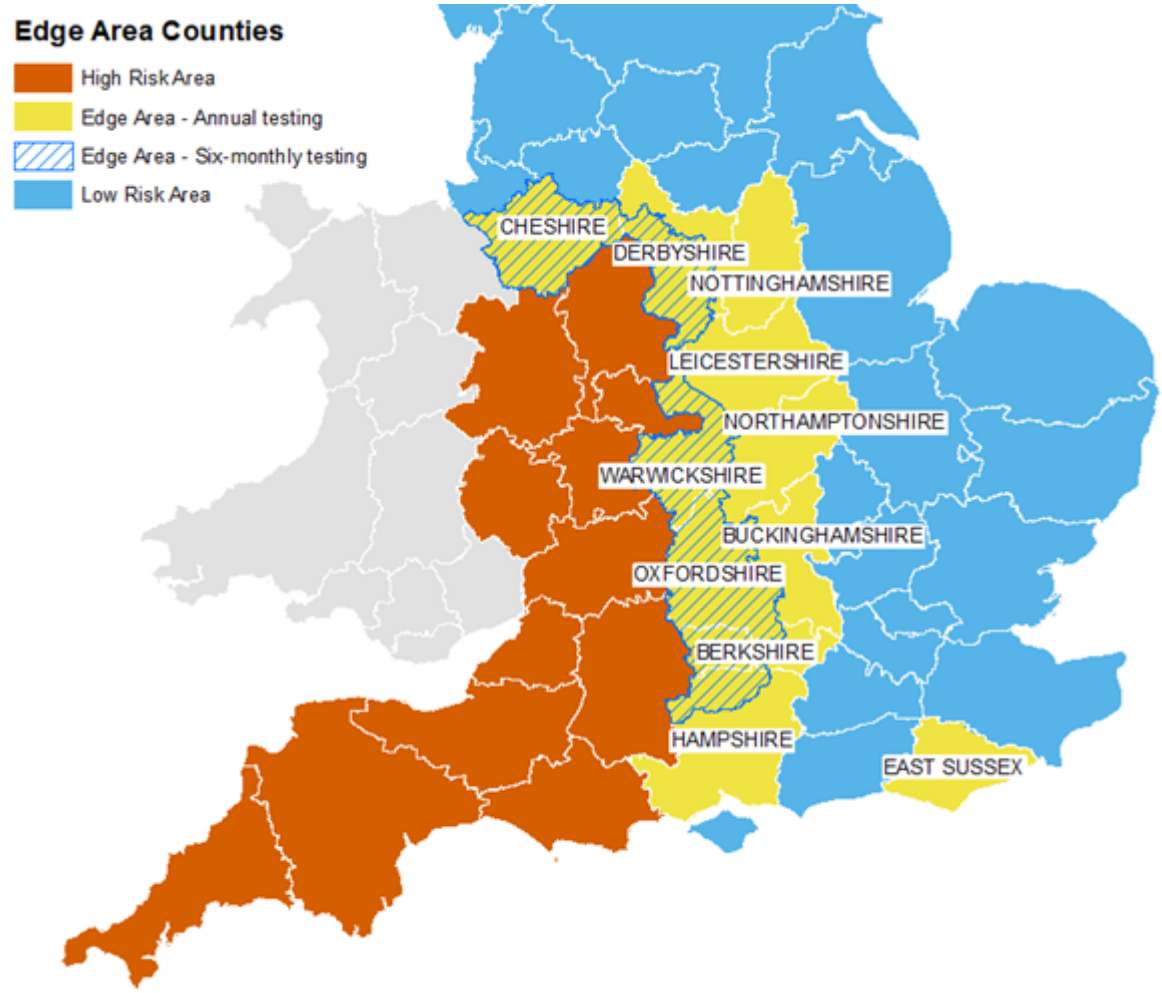
- New areas of endemic infection and new clusters emerged in several counties in the Edge Area, whereas other zones hitherto considered to be affected by endemic TB infection shrunk in 2022 relative to 2021.

Geographical coverage of the Edge Area

The Edge Area was established in 2013 to forms a buffer separating the HRA to the south and west of England from the LRA to the north and east of England (Figure 4.2.1). East Sussex is the only county of the Edge Area that is surrounded by the LRA. In 2018, the Edge Area was expanded westward to fully include five counties that were originally split between the HRA and Edge Area (Cheshire, Derbyshire, East Sussex, Oxfordshire and Warwickshire). Data reported in this chapter are for the 11 full counties that make up the Edge Area from 2018 onwards, including comparisons of TB trends over time.

Six-monthly routine herd surveillance testing remained in operation in 2022 in the endemic regions 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 and the HRA with six-monthly surveillance testing have been eligible for annual testing under the Earned Recognition Scheme if they meet specific criteria. Herds must either have been in existence for at least six years and not had a TB incident in that 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



Number of new TB incidents detected by county

The number of new TB incidents was highly variable across counties of the Edge Area. The highest number of new TB incidents were disclosed in Cheshire, Derbyshire, Oxfordshire and Warwickshire (Figure 4.2.2). These counties, which are adjacent to the HRA and have large cattle populations, have historically disclosed the highest number of new TB incidents and continue to do so.

The number of new TB incidents decreased in the Edge Area overall in 2022 (n=490) compared to 2021 (n=573). This was a statistically significant decrease of 14% (p=0.02). The total number of new TB incidents increased in just two of the 11 counties in 2022: Buckinghamshire (27 to 31) and Hampshire (21 to 22) (Figure 4.2.2). Despite Buckinghamshire seeing a 12.9% increase in the number of new incidents in 2022, the county continued to sustain a relatively low annual numbers of new TB incidents (Figure 4.2.2). This increase in Buckinghamshire was due to a doubling of OTF-W TB incidents from seven in 2021 to 14 in 2022. In Hampshire, there was an increase in the number of OTF-S incidents from 13 in 2021 to 16 in 2022.

There was a reduction in the number of OTF-W incidents in most counties except for Berkshire, East Sussex, Leicestershire, and Warwickshire. In Berkshire, the number of OTF-W incidents remained unchanged from 2021 to 2022 (n=11). In East Sussex, Leicestershire, and Warwickshire, despite a drop in the number of total TB incidents, there was a rise in the number of OTF-W incidents (4 to 5, 14 to 22, and 30 to 33, respectively). The number of OTF-W incidents dropped from 11 in 2021 to 6 in 2022 in Nottinghamshire, however the number of OTF-S incidents increased from 2 to 10.

The percentage of new TB incidents that were OTF-W in each county between 2018 and 2022 is shown in Figure 4.2.3. In 2022, the percentage of OTF-W incidents was highest in Berkshire and Warwickshire (both 61%) and lowest in East Sussex (23%). The percentage of OTF-W incidents has decreased over five consecutive years in Oxfordshire from 76% in 2017 to 55% in 2022 (Figure 4.2.3). Similarly, this percentage has decreased for four consecutive years (from 2019 to 2022) in Derbyshire and Hampshire, from 71% to 35%, and 43% to 27%, respectively. In Northamptonshire, the percentage of OTF-W incidents has been steadily rising from 47% in 2019 to 58% in 2022.

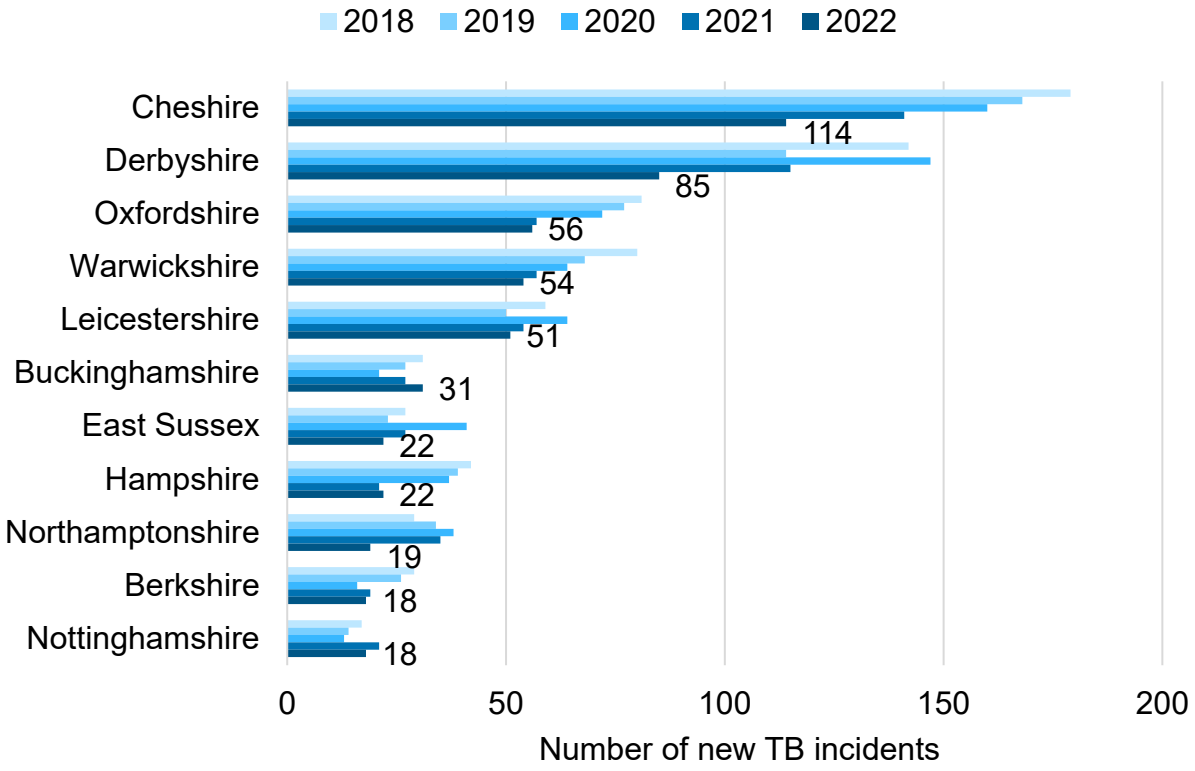
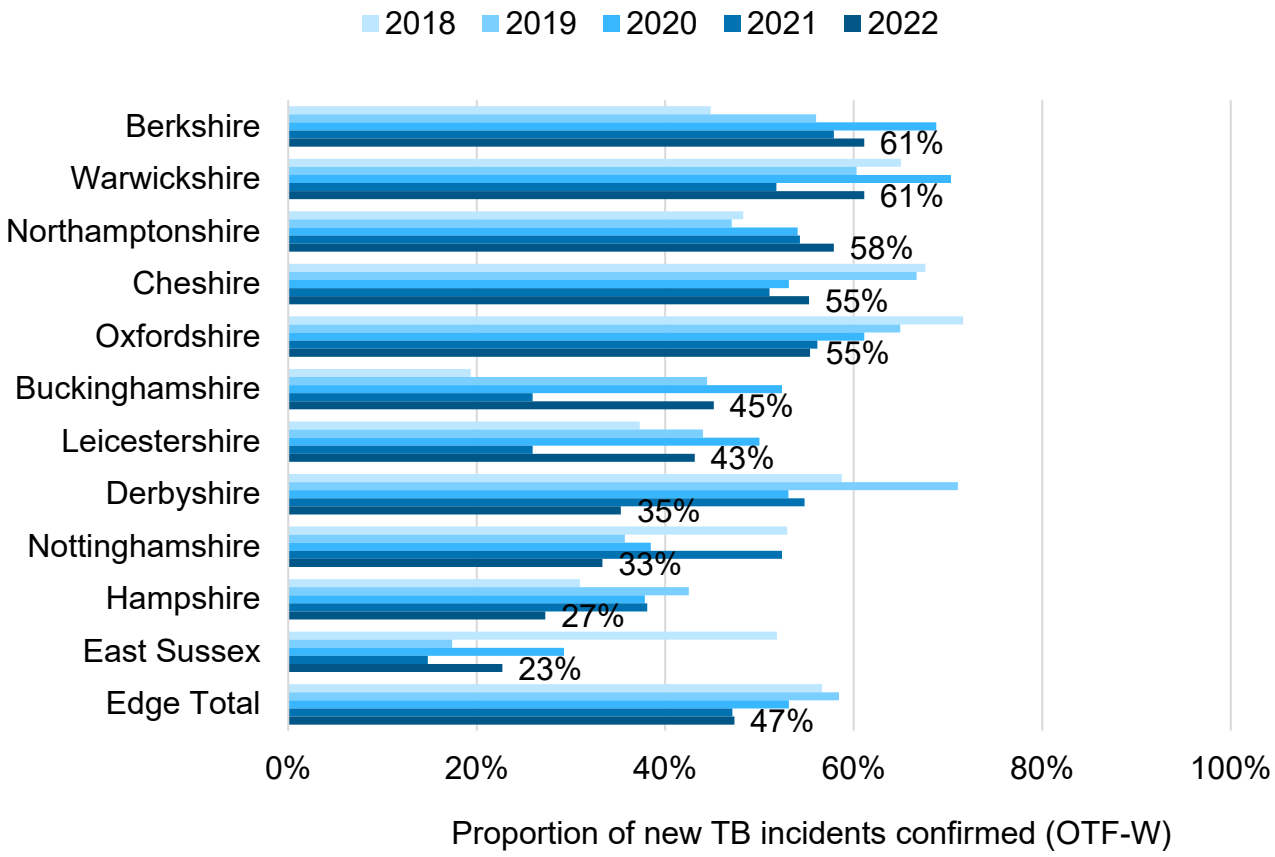


Figure 4.2.2 Annual total number of new TB incidents (OTF-W and OTF-S) by Edge Area county 2018 to 2022. 2022 incidents labelled on chart.

Figure 4.2.3 The percentage of new TB incidents with OTF-W status in Edge Area counties, 2018 to 2022. Counties ranked by total new TB incidents in 2022. Percentage of OTF-W incidents in 2022 labelled on chart.



TB herd incidence rate by county

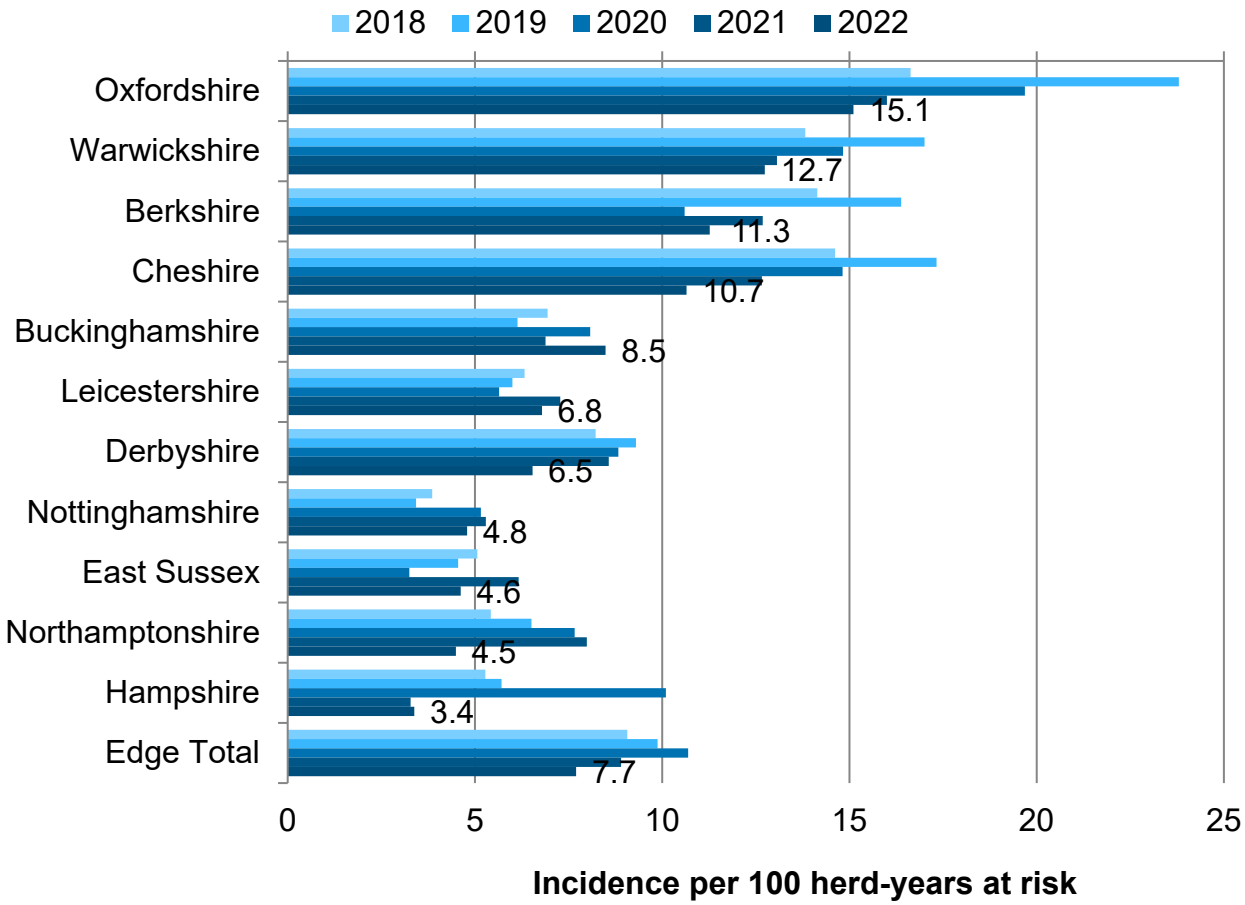
Most incidents occurred in herds in the six-monthly testing part of the Edge Area. Measures of incidence presented here include all incidents (OTF-W and OTF-S). They may differ from those published in the Year End Descriptive Area Epidemiology reports, which exclude TB incidents in non-grazing Approved Finishing Units. There was a statistically significant drop in the TB herd incidence rate in the Edge Area in 2022 compared to 2021 (7.7 TB incidents per 100 HYR in 2022, down from 8.9 in 2021, p=0.018).

At the county level, incidence per 100 HYR increased in two counties (Buckinghamshire and Hampshire) and decreased in nine (Figure 4.2.4). Changes in incidence per 100 HYR in 2022 compared to 2021 were not statistically significant for all Edge Area counties except in Northamptonshire, where there was a significant decrease (4.5 in 2022 compared to 8.0 in 2021, p=0.04).

As in previous years, there was variation in the burden of TB across the Edge Area in 2022. Incidence ranged from 15.1 incidents per 100 HYR in Oxfordshire down to 3.4 in

Hampshire (Figure 4.2.4). Of note, the incidence rate reported in Oxfordshire was higher than the incidence per 100 herd years at risk reported in six of the 11 HRA counties, ranking as the county with the seventh highest herd incidence rate in England in 2022 (Figure 4.1.4, Chapter 4.1 Epidemiology of TB in the High Risk Area). Incidence per 100 HYR decreased in Oxfordshire in 2022 for a third consecutive year, but the change from 2021 was not statistically significant (p=0.24). For Warwickshire, incidence rate in 2022 was higher than in four HRA counties. Incidence rates in Berkshire, Cheshire and Buckinghamshire were higher than one HRA-county.

Figure 4.2.4 Incidence rate (per 100 herd-years at risk) from 2018-2022, by Edge Area county. Counties ranked by incidence in 2022.



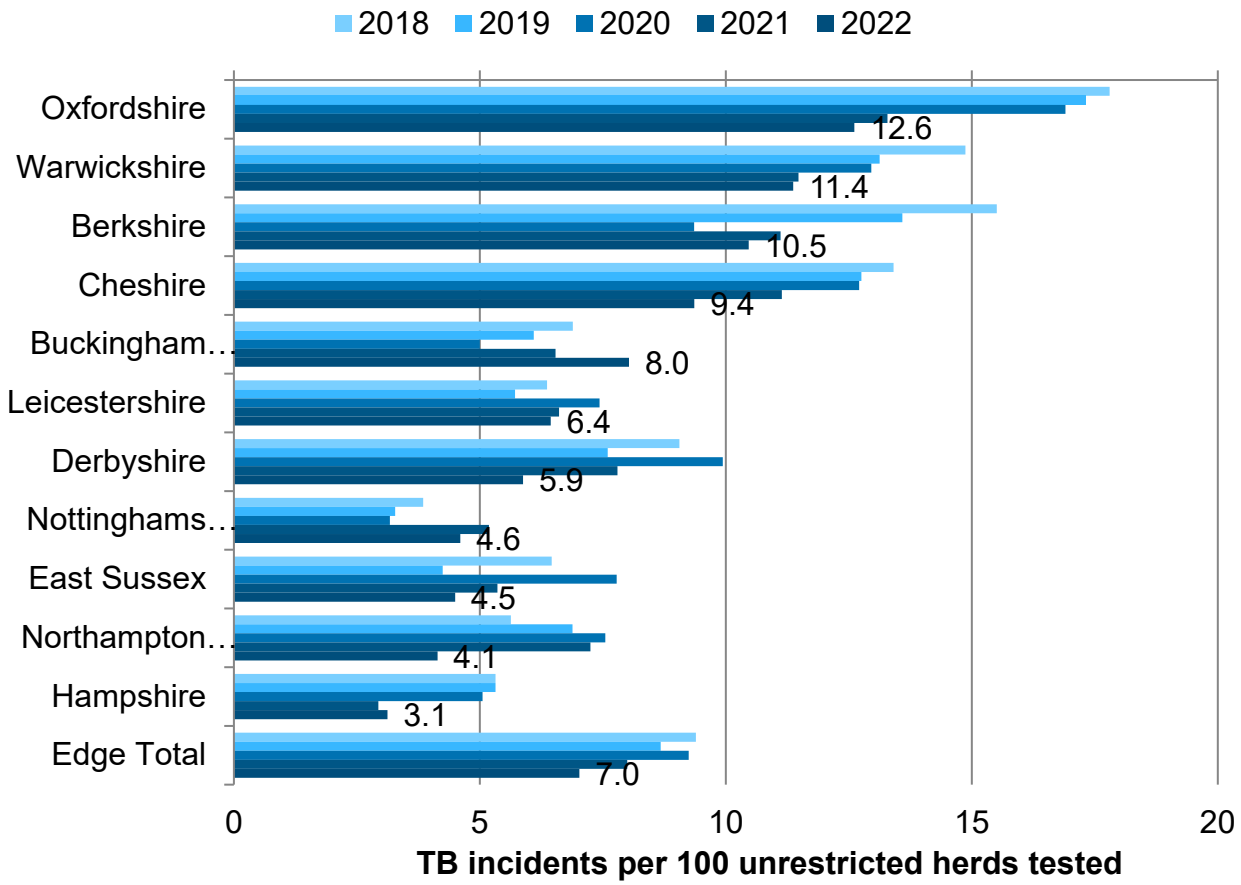
Some of the temporal variation in incidence rates may be due to changes in testing frequency over time. Since 2018, most herds in Oxfordshire, Cheshire, Warwickshire, West Berkshire, much of Derbyshire, and north-west Hampshire were all subject to six-monthly routine testing, and this continued in 2022. 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 within the reclassified Edge Area boundaries, incidence per 100 HYR initially declined. In

2019, when the Earned recognition scheme allowed eligible herds to revert to annual testing, incidence per 100 HYR increased again. The frequency of routine TB surveillance testing in the Edge Area has not changed since 2019. Even so, the number of herds eligible for earned recognition may vary annually, therefore the overall frequency of surveillance will still change slightly each year even when the area testing frequencies nominally remain the same.

A simpler additional measure of herd 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 than incidence per 100 HYR. 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 and 2019.

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 9.4 in 2018 to 7.0 in 2022. Like the incidence rate per 100 HYR, incidence per 100 unrestricted herds tested decreased or remained the same in most of the counties in 2022 compared to 2021, except for Buckinghamshire and Hampshire (Figure 4.2.5). In Buckinghamshire, incidence per 100 unrestricted herds increased for the second consecutive year since 2020 (from 4.8 to 6.5 to 8.0), consistent with the trend in new TB incidents and incidence per 100 HYR (Figures 4.2.2 and 4.2.4). Hampshire saw a marginal increase from 3.3 to 3.4. In Cheshire, Oxfordshire and Warwickshire, incidence per 100 unrestricted herds decreased year on year between 2018 and 2022.

Figure 4.2.5 New TB incidents per 100 unrestricted herds tested from 2018-2022, by Edge Area county. Counties ranked by 2022 incidence value.



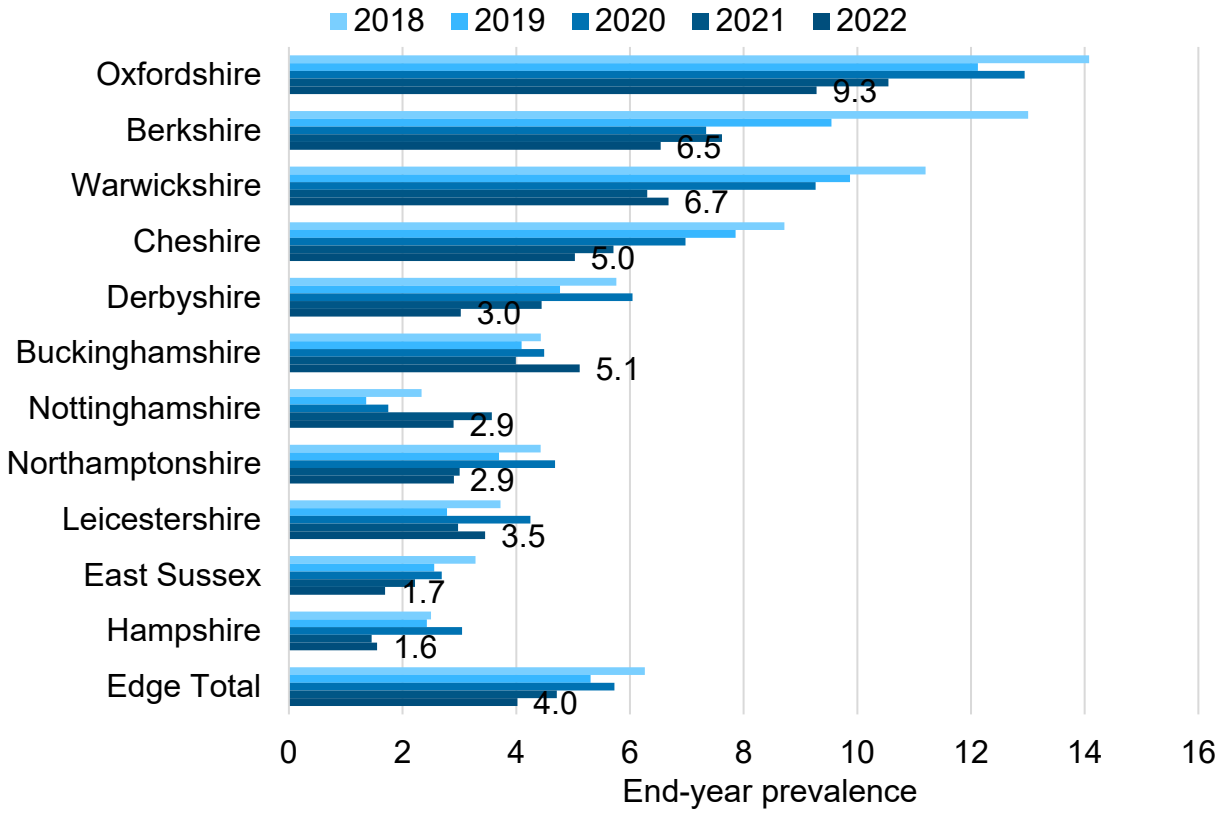
End-of-year herd prevalence by county

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 2022 compared to 2021 (3.6% and 4.0% respectively, z-test p=0.65, Figure 4.2.6).

A decline in prevalence was observed in most Edge Area counties in 2022 compared to 2021, except for Buckinghamshire, Hampshire, Leicestershire and Warwickshire (Figure 4.2.6). Herd prevalence was lowest in Hampshire (1.6%). Oxfordshire had the highest prevalence at the end of 2022 (9.3%), which was higher than the prevalence reported in nine of the 11 HRA counties, ranking as the third highest county in England overall for this metric in 2022 (Figure 4.1.5, Chapter 4.1 Epidemiology of TB in the High Risk

Area). 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 2018-2022, by Edge Area county ranked by decreasing order of prevalence in 2022.

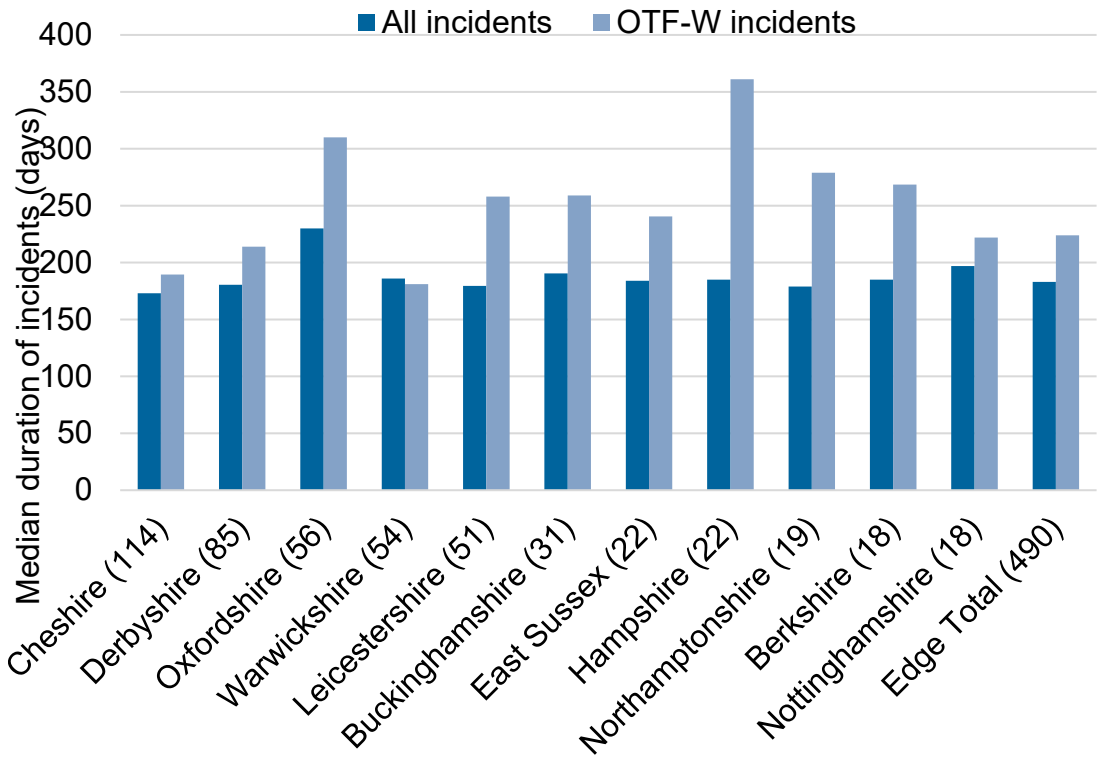


TB incident duration and persistence

A total of 490 TB incidents ended in the Edge Area during 2022. The median duration for those incidents was 185 days (Interquartile Range (IQR) 160 to 266.5 days). At the county level, the longest median duration was observed in Oxfordshire (230 days), followed by Nottinghamshire (197 days) and Buckinghamshire (190.5 days). Counties with the shortest median durations were Cheshire (173 days), Leicestershire (179.5 days), Derbyshire (180.5 days) and Northamptonshire (179 days) (Figure 4.2.7).

The median duration of OTF-W incidents was greater than the duration of all incidents in every county except Warwickshire (all incidents 186 days, OTF-W incidents 181 days). The greatest differences were observed in Hampshire (all incidents 185 days, OTF-W incidents 361 days) and Northamptonshire (all incidents 179 days, OTF-W incidents 279 days).

Figure 4.2.7 Median duration (days) of TB herd incidents that ended in 2022, by Edge Area county ranked by number of incidents (in parentheses).



- Median duration was highest in Oxfordshire for all TB incidents (230 days) and Hampshire for OTF-W incidents (361 days).

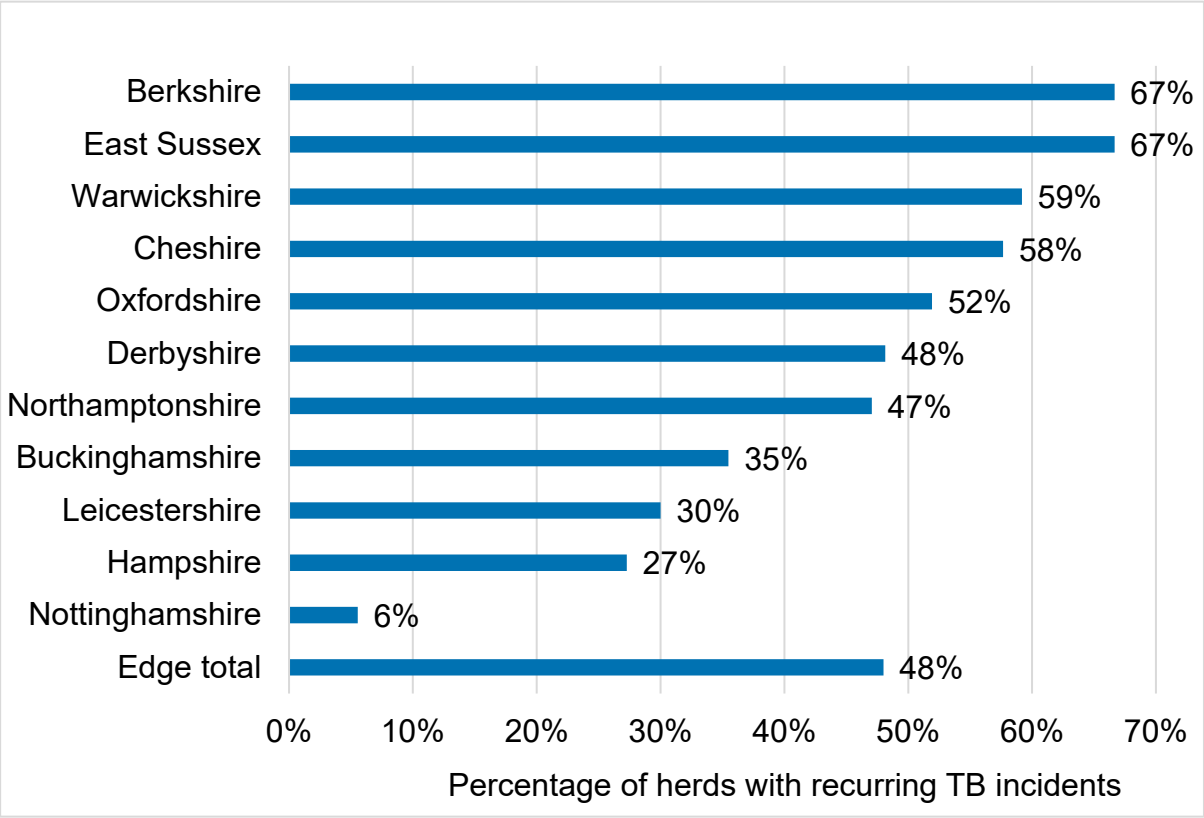
Recurrence of TB incidents

In the Edge Area in 2022, 48% 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 counties of Berkshire (67%), East Sussex (67%) and Warwickshire (59%) (Figure 4.2.8).

In 2022, recurrence in Berkshire and East Sussex was the same as the highest recurrence reported in the HRA, which was in the county of Avon (Figure 4.1.9, Chapter 4.1 Epidemiology of TB in the High Risk Area). Furthermore, recurrence in Warwickshire and Cheshire was higher than the average recurrence reported across the whole of the HRA (56%).

Most (seven out of eleven) counties in the Edge Area saw an increase in the proportion of recurrent TB incidents in 2022 relative to 2021. The exceptions were Oxfordshire (67% to 52%) and Derbyshire (50% to 48%), which experienced decreases (Fig 4.2.8), and Berkshire and Buckinghamshire, where recurrence was unchanged from 2021 to 2022 (67% and 35%, respectively).

Figure 4.2.8 Percentage of TB incidents in 2022 in herds that had experienced any TB incident in the previous three years, by Edge Area county.



Sources of infection

For most herds with new TB incidents in the Edge Area (52%), there was no evidence of cattle movements with a high likelihood of infection and there was no WGS data available to explore the presence of a local reservoir.

The proportion of incidents where a local reservoir was identified varied greatly across the Edge, from none in Nottinghamshire (as no whole genome sequences from *M. bovis* were able to be extracted from any OTF-W incidents) to 45% in Oxfordshire. Additionally, around 20% of incidents in the Edge Area had WGS evidence of a putative local reservoir and no high-risk cattle movements onto the herd. This was highest in Oxfordshire (38% of incidents in the county), where there are clusters of infection in cattle and wildlife.

Cattle movements with a high likelihood of infection were associated with 17% of incidents in the Edge Area, varying from 11 to 21% of incidents within most counties. Warwickshire had only 9% of incidents within the county associated with cattle movements with a high likelihood of infection, compared to 22% associated with the presence of a local reservoir.

For 53 incidents in the Edge Area (11% of incidents), no local reservoir was identified from available WGS data and no cattle movements with a high likelihood of infection were associated with the incident.

More details on the methodology for-determining the risk pathways for the sources of infection can be found in Chapter 3.2 Characteristics of herds found infected with TB and the Explanatory Supplement.

New areas of endemic infection and new clusters emerging

The Edge Area is strategically located along the endemic front of TB and as such, areas of spread and retraction often occur within Edge Area counties. Figure 3.1.6 (spread and retraction of endemic TB areas in 2022, Chapter 3.1) provides a visual depiction of changes to the endemic area in 2022. 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: the incidence rate per 100 HYR and the prevalence were the highest they have been in the past decade. Also, for the first time since before 2013, both were higher than the incidence and prevalence in the Edge Area overall.
- Cheshire: several clusters emerged in 2022, although they appeared in different areas to previous years. There are three predominant clades of *M. bovis*: B3-11 (genotype 25:a), B6-11 (genotype 17:a), and B6-62 (genotype 10:a). Exposure to infected wildlife continues to be the main risk pathway, though there is still a high degree of uncertainty around the source for many incidents.
- Hampshire: clusters of incidents have continued to occur in the central-western area of the county over the past few years. *M. bovis* clade B6-62 has been isolated from both cattle and infected wildlife, suggesting there is evidence of a local reservoir.
- Nottinghamshire: although the number of TB incidents decreased from 2021 to 2022, it was still higher than the incidents reported between 2017 and 2020. This could suggest that *M. bovis* is becoming endemic in the south and centre of the county.
- Oxfordshire: there were several persistent clusters in Oxfordshire in 2022. Whole Genome Sequencing has provided increased evidence of a local source of infection.

Areas of observed improvement

- The incidence per 100 HYR, and the number of new TB incidents decreased in the Edge Area.
- The end-of-year herd prevalence dropped for the second consecutive year.

- Cheshire: the number of new TB incidents continued to decline in 2022. Between 2021 and 2022 there was a 19% decrease in new incidents. This likely indicates a lower burden of infection.
- Derbyshire: the lowest annual number of TB incidents was reported since before 2013. After a peak of incidents in 2020 (147) the number of incidents in 2022 almost halved (85). This reduction is likely due to control measures.
- There was also a decrease in the number of TB incidents around the Bakewell area in the north of the county, which was previously an area of concern.
- Leicestershire: the total number of new TB incidents continued to decrease since 2020.
- Northamptonshire: there was a reduction in the total number of incidents across the county in 2022, and the number of incidents was the lowest reported since 2017.
- Warwickshire: TB incident numbers dropped for the fifth consecutive year.

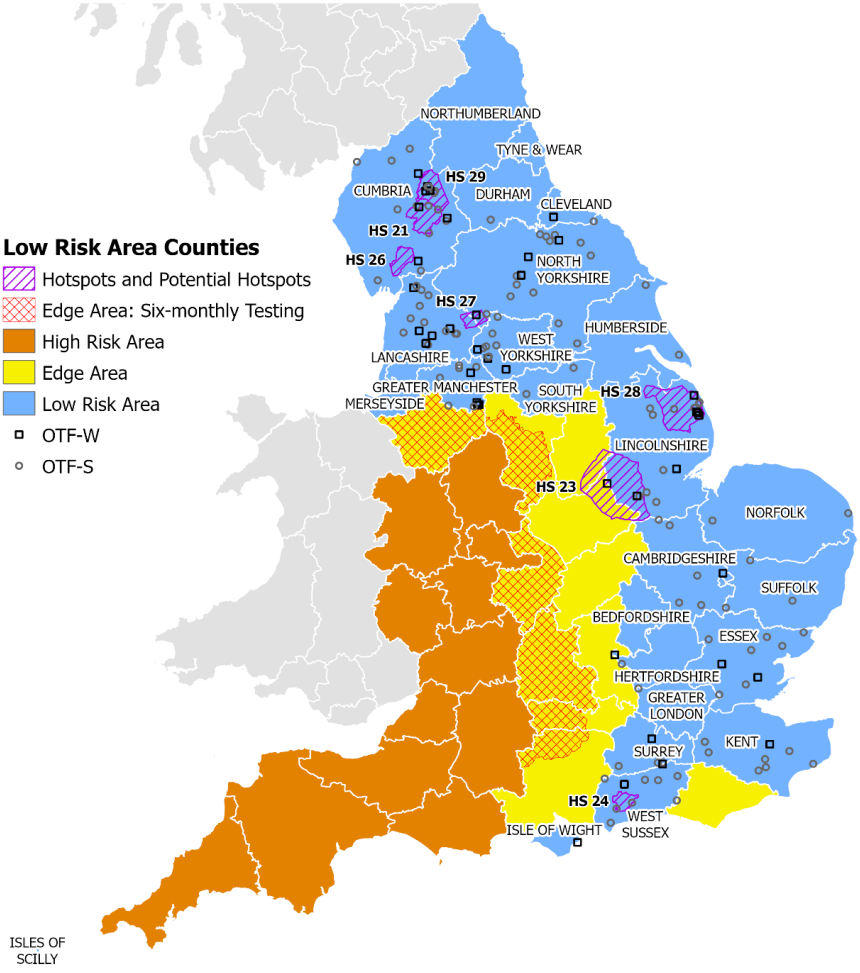
4.3 Epidemiology of TB in the Low Risk Area

This chapter summarises key findings from the LRA TB Epidemiology reports for 2022.

Geographical coverage of the LRA

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. It is also supplemented by post-movement TB testing of cattle brought in from herds in higher risk areas of England and from Wales, and slaughterhouse surveillance.

Figure 4.3.1 LRA county map, showing the location of incidents in 2022 (OTF-W and OTF-S), as well as the two confirmed (HS21 and HS23) and five potential (PHA24, PHA26, PHA27, PHA28 and PHA29) hotspots that were active in 2022.



Number of new TB infected herds

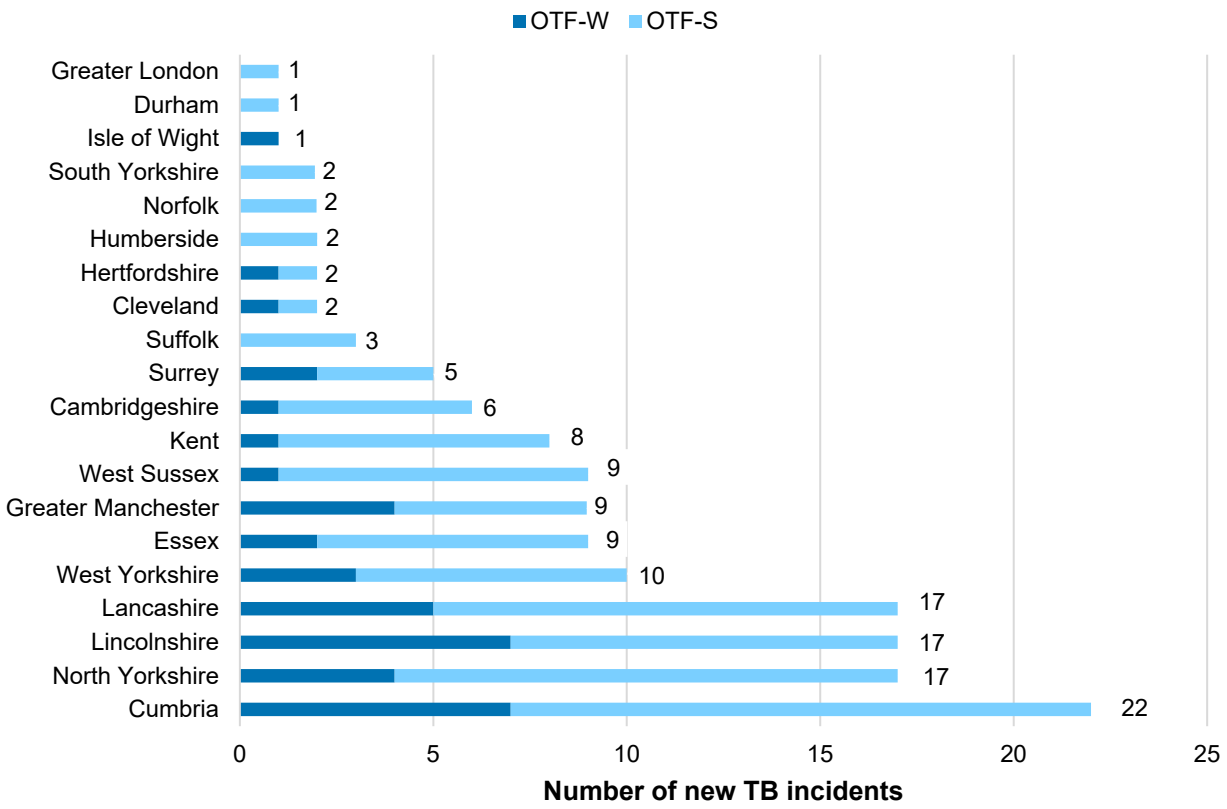
Overall, the herd incidence rate in the LRA remained very low and stable (1.1 incidents per 100 herd-years at risk and 0.3 OTFW incidents per 100 herd-years at risk).

The number of new incidents increased in 2022 compared to 2021 (145 incidents and 123, respectively). Of those 145 new herd incidents in 2022, 40 (28%) were OTF-W (Figure 4.3.2), compared with 38 (31%) in 2021.

Notable increases in new incidents were seen in the South East (26 in 2021 to 46 new in 2022). This was due to increases in Essex (2 in 2021 to 9 in 2022), Kent (3 in 2021 to 8 in 2022) and West Sussex (5 in 2021 to 9 in 2022). Following no new incidents in 2021, new incidents were seen in Surrey (5), Cleveland (2), and one each in Greater London and the Isle of Wight.

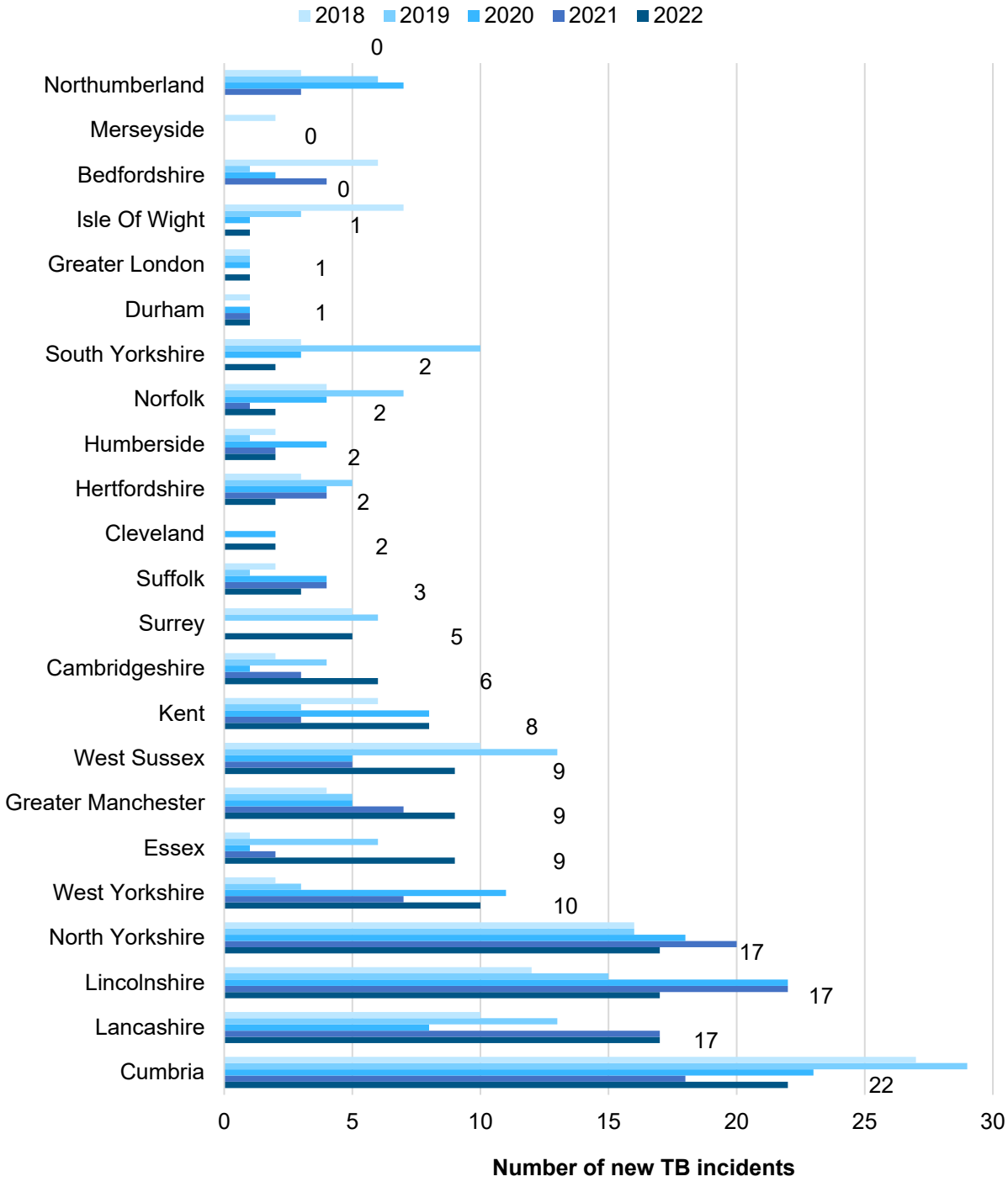
Notable decreases in the number of new TB incidents detected were seen in Lincolnshire (22 in 2021 to 17 in 2022), Bedfordshire (4 in 2021 to 0 in 2022), and Northumberland (3 in 2021 to 0 in 2022) (Figure 4.3.3).

Figure 4.3.2 Total number of new TB incidents (OTF-W and OTF-S) by LRA county in 2022. Total incidents labelled on chart.



Not shown: four LRA counties that did not report any new TB incidents between in 2022 (Bedfordshire, Iscles of Scilly, Merseyside, and Northumberland)

Figure 4.3.3 Annual total number of new TB incidents (OTF-W and OTF-S) by LRA county (2018 to 2022). Number of 2022 incidents labelled on chart.



Not shown: two LRA counties that did not report any new TB incidents between 2018 and 2022 (Isles of Scilly and Tyne & Wear).

Sources of infection

The risk pathway for determining the source of infection in new TB incidents in the LRA combines information on cattle movements onto the herd with WGS data from *M. bovis* isolates cultured from OTF-W incidents. The low number of confirmed incidents in the LRA, due to the low incidence of bovine TB, is reflected in the risk pathways assigned in new incidents in the LRA.

For most incidents, there were no WGS data and no cattle movements associated with a high likelihood of infection were identified (70% of incidents).

Cattle movements associated with a high likelihood of infection were implicated in 15% of all incidents in the LRA. This included 6 incidents where WGS data was available but did not find a local reservoir of infection, as well as 16 incidents where no WGS data were available for further investigation.

Where WGS information was available, it identified a potential local reservoir in 10 incidents (7%) in the LRA. These were in Greater Manchester (3, 33% of all incidents), Lincolnshire (4, 24% of all incidents), and Cumbria (3, 14% of all incidents).
In 11 incidents (8% of incidents in the LRA), WGS data were available but did not find evidence to support a local reservoir of TB, nor were any cattle movements identified that were associated with a high likelihood of infection. These incidents were located in Lancashire (4, 24% of all incidents), West Yorkshire (2, 20% of all incidents) and in Cumbria, Greater Manchester, Isle of Wight, and North Yorkshire (1 incident each).

Despite having WGS data, no local reservoirs of infection were found for eleven incidents in the LRA (11%) – these incidents were also not associated with any cattle movements associated with a high likelihood of infection.

More details on the methodology for determining the risk pathways for the sources of infection can be found in Chapter 3.2 Characteristics of herds found infected with TB and the Explanatory Supplement.

Confirmed and potential TB hotspot areas

In the LRA, hotspot procedures are initiated around OTF-W incidents of undetermined origin in cattle herds. Within a potential hotspot area (PHA), 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 detected in the local wildlife that can be epidemiologically linked to the cattle TB incidents (i.e. a close genetic match between the cattle and wildlife *M. bovis* isolates), then the potential hotspot becomes a confirmed hotspot (HS).

In 2022, there were six TB hotspots ongoing in the LRA: 2 confirmed (HS21 in Cumbria and HS23 in Lincolnshire) and 5 potential hotspot areas (PHA24 in West Sussex, PHA26 in Cumbria, PHA27 spanning Lancashire and North Yorkshire, PHA28 in Lincolnshire and PHA29 in Cumbria).

Confirmed hotspot 21

There was only one new OTF-W incident in HS21 (East Cumbria) in 2022, of which the WGS clade was unknown because *M. bovis* could not be isolated in bacteriological cultures from the suspected TB lesions in the test reactor cattle removed from the affected farm. No WGS isolates of clade B6-23 (genotype 17:z) of *M. bovis* were identified in the hotspot area for the fourth consecutive year, however there was one new OTF-W TB incident detected on a cattle farm to the west of HS21, where *M. bovis* was isolated with clade B6-23. Similar to 2020 and 2021, there were 4 new OTF-S incidents in HS21 during 2022. No incidents remained open at the end of 2022.

Confirmed hotspot 23

In 2022 there were 3 new OTF-W incidents in HS23, an increase by one from 2021. There were no collections of badger or wild deer carcases in HS23 during 2022. Although reports of carcases were received from the public, collections were suspended during part of the year due to other prioritisation of the avian influenza outbreak. Licensed badger culling operations began in part of HS23 in September 2020 and took place for a third year in 2022.

Potential hotspot area 24

Potential Hotspot 24 (West Sussex) was opened in March 2019 following a bacteriologically confirmed slaughterhouse case in April 2017, with no cattle movements from the HRA or a premises which had had a TB incident, and with an out-of-homerange genotype. In 2022, a historical review of WGS phylogeny was carried out to ensure ongoing PHA24 was not closed prematurely due to a lack of wildlife surveillance data.

Potential hotspot area 26

Since potential hotspot PHA26 was established in 2019 in South Cumbria, wildlife surveillance has not identified *M. bovis* in local badgers or wild deer. In 2022 there were no new OTF-S or OTF-W incidents in PHA26.

Potential hotspot area 27

Potential hotspot PHA27 was implemented in January 2020 in the south-west of North Yorkshire straddling the boundary with Lancashire. In 2022 there was one new OTF-W incident in the North Yorkshire part of PHA27. Since its implementation, only one wild deer carcase has been submitted for examination, which was *M. bovis* negative.

Potential hotspot area 28

There were four new OTF-W incidents in potential hotspot PHA28 (East Lincolnshire) during 2022, a figure unchanged from 2021. All incidents were caused by WGS clade B3-11. No infection was detected in the 3 badger carcases examined in 2022.

Potential hotspot area 29

A new potential hotspot was established at the start of 2023 along the Eden Valley in East Cumbria following the detection of 4 OTF-W incidents in 2021 caused by WGS clade B3-11 of *M. bovis*, and 3 incidents in 2022, also with clade B3-11. There are currently no enhanced control measures, except radial testing of cattle herds around the OTF-W incidents. Surveillance of badgers and deer began early in 2023, although no *M. bovis* has been identified in wildlife to date.

Areas that require monitoring

As well as potential hotspot areas, APHA monitors any emerging clusters of cattle TB incidents in the LRA that may in the future require the initiation of hotspot procedures. Parts of the LRA that may be at risk of the spread of infection from adjoining areas of endemic TB in the Edge Area are also closely watched. Parts of the LRA identified as being at particular risk for this reason in 2022 included:

- South-East Greater Manchester: three new OTF-W incidents (clade B3-11) occurred in Stockport in 2022. Due to its proximity to the border with Cheshire (Edge Area), there are concerns that *M. bovis* infection could be spilling over the county boundary.
- North-East Greater Manchester: there was one new OTF-W incident (clade B3-11 of *M. bovis*) identified near Oldham in 2022, which was close to OTF-W incidents of the same clade identified in both 2020 and 2021. All incidents over the last three years 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.
- Hertfordshire: there was a cluster of OTF-W and OTF-S incidents in 2022 around the town of Tring in west Hertfordshire. New incidents have repeatedly occurred for the last few years in this area close to the border with Buckinghamshire (Edge Area).

There are other areas within the LRA, not adjacent to the Edge Area, that also require close monitoring due to the detection of incidents where there was no obvious source of infection via incoming movements of cattle. In 2022 these include:

- East Lancashire: one OTF-W incident (culture-negative, therefore the clade was unidentified) and 3 OTF-S incidents were disclosed near Burnley in 2022. This area disclosed 2 OTF-W incidents and 3 OTF-S incidents in 2021, and 3 OTF-S incidents in 2020. This area will require close monitoring in case the situation deteriorates further.

- North Yorkshire: in 2022, there was a cluster of incidents with WGS clade B3-11 that occurred in the same area as in previous years. Cattle movements were the most likely source of infection for these incidents over the past few years.
- West Yorkshire: three OTF-W incidents caused by the same clade (B3-11) of *M. bovis* were disclosed in the west of the county in 2022. Six OTF-S incidents were also detected in this area in 2022. Direct or indirect contact with wildlife was a potential source of infection for these incidents and this area requires careful monitoring.
- East Cumbria: in 2022 there was an OTF-W incident associated with clade B6-23, which is the same clade of *M. bovis* most commonly found within HS21. The isolate was found to be very closely related to isolates from HS21. The area will be monitored for any further cases that may indicate lateral spread of infection outside the hotspot boundary.