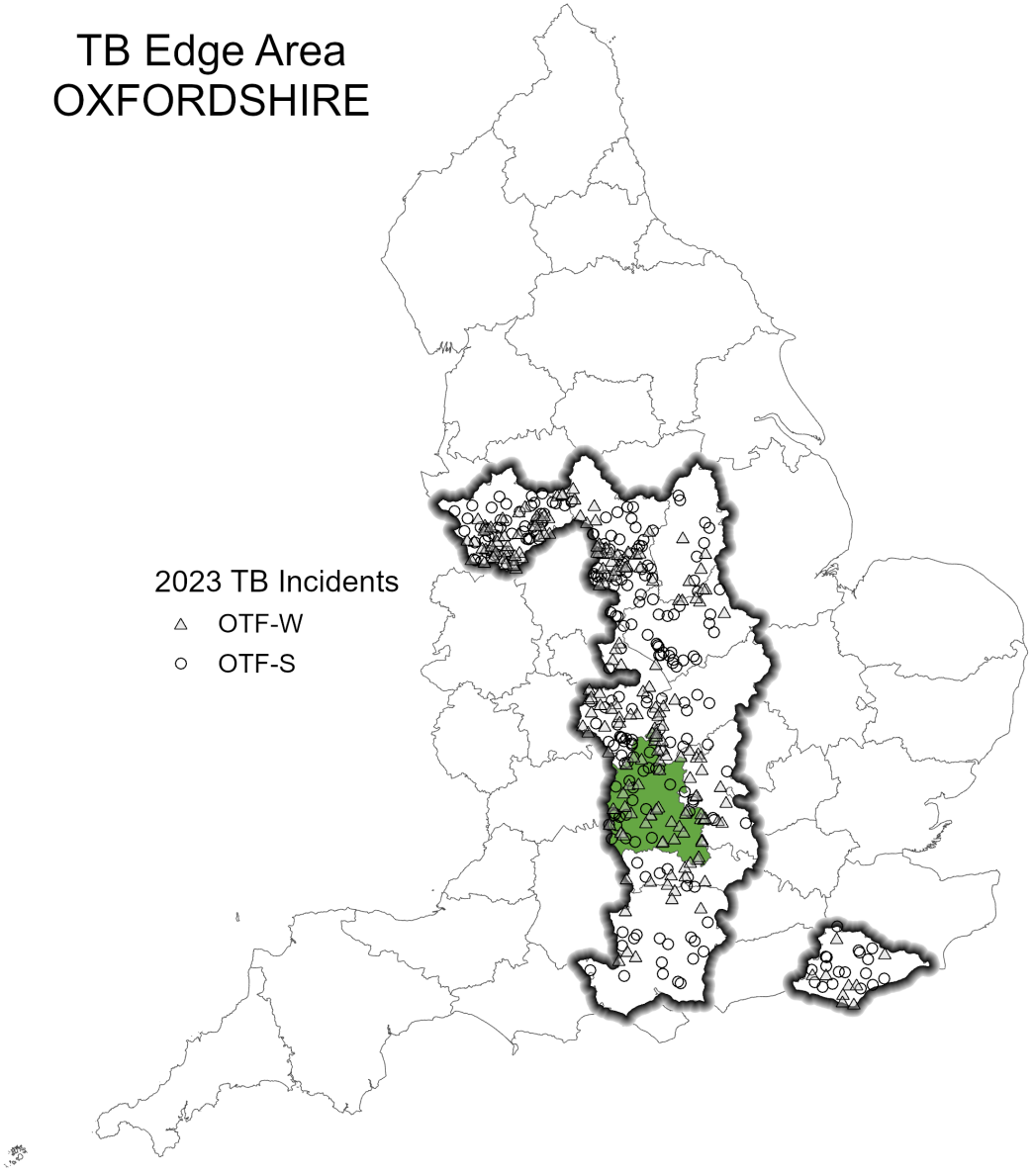
Animal &
Plant Health
Agency

Year End Descriptive Epidemiology Report: Bovine TB in the Edge Area of England 2023 County: Oxfordshire



Contents

Introduction

The Edge Area was originally established in 2013, along with the Low Risk Area (LRA) and High Risk Area (HRA) of England. In 2014, the 3 bovine tuberculosis (TB) risk areas were incorporated into the UK government's strategy to achieve Officially TB-Free (OTF) status for England by 2038. A key action was to recognise the different levels of TB in different parts of the country and to adjust the approaches to TB surveillance and control in each risk area accordingly. The current aim is to obtain OTF status for the Edge Area as soon as possible.

This report describes the frequency and geographical distribution of TB in cattle herds in Oxfordshire, an Edge Area county, in 2023. It examines what factors are likely to be driving TB in this area, and the risks the disease in this county may pose to neighbouring areas.

TB in cattle and other mammals is primarily caused by the bacterium *Mycobacterium bovis* (*M. bovis*), and the disease is subsequently referred to in this report as TB. Although other sources may refer to TB 'breakdowns', this report will use the term 'incidents' throughout.

This report is intended for those involved in the control of TB, both locally and nationally. This includes, but it is not limited to, cattle farmers, government and private veterinarians, policy makers and the scientific community.

Details of the data handling methodology used in this report, a glossary of terms, and the TB control measures adopted in the Edge Area, can be found in the explanatory supplement to the annual reports 2023.

Types of TB incidents

Unless otherwise specified, this report includes all new TB incidents detected during the reporting period (1 January to 31 December 2023). This includes both 'Officially Tuberculosis-Free Status Withdrawn' (OTF-W) and 'Officially Tuberculosis-Free Status Suspended' (OTF-S) incidents.

- OTF-W incidents are those involving at least one skin test reactor (an animal positive to the Single Intradermal Comparative Cervical Tuberculin [SICCT] test), with either: typical lesions of TB identified at post-mortem (PM) meat inspection
- at least one animal with *M. bovis*-positive polymerase chain reaction (PCR) test (or bacteriological culture) results in tissue samples collected from carcasses during the PM inspection

OTF-S incidents are triggered by reactors to the skin test, but without subsequent detection of TB lesions or positive PCR test (or culture) results in any of those animals.

TB incidents in Approved Finishing Units (AFUs) without grazing are not included in the prevalence and incidence calculations in this report due to the limited epidemiological impact of these incidents.

Furthermore, the number of TB incidents and designation of those incidents as OTF-W or OTF-S may differ in this report compared to other official TB statistics, due to differences in the information available at the time datasets are accessed.

Cattle industry

Cattle farms in Oxfordshire are predominantly small to medium sized suckler herds, as indicated in Appendix 1. Large herds tend to be dairies in West Oxfordshire and finishing units in the rest of the county. There were 11 AFUs in 2023, which was unchanged from 2022.

Purchases of cattle are mainly from the HRA and neighbouring Edge Area counties. Smaller farms tend to buy locally within the county. Thame market was the only livestock market operating in Oxfordshire in 2023. Dedicated sales for TB-restricted cattle in the south-west are the main outlet for calves from TB incident herds.

The number of cattle markets in operation in 2023 is captured and maintained centrally by the Animal and Plant Health Agency (APHA) TB Customer Service Centre. Where possible, this data is then subject to further validation by APHA veterinarians subject to their best knowledge of the local area. Some small discrepancies may therefore exist where changes to markets were not captured in time for this report.

Oxfordshire was originally divided between 2 TB risk areas. The HRA where TB infection was endemic in the west of the county, and the Edge Area in the centre and east of the county where TB infection was believed to be spreading or at risk of spreading in the short to medium term.

The whole of Oxfordshire was fully incorporated into the Edge Area in January 2018.

Cattle herds routinely undergo 6-monthly TB surveillance testing in Oxfordshire. However, 27% of cattle herds were regarded as having a lower risk of contracting TB, and thus eligible for annual testing under the earned recognition scheme in 2023 (compared to 26% in 2022).

New TB incidents

In 2023, there were 69 new TB incidents detected in the whole of Oxfordshire, which is an increase of 13 (23%) from 2022, as shown in Figure 1. This increase was driven in part by a 32% increase in the number of OTF-W and an 11% increase in the number of OTF-S incidents in 2023 compared to 2022.

Following a continual decrease in OTF-W incidents since 2018, the number of incidents rose from 31 incidents in 2022 to 41 in 2023 which is similar to the numbers of incidents in 2020 (47 OTF-W). The number of OTF-S incidents also rose slightly from 25 in 2022 to 28 in 2023, which is the highest number of OTF-S incidents in the last 10 years.

New incidents in the original Edge Area of East Oxfordshire OTF-W increased in 2023 to 30, from 21 in 2022. The number of new OTF-S incidents in this same area remained unchanged from 2022 (16). The original HRA in West Oxfordshire has also remained relatively unchanged with around 22 incidents disclosed every year since 2020 (19 in 2022 and 23 in 2023).

The original Edge Area of East Oxfordshire is therefore the main driver of TB in the county especially in the last 3 years, with an increase of OTF-W incidents in 2023. This suggests that TB is actively spreading in the original Edge Area of the county, despite the initial decrease in the total number of incidents following deployment of interferon gamma (IFN-γ) blood testing and increased TB testing in 2018.

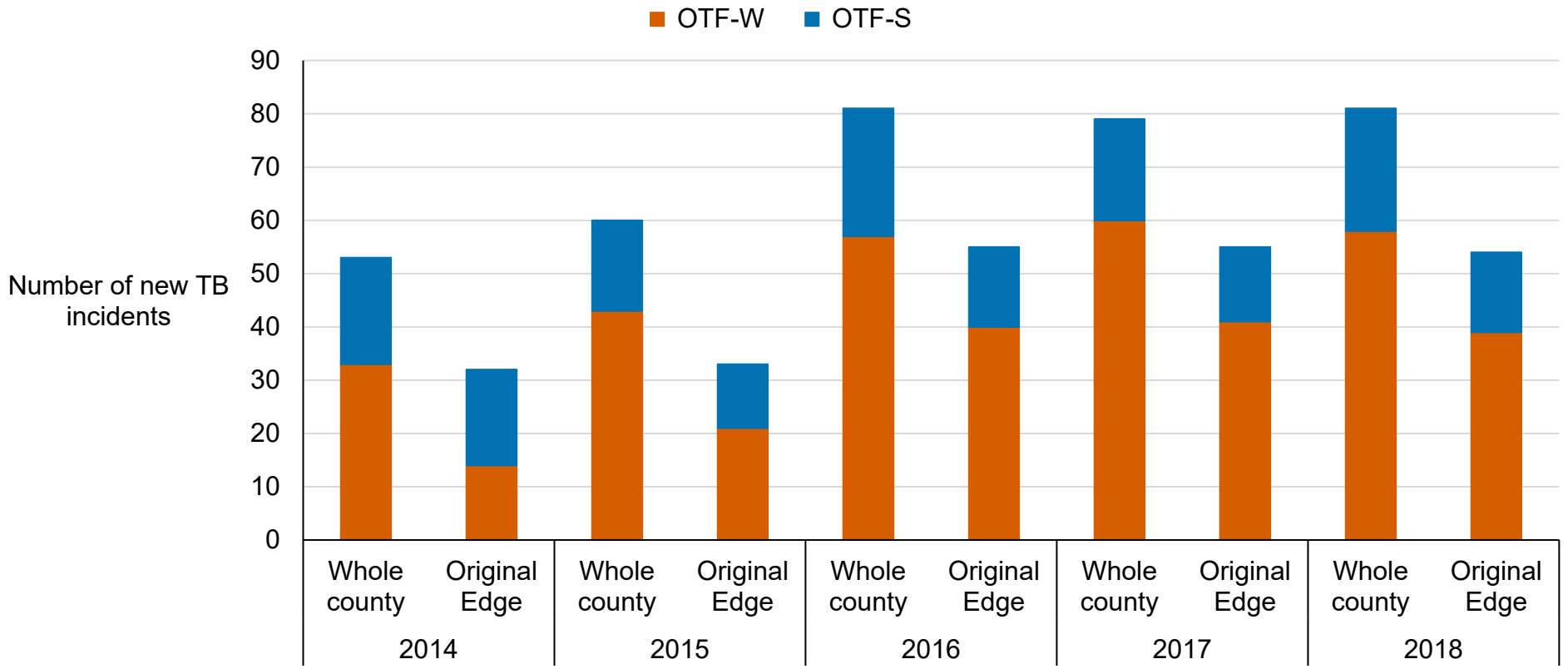


Figure 1a: Annual number of new TB incidents in Oxfordshire, from 2014 to 2018.

Figure 1a description: Bar chart showing the number of confirmed TB incidents (OTF-W, in orange) and suspected (OTF-S, in blue) in the whole of Oxfordshire and the original Edge part of Oxfordshire (prior to the incorporation of the HRA part in 2018) between 2014 and 2018, and the figure is continued in Figure 1b. The total number of cases in Oxfordshire increased between 2014 and 2018, with a high of 81 cases in 2016 and 2018. In 2023, there were 69 TB incidents in the whole county, 41 OTF-W and 28 OTF-S. Out of those 69, 30 OTF-W and 16 OTF-S were in the original Edge Area of Oxfordshire.

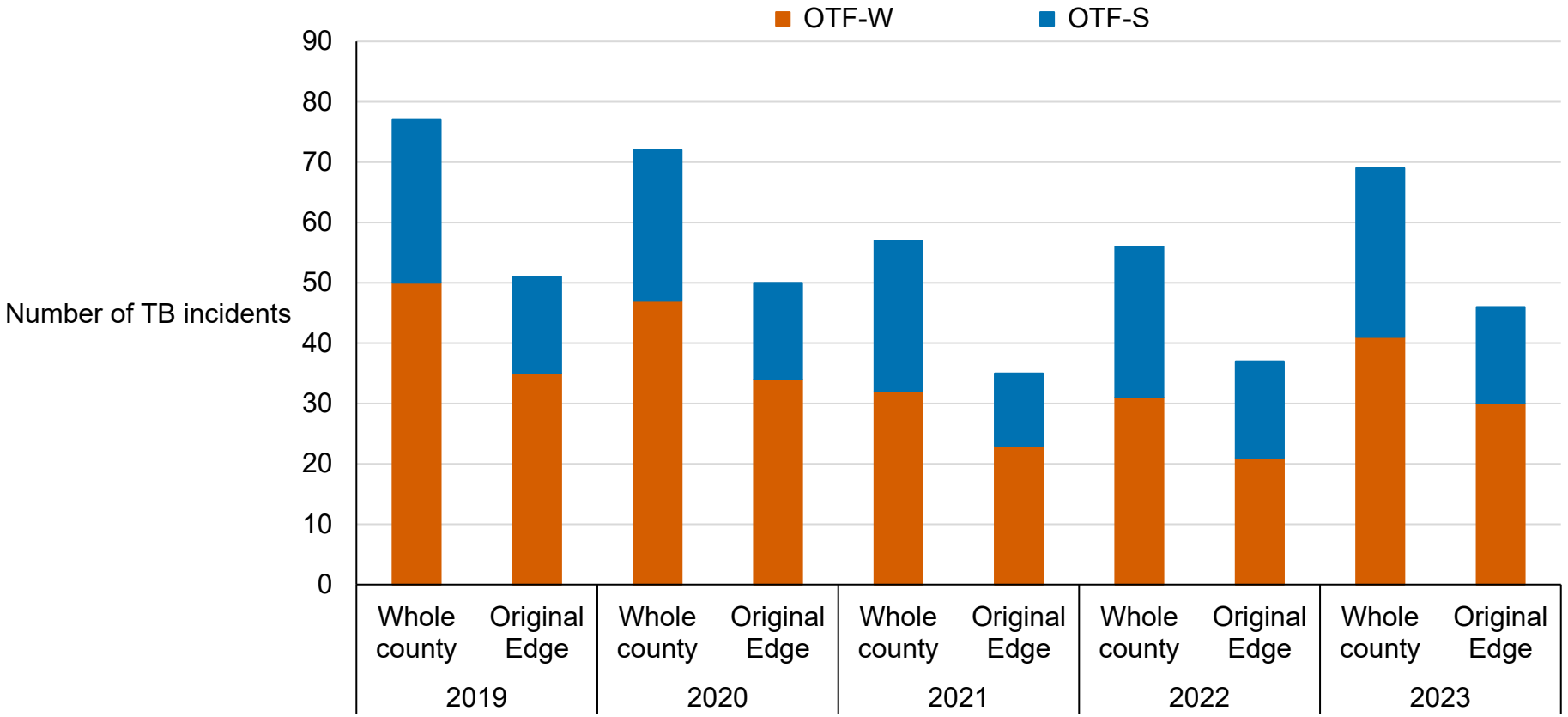


Figure 1b: Annual number of new TB incidents in Oxfordshire, from 2019 to 2023.

Figure 1b description: Bar chart showing the number of confirmed TB incidents (OTF-W, in orange) and suspected (OTF-S, in blue) in the whole of Oxfordshire and the original Edge part of Oxfordshire (prior to the incorporation of the HRA part in 2018) between 2014 and 2023. In 2023, there were 69 TB incidents in the whole county, 41 OTF-W and 28 OTF-S. Out of those 69, 30 OTF-W and 16 OTF-S were in the original Edge Area of Oxfordshire.

In 2023, 35% of the total number of new TB incidents occurred in beef suckler herds (32% of all OTF-W and 39% of all OTF-S incidents in Oxfordshire). Beef fattener herds accounted for a further 38% of all new TB incidents.

Herds of 200 or fewer cattle were responsible for 62% of all new incidents compared to herds with 201 or more (38%).

Disclosing test types

As in previous years, whole-herd testing, (6 or 12-month routine surveillance) continued to detect the most incidents of TB in Oxfordshire in 2023 (43). This was followed by 6-month post-incident surveillance testing (15), as shown in Figure 2.

In 2023, slaughterhouse (SLH) surveillance detected 5 incidents. Slaughterhouse cases provide evidence of residual infection undetected by routine testing. Pre-movement testing detected 4 incidents, which shows a risk of purchased infection from undetected infected cattle. Both test types disclosed one incident each in 2022. New herd check tests and 12-month testing each detected one incident in 2023.

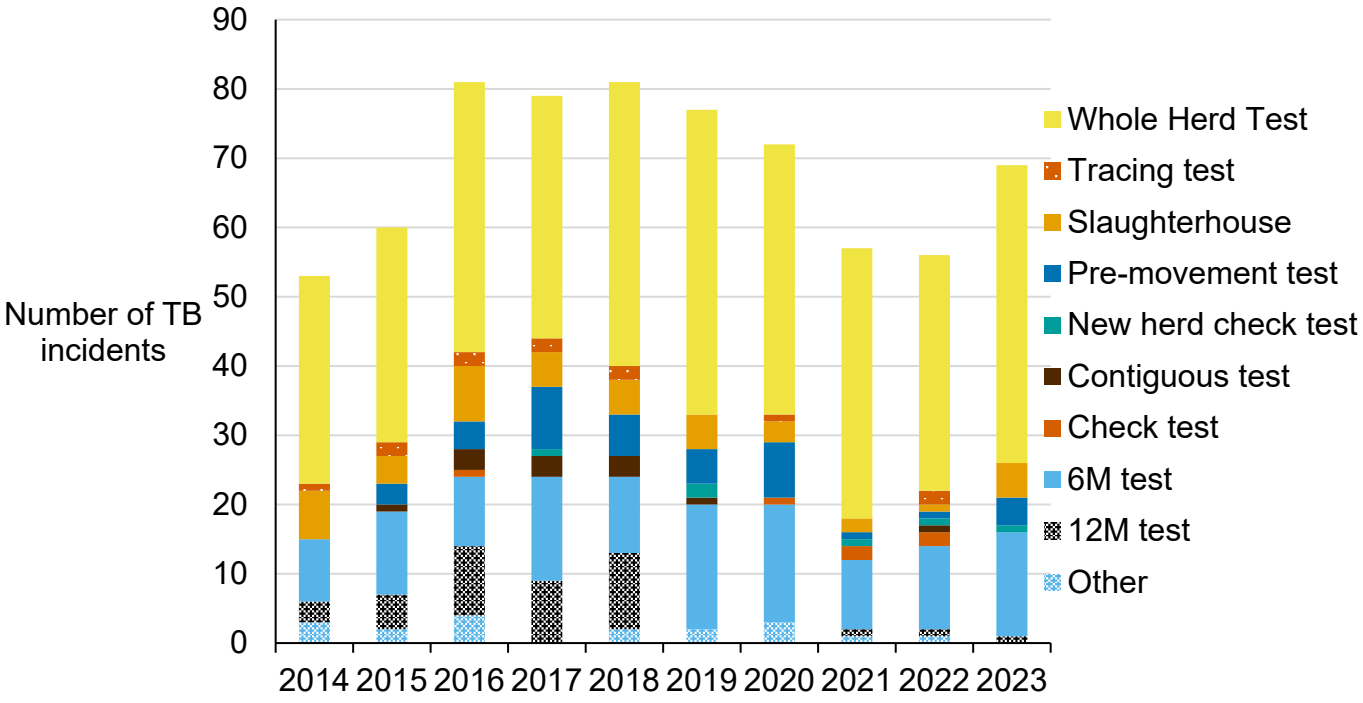


Figure 2: Number of new TB incidents (OTF-W and OTF-S) in Oxfordshire in 2023, according to the surveillance methods that detected them.

Figure 2 description: A bar chart showing the number of new TB incidents disclosed by test type in Oxfordshire between 2014 and 2023. In 2023, most incidents were disclosed by whole herd tests (43) – a detailed breakdown is provided in the text.

Duration of TB incidents

A total of 58 TB incidents were resolved in Oxfordshire during 2023. Of these, 22 were new TB incidents that started in 2023, 32 started in 2022, 3 started in 2021 and 1 started in 2019.

The median duration for OTF-W incidents that ended in 2023 was 204 days, interquartile range (IQR) 171 to 277.5. Three OTF-W incidents took more than 550 days to resolve (called persistent incidents), but the majority (33 out of 36) ended in 550 days or less.

Most OTF-S incidents that ended in 2023 (15 out of 22) were resolved within 240 days, however 7 took between 241 and 550 days to resolve, and the median was 206 days (IQR 182 to 291).

The median duration for all incidents that ended in 2023 was 204 days (IQR 174 to 284). This is shorter than the duration of incidents that ended in 2022, which was 230 days (IQR 173.5 to 398.5), and the fourth highest median duration of any Edge Area county in 2023.

For the whole Edge Area, the median duration of TB incidents that ended in 2023 was 188 days (IQR 159 to 265).

There were 52 TB incidents still open at the end of 2023, including 2 persistent OTF-W incidents that had been open for more than 550 days.

The number of persistent incidents (herds under movement restrictions for more than 550 days) has decreased in 2023 compared to previous years. There were 5 incidents in 2023 (only 2 still open at the end of the year) compared to 11 in 2022 and 15 in 2021, bringing the overall median duration down.

Previously, persistent incidents were a common feature of TB in the original HRA of West Oxfordshire. They have decreased over recent years, with many dairy herds closing down and others implementing control measures such as badger culling since 2019. However, in 2023, there were 3 persistent incidents in the original HRA of west Oxfordshire and 3 in the original Edge Area.

Unusual TB incidents

In 2023, additional Defra approved ancillary tests were used in Oxfordshire to remove infection in incidents where the level of reinfection from purchases and wildlife was believed to be low, but where the effect of residual infection was preventing incidents from becoming clear.

A large dairy and fattening unit (1,000 cattle) in the original HRA west of the county was recommended for the use of these tests. This herd had been repeatedly recurrent since 2014, with the current incident lasting over 15 months with several reactors. TB Advisory

Service (TBAS) visits by private veterinarians had taken place to provide recommendations about management of the TB risks, which had then been implemented.

The flexible extended IFN-γ test was used to increase testing sensitivity to the IFN-γ test in the face of concurrent Johne's infection. The antibody IDEXX test was also used to detect and remove infected animals not disclosed during repeated skin and IFN-γ testing. Skin tests and these 2 ancillary tests were completed, and positives removed - 11% of the 600 cattle that were in contact with the breeding stock. The herd has subsequently completed 2 clear skin tests, improving its chances of becoming free of infection.

TB in other species

There is no statutory routine TB surveillance of non-bovine species, apart from post-mortem examination (PME) of animals slaughtered for human consumption, or carcasses submitted to veterinary laboratories for diagnostic investigations. Targeted TB testing takes place in non-bovine herds under TB movement restrictions due to laboratory-confirmed incidents of *M. bovis* infection, and in specific herds of camelids, goats and captive deer at an elevated risk of infection. Although no active surveillance of wild deer is in place, reporting of suspected TB lesions in wild deer and wildlife carcasses is statutory and suspect carcasses are inspected and tested by APHA.

In Oxfordshire, there was one domestic cat submitted with a non-healing bite wound on a limb, and later confirmed with *M. bovis* infection. The owner lived south of Oxford and was not a farmer. Whole Genome Sequence (WGS) confirmed local clade B6-62 affecting the cat with an identical isolate to the contiguous cattle farm with a TB incident the same year. Most likely sources of infection for the cat were concluded as direct or indirect contact with these cattle or local infected wildlife.

Reports of suspicion of TB in wild deer increased in 2023. This is likely due to the creation in 2022 of the Oxfordshire Cluster Project, which offered training to local stalkers to identify typical lesions of TB in game carcasses. Reporting of suspect TB lesions observed in wildlife carcasses is statutory.

There were several wild deer carcasses reported to APHA in 2023. Two were in roe deer, one in fallow and one in muntjac. All were sampled and sent for TB culture, B6-62 clade was confirmed in all of them which is the local clade in Oxfordshire. WGS also enabled the linking of these incidents to specific cattle incidents in the same geographical area, giving further evidence of the relationship between cattle and local wildlife in the transmission of TB.

A badger carcass was also submitted after a local vet found suspected lesions of TB. This badger had the same clade (B6-62) as cattle in Oxfordshire but was linked to a cluster of incidents a few miles away from where it was found.

APHA, in collaboration with the University of Nottingham, conducted a project to detect the presence and location of TB infection in badgers in Buckinghamshire, Oxfordshire, Berkshire, Hampshire and East Sussex - collectively known as the ‘Southern Edge Area’. Volunteers were recruited in each county to help with the safe and timely retrieval of badger carcasses. They were delivered to the University of Nottingham, where they underwent post-mortem examination and testing for the presence of TB infection by culture. Those that tested positive were sent for further WGS and clade identification (genetic strain). The project aimed to collect 100 carcasses of badgers found dead per county, most likely those killed in road traffic accidents (RTAs). Once 100 carcasses of a sufficient quality were examined per county, collection ceased in that county. Once county targets were achieved, all stakeholders were informed. The survey ended in April 2023 and its results will be communicated to all stakeholders once all the bacteriological cultures and WGS analysis have been completed. Its results will help develop a picture of the disease situation in the Southern Edge Area.

Incidence of TB

In 2023, Oxfordshire had the highest incidence of TB per 100-herd years at risk (18.2) out of the 11 Edge Area counties. It is also more than double the incidence rate for the Edge Area overall (7.2 in 2023).

The incidence in Oxfordshire was also higher than all other 11 High Risk Area counties and the HRA overall (13.2). The incidence rate in Oxfordshire increased following a 3-year decrease between 2019 and 2022 (23.5 to 15.1), as shown in Figure 3a. The incidence in the original Edge Area portion of Oxfordshire increased to 16.0 in 2023 from 12.9 in 2022.

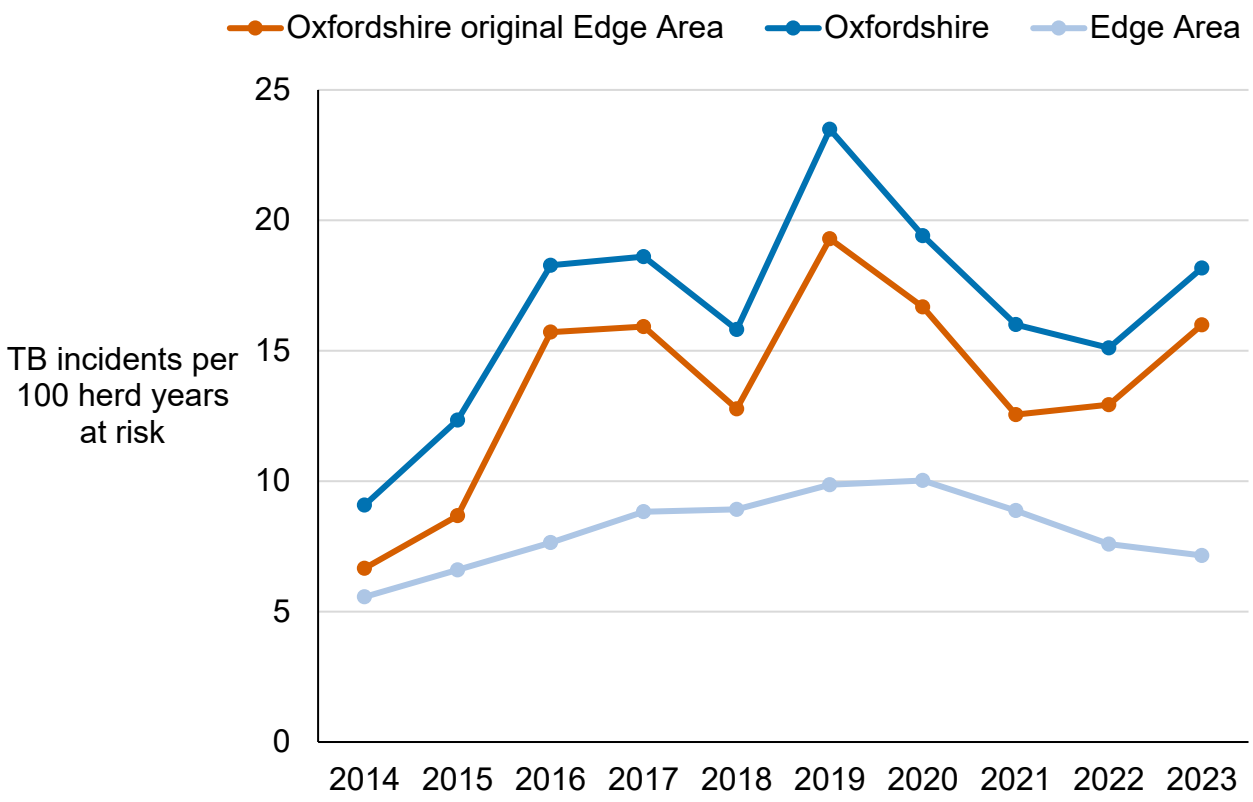


Figure 3a: Annual incidence rate (per 100 herd-years at risk) for all new incidents (OTF-W and OTF-S) in Oxfordshire, from 2014 to 2023.

Figure 3 description: Line chart showing the incidence rate of new TB incidents per 100 herd-years at risk (100 HYR) in Oxfordshire, the original Edge Area of Oxfordshire, and the overall Edge Area between 2014 and 2023. The incidence trend in Oxfordshire has been above that of the overall Edge Area for the whole time period, as has the original Edge Area of Oxfordshire. Both the overall Oxfordshire county and original Edge Area of Oxfordshire follow very similar increasing trends over time. Incidence peaked in 2019 at 23.5 new TB incidents per 100HYR in the county overall, and had been falling until 2023 when it increased again.

The marginal decrease in incidence in the previous 3 years since 2020 and subsequent rise in 2023 was potentially explained by several factors:

1) A reduction of residual infection by using mandatory IFN-γ blood testing in the original Edge Area since 2016 and extending to the whole Edge in 2018 in all cattle herds affected by OTF-W TB incidents, leading to fewer recurrent incidents.
2) Earlier detection of incidents (due to increased frequency of surveillance herd testing since 2018) also reducing spread and residual infection within the herd causing recurrence.
3) Changes to the IFN-γ testing policy in England were introduced in July 2021, with a net result of reducing the number of such tests completed in OTF-W incidents in the 6-month routine surveillance testing parts of the Edge Area. Whole-herd IFN-γ

blood testing decreased to a limited number of recurrent incidents (those with an OTF-W incident in the previous 18 months). A further reduction followed due to an emergency interim action introduced in December 2021 with the diversion of APHA staff to controlling the 2021-2022 and 2022-2023 highly pathogenic avian influenza outbreaks. Gamma testing was prioritised to the LRA and Edge Area counties on 12-month testing during that time further reducing the number of tests in Oxfordshire. This change in gamma policy has likely contributed to slowing down the decrease in incidence in 2022 and increased it in 2023, amongst other factors.

4) Licensed intensive badger culling operations started in the west side of Oxfordshire in 2019. Additional areas were licensed in 2022 covering the east of the county, which had an increasing incidence of TB in 2022. This additional intervention has probably started to have a positive impact in western areas of the county but not yet in the original Edge Area of the county where TB is spreading further east.

Figure 3b shows the incidence calculated as the number of new TB incidents per 100 unrestricted herds tested. This additional measure was introduced to account for the effects of changing testing frequency between 2018 (when 6-month testing was introduced) and 2019 (when earned recognition allowed for some herds to return to annual testing). The county incidence per 100 unrestricted herds tested plateaued from 2016 to 2020, decreased in the 2 following years, and increased in 2023 (15.8).

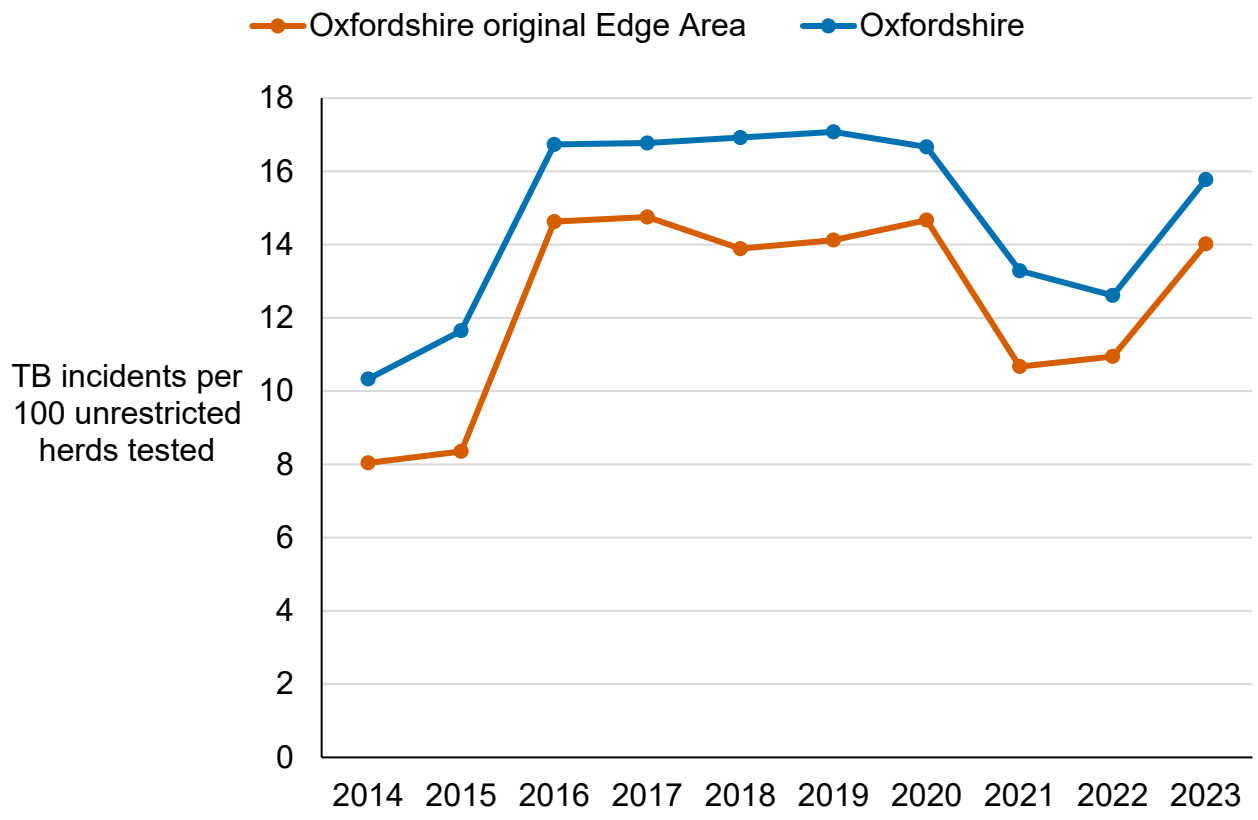


Figure 3b: Annual incidence rate per 100 unrestricted herds tested for all new incidents (OTF-W and OTF-S) in Oxfordshire, from 2014 to 2023.

Figure 3b description: Line chart showing the annual incidence rate per 100 unrestricted herds tested for all new incidents (OTF-W and OTF-S) in Oxfordshire, between 2014 and 2023. The county incidence per 100 unrestricted herds tested plateaued from 2016 to 2020, decreased in the 2 following years, and increased in 2023 (15.8).

Prevalence of TB

The herd prevalence for both the whole of Oxfordshire and the original Edge Area increased in 2023 (10.4% and 8.5%) compared to 2022 (8.3% and 6.7% respectively, see Figure 4).

The herd prevalence in Oxfordshire had been falling since 2020, however there was an increase in 2023 compared to 2022. A reason for the decline in 2021 and 2022 was the reduction in the number of new TB incidents. The increase in 2023 was due to the increase in the number of new TB incidents.

Oxfordshire had the highest end of year prevalence out of the 11 counties in the Edge Area. This was higher than the overall rate for the whole of the Edge Area in 2023 (3.7%).

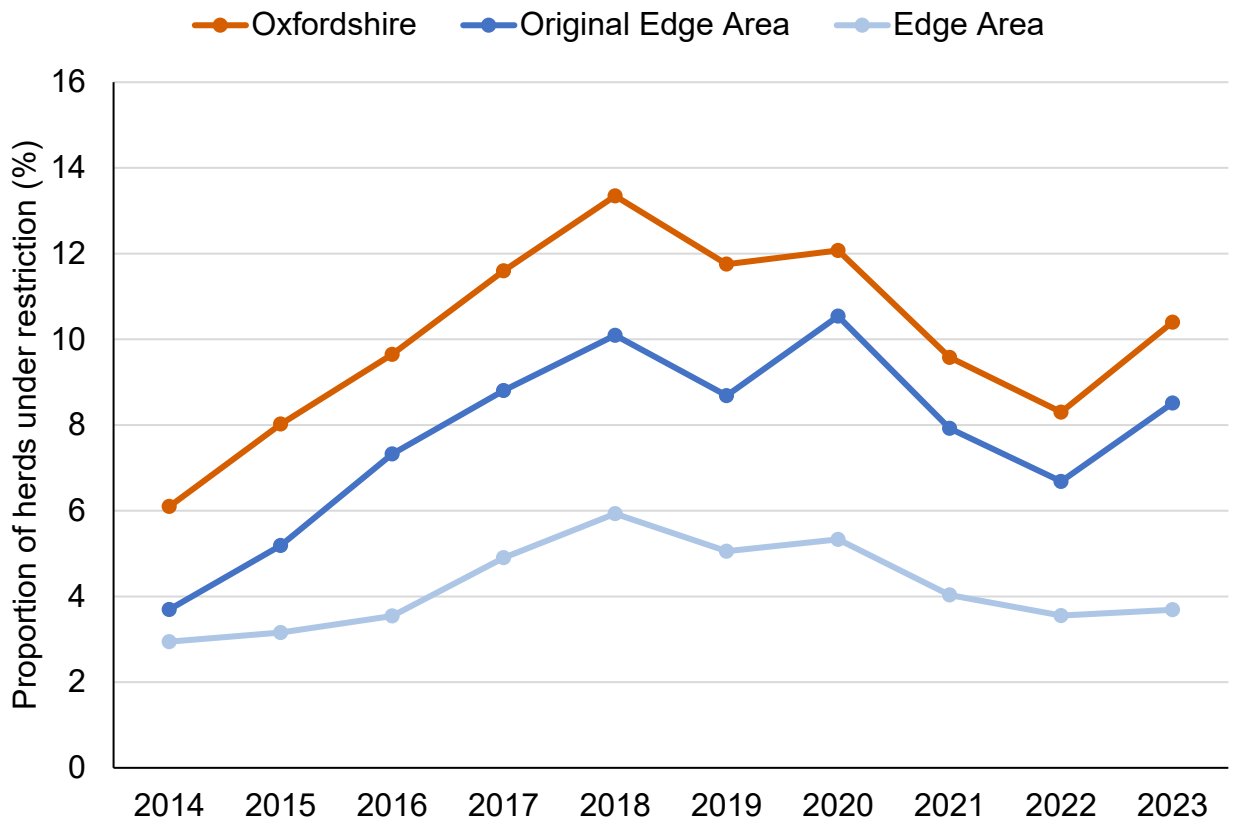


Figure 4: Annual end of year prevalence in Oxfordshire, from 2014 to 2023.

Figure 4 description: Line chart showing the annual end of year prevalence in Oxfordshire between 2014 and 2023. Both the overall Oxfordshire county and the original Edge Area of

Oxfordshire have had a prevalence rate that is higher than that of the Edge Area overall throughout the time period and that closely mirrors each other. Prevalence in Oxfordshire increased until 2018, had a second peak in 2020 and appears to have had a third peak in 2023 after decrease for the past two years.

Recurring TB incidents

Three-year recurrence

In Oxfordshire, a total of 34 (52%) of new TB incidents were in herds which had experienced another TB incident in the previous 3 years, see Figure 5. The proportion of OTF-W and OTF-S herds which had had a TB incident in the previous 3 years was similar (54% and 48% respectively).

The recurrence rate in Oxfordshire was similar to that of the whole of the Edge Area (54%). Recurrence of an incident in the same herd is a problem in Oxfordshire. Residual cattle infection remaining in the herd from a previous incident and reinfection from other sources, especially wildlife, likely explain most of the recurrent incidents.

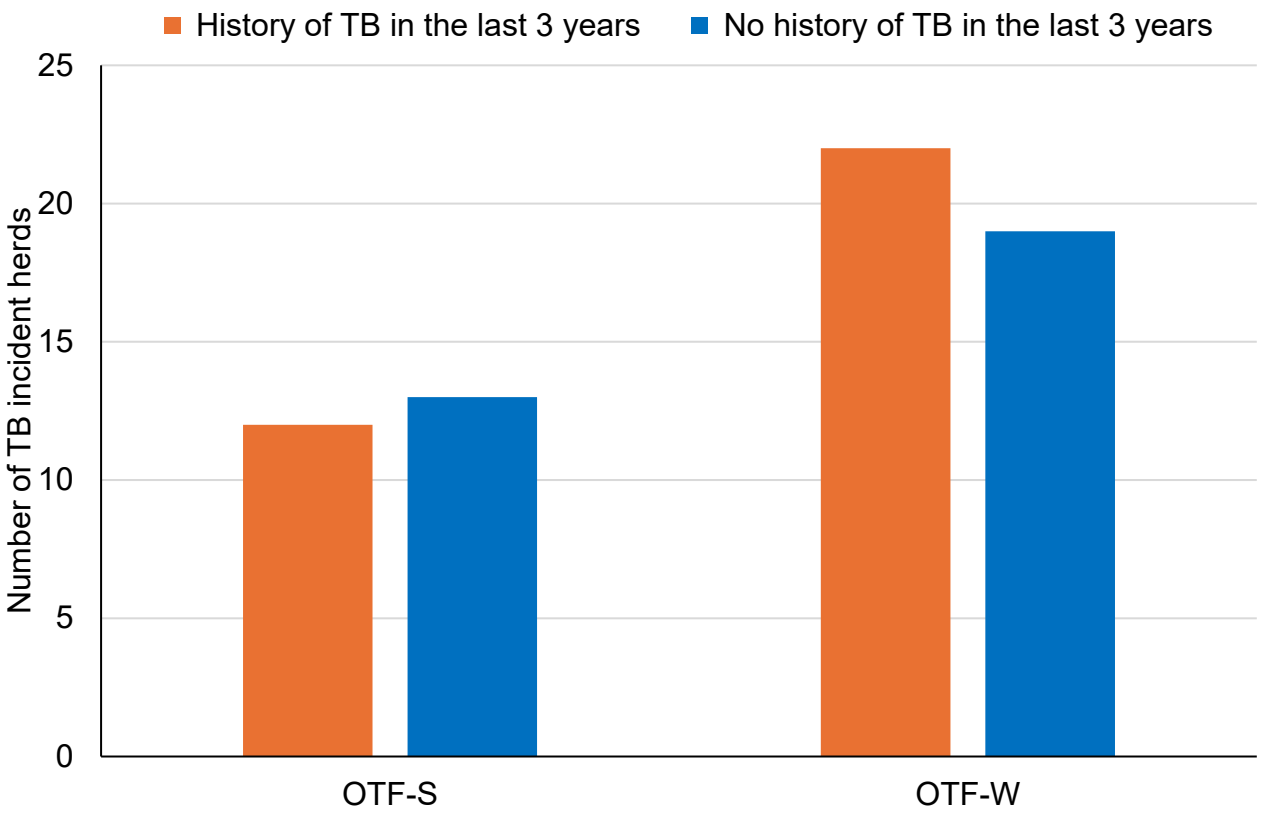


Figure 5: Number of herds with a TB incident (by OTF-W and OTF-S) in Oxfordshire in 2023, with and without a history of any TB incident in the previous three years. One OTF-S incident was not included in this figure as the herd was already under restrictions in the first 4 months of 2023.

Figure 5 description:bar chart showing the number of herds with a TB incident (by OTF-W and OTF-S) in Oxfordshire in 2023, with and without a history of any TB incident in the previous three years. A detailed breakdown is provided in the text.

Overall recurrence

In 2023, 82% of incidents reported across the county were in herds with a history of TB during the herd's lifetime, including more than 3 years previously (18 out of 25 OTF-S and 36 out of 41 OTF-W), as shown in Figure 6.

This is an increase compared to 2022, when the overall recurrence rate for Oxfordshire was 73% (15 out of 25 OTF-S and 26 out of 31 OTF-W incidents).

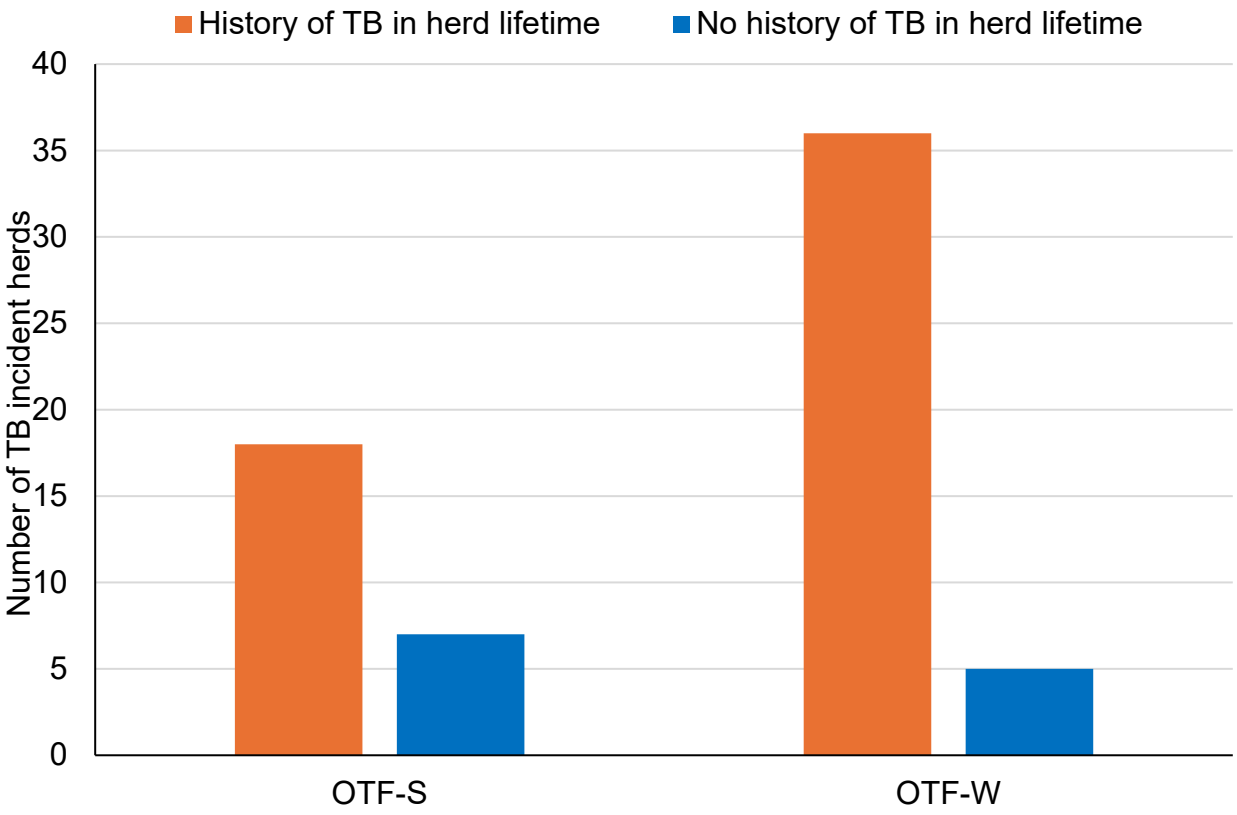


Figure 6: Number of herds with a TB incident (by OTF-W and OTF-S) in Oxfordshire in 2023, with and without a history of any TB incident during the herd's lifetime.

Figure 6 description:bar chart showing the number of herds with a TB incident (by OTF-W and OTF-S) in Oxfordshire in 2023, with and without a history of any TB incident during the herd's lifetime A detailed breakdown is provided in the text.

The rise of TB incidence and recurrence in Oxfordshire is likely to have been caused by a number of factors:

1. The increased number of recurrent OTF-W incidents which could be a result of reduced IFN-γ application from mid-2021 in the 6-month testing Edge Area, compounded by reduced delivery capacity related to avian influenza outbreak workloads in 2021 to 2023.
2. The increased detection of incidents due to SLH cases and pre-movement testing which accounts for about half of this increase and suggests issues with test sensitivity and delays in the detection of infection.
3. The increase in incidents in the original Edge Area (eastern two thirds of the county) where clusters of genetically related incidents continue to be active and spreading geographically.

Geographical distribution of TB incidents

Over the past decade, the distribution of incidents in Oxfordshire has continued to advance eastwards, now covering most of the county (see Figure 7).

Prior to 2004, incidents in Oxfordshire were mostly attributed to purchased cattle, which were quickly resolved and rarely recurred. Thereafter, incidents started to increase in the south-west of the county, moving from the neighbouring HRA counties with various genotypes. In 2010, one genotype 10:a became prevalent in Oxfordshire a reflection of this genotype becoming established in the local wildlife. In 2014, when Edge Reports started to be generated, new areas of genotype 10:a were appearing in the north, east and south-east of the county. In 2016, a cluster of incidents appeared in the south-east of the county. This represented a sudden large spread of the infected area of about 20km from the previous years' mapped endemic areas. From 2017 to 2019, there has been accumulating evidence of new clusters appearing and becoming established in the east of the county close to the Buckinghamshire border. The number of TB incidents peaked at around 80 in 2019 and reduced modestly to 70 in 2020 and 57 in 2021. Since 2020, the extra information provided by WGS, has enabled the identification of emerging clusters around the whole county and their progression. Clusters provide evidence of local spread, and where local cattle purchase has not occurred, they are most likely caused by infected wildlife.

In the south-west of the county, evidence points towards clusters of infection being present and sometimes overlapping each other but are fluctuant from year to year in their strength of presence. This indicates locally driven infection from different sources potentially occurring at the same time. This pattern is also emerging in the original Edge Area of the county where two WGS clades B6-62 and B6-85 are now established.

Newly established areas of TB in the county are shown by identifying these clusters. Clusters were first identified in Oxfordshire in 2017. WGS investigations and phylogenetic

trees have increased our knowledge of the transmission of *M. bovis* but cannot always answer the direction of transmission and/or ancestry due to limited numbers of isolates.

As in previous years, most new incidents across the county in 2023 were caused by infection with the WGS clade B6-62. Additionally, more incidents with clade B6-85 were disclosed in 2023 in the south of the county. Clade B6-11 was reported in 2023 in 2 incidents in the south and east of Oxfordshire which were linked to purchased cattle. One incident in the west of Oxfordshire was identified with clade B6-42 also linked to a purchase. The WGS clade was undetermined for 2 TB incidents in 2023.

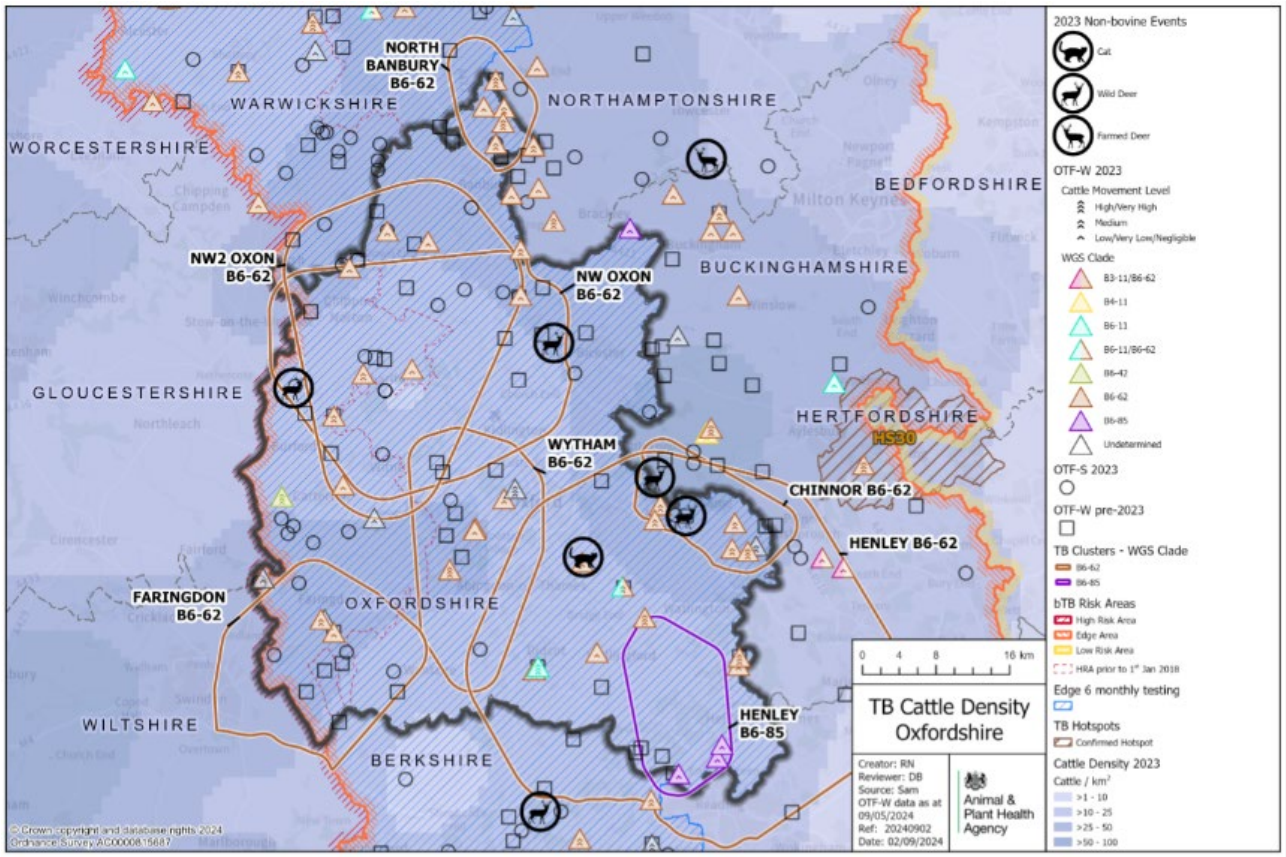


Figure 7: Location of cattle holdings in Oxfordshire with new TB incidents (OTF-W and OTF-S) in 2023 and cattle holdings with pre-2023 OTF-W incidents still ongoing at the beginning of 2023, overlaid on a cattle density map. The movement score for each farm is symbolised with 3 chevrons for cattle movements associated with a high likelihood of infection, 2 chevrons for a medium likelihood and one chevron for a low likelihood.

Figure 7 description: Map of the Oxfordshire county showing the locations of cattle holdings in Oxfordshire with new TB incidents (OTF-S and OTF-W) in 2023 and pre-2023 OTF-W incidents on the map. 2023 OTF-W incidents are shown as triangles, 2023 OTF-S as circles and pre-2023 OTF-W as squares. The 2023 OTF-W incidents are also coloured by WGS clade and contain chevrons to show the cattle movement algorithm score allocated to the incident (low, medium or high risk of cattle movements). Incidents occurred throughout the county – further detail provided in the text.

North Banbury B6-62 cluster

This cluster (originally genotype 10:j – part of clade B6-62) is located in the north of the county, as indicated in Figure 7. It was first identified in 2020 including incidents in the neighbouring Edge counties of Warwickshire and Northamptonshire.

WGS analysis links this cluster to a larger cluster in Warwickshire/Northamptonshire including a sub-cluster which developed north of Buckinghamshire (Akeley B6-62 Cluster). The Buckinghamshire cluster included cattle incidents, an alpaca incident, wild deer isolates and badgers isolates all sharing the same phylogeny and found in the same geographical area.

This small cluster in the north Banbury area has 8 cattle herds identified with incidents first disclosed one in 2018, 2 in 2020, 3 in 2021 and 4 in 2023 (one of these in Warwickshire).

North-West Oxfordshire B6-62 cluster

This cluster is located in the north of the county, as indicated in Figure 7.

Historically, the most common *M. bovis* genotype in this area had been the local genotype to Oxfordshire, 10:a. This appeared to have mutated in 2017 in this locality to a different spoligotype, 130. Both 10:a and 130 are in the same WGS clade, B6-62.

WGS analysis of these *M. bovis* isolates has found 22 farms with genetically related incidents since 2015, including one incident in an alpaca farm in 2020. Of these, 2 occurred in 2023, compared to 5 in 2022, 2 in 2021, 7 in 2020, and 6 in 2019. It includes several recurrent incidents and one persistent incident in 2023. WGS analysis also identified closely related isolates from a wild muntjac deer disclosed in 2023 and 2 other badger isolates from wildlife surveillance.

North-West Oxfordshire-2 B6-62 cluster

Overlapping the previous cluster in the north of the county a separate cluster was identified in 2023 with incidents genetically related in the phylogenetic tree and geographically close (Figure 7).

WGS analysis found 10 farms in Oxfordshire within this cluster since 2018, linked to 2 other clusters from the neighbouring HRA counties. Two of these farms also had other incidents genetically related to the other North-West Oxfordshire cluster described above in previous and more recent years. This confirms different sources affecting the same farms. In 2023, only one incident was disclosed in this cluster, this was identical to 2 neighbouring farms with incidents in 2022, none were disclosed in 2021, one in 2020, 4 in 2019 and the oldest 2 in 2018.

Henley-on-Thames to Watlington B6-62 cluster

This cluster is located in the south-east of the county from Henley-on-Thames to Watlington (Figure 7).

Historically the 10:a genotype (part of clade B6-62) has been the most commonly found genotype in this area since 2015, including several confirmed infected wild deer (in 2018 and 2022) and 2 alpaca incidents (in 2019 and 2021). One was a large alpaca breeding farm which became persistent from 2020 until 2023. In 2022, another clade was isolated from this alpaca farm, B6-85, which was part of the B6-85 Henley cluster as described below. *M. bovis* isolates from several incidents of TB in domestic cats, linked to the consumption of raw pet food distributed nationwide, were closely genetically related to this cluster in 2020.

For the period 2015 to 2023, WGS analysis has identified 35 incidents attributed to almost identical *M. bovis* isolates within an 13km radius adjacent to Henley. The cluster started with 4 cattle incidents in 2015 to 2016 in the geographical centre, with identical isolates of *M. bovis*. Spread occurred concentrically outwards in the following years. Eight more cattle incidents linked to this cluster were disclosed in 2023 one of them in Berkshire and one in the Chinnor area increasing the area of spread.

In 2023, there was one incident reported in a local cat with identical WGS to the neighbouring cattle farm, and both incidents were in the cluster in the same year. WGS analysis also identified closely related isolates from 5 badger isolates in this cluster. These were closely related if not identical to 5 cattle incidents from 2021, 2022 and 2023 including the cat above.

Henley-on-Thames B6-85 cluster

Located within a similar area to the cluster above close to the south-east border with Berkshire (Figure 7).

The genotype 11:a was first identified in this area which is part of WGS clade B6-85. From 2017, incidents with this genotype (home range in the south-west of England) started to appear and were mostly attributed, incorrectly because of lack of data at the time, to purchases of cattle, but in 2022 and 2023 incidents (including one in a known breeding herd of alpacas in 2022 described above) suggest this clade is now established in this area.

WGS investigations have found a total of 11 cattle herds (2 in Berkshire) within a 5-mile radius closely related in the phylogenetic tree appearing since 2017. In 2023, there were 3 incidents disclosed in this cluster in close proximity to each other and along the border with Berkshire. One of these herds also had an incident in 2021 with B6-62 clade which was genetically related to the B6-62 Henley cluster (as above), again indicating several

sources affecting the same farms. WGS analysis also identified closely related isolates from one badger isolate, identical to isolates from the cattle farm where it was found.

Chinnor-Thame B6-62 cluster

This cluster started in the most eastern part of the county and has since spread into Buckinghamshire, which was until now, a lower risk Edge county (Figure 7).

In 2017, in this area, a new *M. bovis* genotype NT:7-5-5-4*-3-3.1 (considered a mutation of genotype 10:a, and part of WGS clade B6-62), was first identified in 3 incidents geographically close to each other. This genotype was later found to be closely related to genotype 17:g (now part of B6-62 clade), found in 4 more incidents, all of which were within 6 kilometres of each other. Some incidents were recurrent with the same genotype identified. WGS analysis indicated very close genetic relatedness between isolates.

Radial testing was triggered by these OTF-W incidents in the Chinnor-Thame cluster to investigate lateral spread into the neighbouring county of Buckinghamshire.

This cluster has now spread to include 16 cattle herds (4 of which are in Buckinghamshire) all closely related genetically and geographically. This lateral spread started with 3 farms in 2017, rising to affect a cumulative total of 6 farms in 2018, 7 in 2019, 8 in 2021,13 in 2022 and 16 in 2023. In 2023, 5 new incidents were disclosed in this cluster, 2 of which were recurrent from previous years.

WGS analysis also identified closely related isolates from both, 2 wild roe deer disclosed in 2023, and nearby cattle incidents disclosed in 2022. One badger carcass found in another farm on the south-western border of the cluster was submitted to an APHA laboratory and the *M. bovis* isolate cultured was not related to this cluster but to the adjacent Henley B6-62 cluster on the south-western side of the M40.

This cluster has also been genetically linked to Hotspot 30 in the LRA county of Hertfordshire, to the east of Buckinghamshire, about 10 miles away from Chinnor.

Wytham-Eynsham B6-62 cluster

This cluster (10:7-3-5-4*-3-3.1 – part of clade B6-62) was identified in 2020 to the west of the city of Oxford in the centre of the county.

WGS investigations in 2022 identified a larger cluster of incidents genetically linked to each other within an 8km radius. Phylogenetic analysis identified that this cluster within clade B6-62 is ancestral to the Chinnor cluster including Hotspot 30, and maybe to emerging clusters in Buckinghamshire. It is possible that animal movement from this cluster has seeded infection into the Chinnor area that has then spread and evolved independently.

This large cluster has had 16 cattle herds disclosed since 2016. In 2023, 4 new incidents were disclosed. Two persistent incidents not far from each other were also part of this cluster. In the phylogeny there were 3 badger isolates closely related to isolates from cattle farms in the same location showing the link to the local wildlife.

Faringdon to Swindon B6-62 cluster

This cluster is located in the original HRA side of Oxfordshire, in the south-west of the county including Wiltshire. It has some of the oldest recurrent incidents and persistent incidents that have occurred in Oxfordshire since 2015 within an 8km radius.

WGS investigation has found 21 farms linked genetically to this cluster which are all geographically close; 11 of these are in Oxfordshire (Faringdon) and 10 in the neighbouring HRA county of Wiltshire (Swindon), plus a domestic cat disclosed in Wiltshire in 2023. Two new cattle incidents were disclosed within the cluster in 2023, one in the Oxfordshire portion of the cluster and one in Wiltshire. Another farm in the cluster remained persistent. There were 4 recurrent incidents without WGS data, for which in previous incidents on these farms, isolates had been obtained that matched the cluster.

Skin test reactors and interferon gamma test positive animals removed

Appendix 2 provides a summary of headline cattle TB statistics in Oxfordshire. In 2023, there was a total of 566 TB test-positive animals in Oxfordshire, as shown in Figure 8. This was a minor increase following 2022 in which the lowest total number of test positive animals removed from herds was reported (537). There has been a steady decline in the total number of test positive animals removed since a peak of 1,410 animals in 2018.

Of the 566 test positive animals in 2023, 65% were skin test reactors, compared to 67% in 2022. 35% of animals removed in 2023 were IFN-γ test positive, compared to 33% in 2022. The number of IFN-γ test-positive animals removed has been falling in since changes to the eligibility for IFN-γ testing were introduced in 2021: 351 IFN-γ reactors were removed in 2021, 175 in 2022 and 199 in 2023.

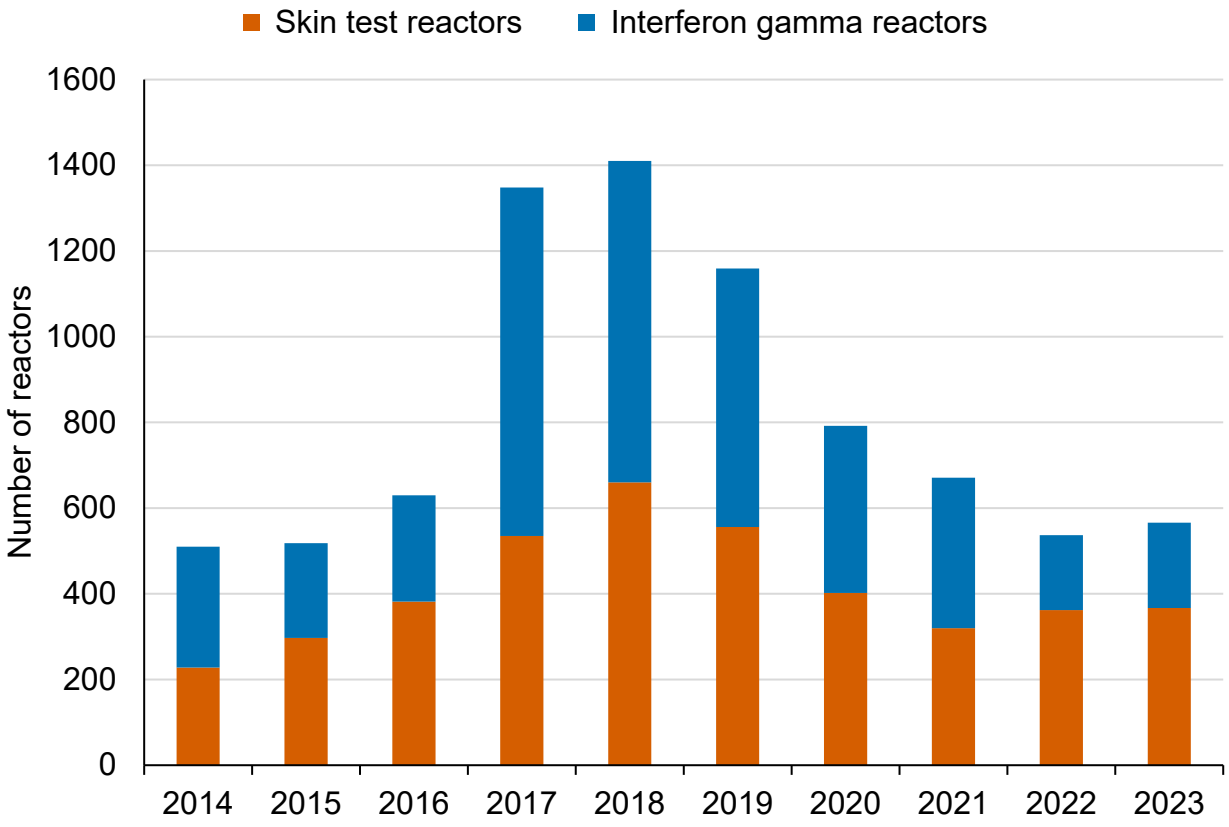


Figure 8: Number of skin test reactors and IFN-γ test positive cattle removed by APHA for TB control reasons in Oxfordshire, from 2014 to 2023.

Figure 8 description: Bar chart showing the number of skin test reactors and interferon gamma test reactors removed for TB control reasons in Oxfordshire between 2014 and 2023. In 2023, 367 skin test and 199 interferon gamma reactors were removed from the county – the total number of reactors removed has been decreasing from a peak in 2018.

Main risk pathways and key drivers for TB infection

It is important to try to understand the risk pathways and key drivers that are likely to have introduced TB infection into a herd. This information can help identify biosecurity measures that may reduce the TB risk for individual businesses.

Implementing practical measures can help to reduce the risk of TB incursion into a herd that is TB free (biosecurity), as well slowing disease spread within a herd where TB is present (biocontainment).

Furthermore, the ibTB online mapping tool can be used to inform purchasing choices, reducing the risk of introducing undetected infection when moving cattle into a herd.

In 2023, 16 out of 69 (23%) new TB incidents in Oxfordshire received a preliminary or final APHA veterinary investigation to identify the source of infection. The findings from this

investigation are reported in Appendix 3. Not all investigations were carried out in 2023. This is due to the continued impact and diversion of field resources as part of the 2022 to 2023 avian influenza outbreak which continued into spring 2023, in addition to the Bluetongue virus outbreak from summer 2023 onwards.

New data-driven methods to quantify the likelihood of risk pathways for TB infected herds have been developed by APHA. These include the:

- cattle movement algorithm

WGS local transmission of infection 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. At the herd level, the cattle movement score is dictated by the animal with the highest ranked movement into that herd. 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 WGS local transmission of infection indicator uses WGS data from cattle *M. bovis* isolates to identify TB incidents that are linked by genetics, time and space. A TB incident where at least one other TB incident is identified that satisfies all the following 3 criteria is considered to have evidence of a local transmission event:

- 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 2023.

There is always a degree of uncertainty about the estimated true routes of TB infection into a herd. The absence of a local transmission event, or cattle movements associated with a high likelihood of infection does not completely negate these pathways. Nonetheless, the evidence provided by the cattle movement and WGS data, when combined, can provide valuable insights into the possible risk pathways. Figure 9 provides the percentage of herds where each risk pathway combination was identified. The spatial distribution of these categories is presented in Figure 10. Each category is described in greater detail in the following text.

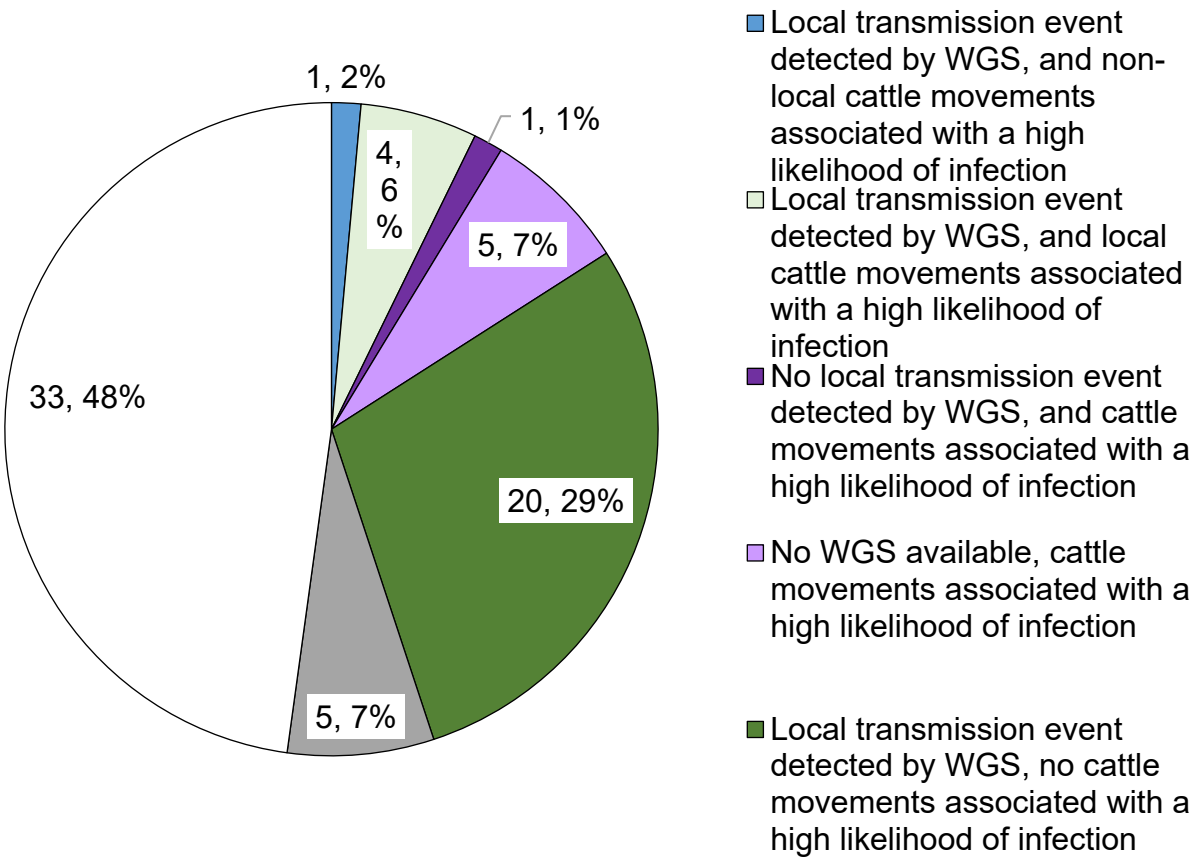


Figure 9: Risk pathway combinations identified by the WGS local transmission of infection indicator and cattle movement algorithm for all 69 new TB incidents starting in Oxfordshire in 2023.

Figure 9 description: Pie chart showing the risk pathway combinations identified by the WGS local transmission of infection indicator and cattle movement algorithm for all 69 new TB incidents in Oxfordshire in 2023. Most (33, 48%) did not have any WGS and no cattle movements were identified with a high likelihood of infection. Further description provided in the text.

WGS data were available for 31 (45%) of all new TB incidents in Oxfordshire. The WGS local transmission of infection indicator identified evidence of local transmission for 25 (36%) new TB incidents in 2023.

Most of the TB incidents with WGS data available (20 of the total 31) supported a local transmission event without evidence of cattle movements associated with a high likelihood of TB infection. These are dark green symbols in Figure 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

A further 4 new TB incidents had evidence of local transmission of infection and local cattle movements (within 25km) associated with a high likelihood of TB infection. 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 Figure 10.

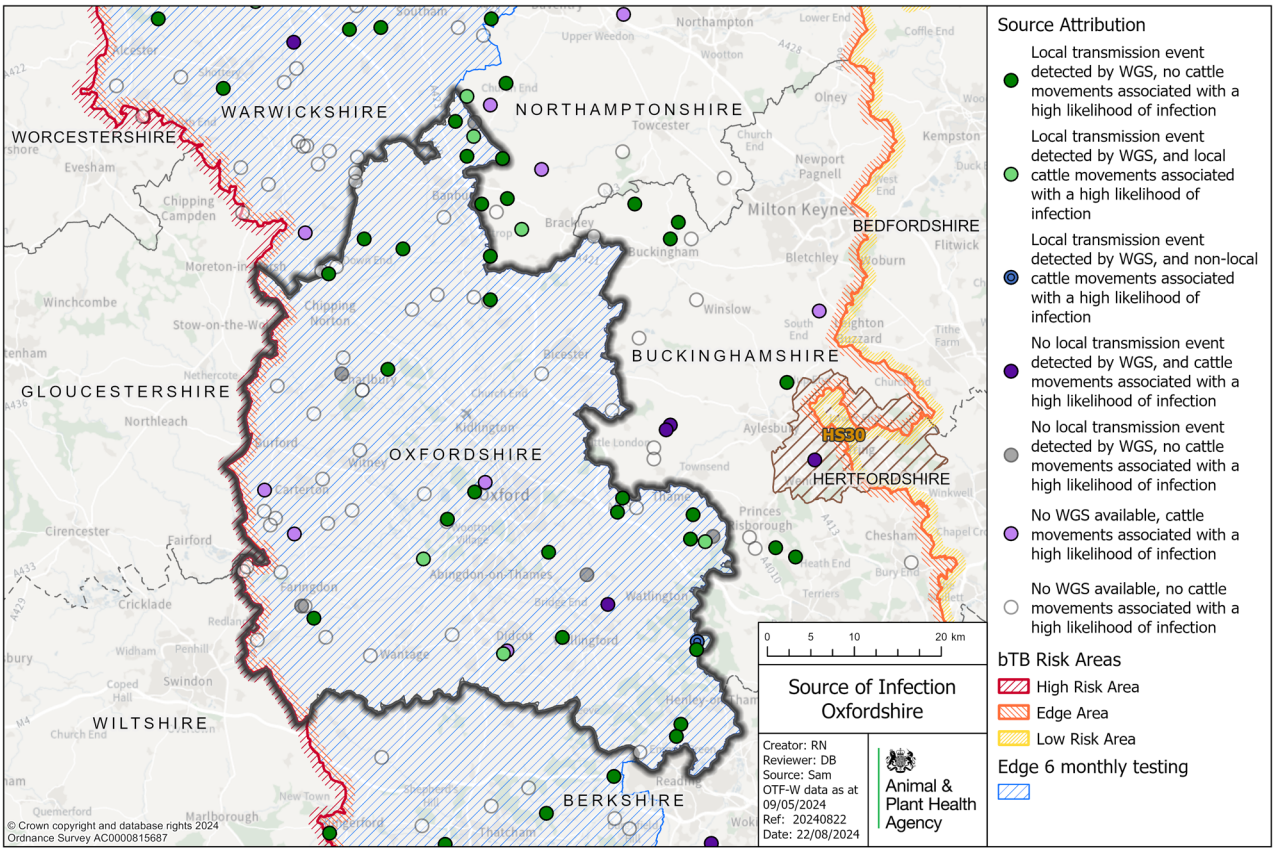


Figure 10: Map of the available evidence for risk pathways of TB infection into the herd, for all TB incidents (OTF-W and OTF-S) in Oxfordshire that started in 2023.

Figure 10 description: Map of the Oxfordshire county showing the locations of the 69 new TB incidents in Oxfordshire, coloured by the risk pathway identified for the incident. Dark green are herds with a local transmission event was identified from WGS and no cattle movements with a high likelihood of infection were identified in the herd; light green represents incidents where local transmission event was identified from WGS and cattle movements with a high likelihood of infection were identified in the herd. Dark purple represents incidents where no local transmission event was identified from WGS and there were cattle movements identified with a high likelihood of infection in the herd. Light purple represents incidents with no WGS available and where there were cattle movements identified with a high likelihood of infection in the herd. Grey shows incidents where no local transmission event was identified from WGS and there were no cattle movements with a high likelihood of infection were identified in the herd either. White shows incidents

with no WGS available and where there were no cattle movements with a high likelihood of infection were identified in the herd either. A breakdown of the incidents by group is provided in the text.

For one TB incident in Oxfordshire there was both evidence of local transmission of infection and of cattle movements over a distance greater than 25km (non-local movements) associated with a high likelihood of TB infection. This is shown in dark blue in Figure 10. For this incident there was a high degree of uncertainty around the source of infection. With multiple likely risk pathways, it is possible there was more than one route of disease incursion into the herd.

In Oxfordshire, one TB incident had evidence of cattle movements associated with a high or very high likelihood of TB infection, and WGS did not identify any local transmission of infection events. For that herd it was considered more likely than not that cattle movements played a part in the introduction of infection (dark purple symbol, Figure 10).

A further 5 TB incidents (7%) had cattle movements associated with a high likelihood of TB infection, but no WGS data was available to explore local transmission of infection. These are depicted in light purple in Figure 10 due to the lack of genetic evidence.

For 5 TB incidents (7%), the WGS Local Infection Indicator did not find identify any local transmission events, and there was no evidence of cattle movements associated with a high likelihood of TB infection. The source of infection is unclear for these incidents (grey symbols).

There was no evidence of cattle movements associated with a high likelihood of TB infection and no WGS data available to explore local transmission of infection for 33 of the 69 (48%) TB incidents. These are shown as white dots in Figure 10, as there is insufficient evidence to determine a likely infection pathway.

The main risk pathways and key drivers for TB infection within Oxfordshire in 2023 were as follows:

- exposure to infected local wildlife
- movement of undetected infected cattle
- residual infection from previous incidents.

Infected wildlife remained the most likely source pathway for TB incidents in cattle in 2023 where a Disease Report Form (DRF) investigation had been conducted in 2023 (16 incidents out of 69). A total of 11 out of 16 incidents which received a preliminary or final DRF investigation included infected wildlife as a potential source pathway, as shown in Appendix 3. The most common source of transmission from wildlife identified during on-farm investigations were potentially infected badgers, but the presence of other wildlife species such as wild deer is increasingly reported in some areas. Evidence of which wildlife source is exposing the herd is still difficult to ascertain and not mutually exclusive. There is still little surveillance information available and high uncertainty as to their role in

transmitting TB to cattle, but recently gathered isolates demonstrate that all 3 species (cattle, badger and deer) are connected in their epidemiology.

Movements of undetected infected cattle remains a source of infection in Oxfordshire, albeit in less than half of the incidents investigated. The cattle movement algorithm provides additional, data-driven evidence to support any suspicions of cattle movements in a source of infection. There were only a few incidents where cattle were moved long distances, or direct movements of purchased reactors could be confirmed. The relatively reduced weight of this pathway in Oxfordshire is likely due to the decreased prevalence of TB in HRA counties (which is the main source of cattle), changes in cattle buying practices towards lower risk herds, and conversion and approval of some beef fatteners to non-grazing AFUs.

Residual cattle infection remains an important factor and reflects the tendency of incidents in Oxfordshire to be more chronic and recurrent. This source remains a factor in incidents in which there was genetic evidence of local transmission of infection, and becomes more complicated when herds are infected with multiple sources, some of which become residual within the herd. Systematic deployment of supplementary IFN-γ testing since 2018 has increased the overall sensitivity of testing in herds sustaining OTF-W TB incidents and has reduced the likelihood of infection being left in the herd at the end of a TB incident. However, the use of this test has been reduced in the last 2 years and targeted to a limited number of herds with recurrent and persistent incidents in Oxfordshire. Distinguishing source attribution between badgers and residual infection in recurrent incidents is difficult and it is likely a combination of both factors. Similarly, purchased cattle and local wildlife infection are not mutually exclusive and can be indistinguishable, particularly when both sources share the same local clade of *M. bovis* and are both contributing to infection within a herd.

Other sources of infection such as contiguous cattle-to-cattle spread from neighbouring premises are considered unlikely, because of adequate separation and farmer awareness to avoid nose-to-nose contact between their cattle and neighbouring cattle. Potential fomite sources such as contaminated shared machinery and manure or slurry spread near livestock farms are challenging transmission pathways to identify and verify, and none were suspected or investigated in 2023.

New TB incidents in 2023 occurred mainly where clusters of incidents were reported in previous years (Figure 11).

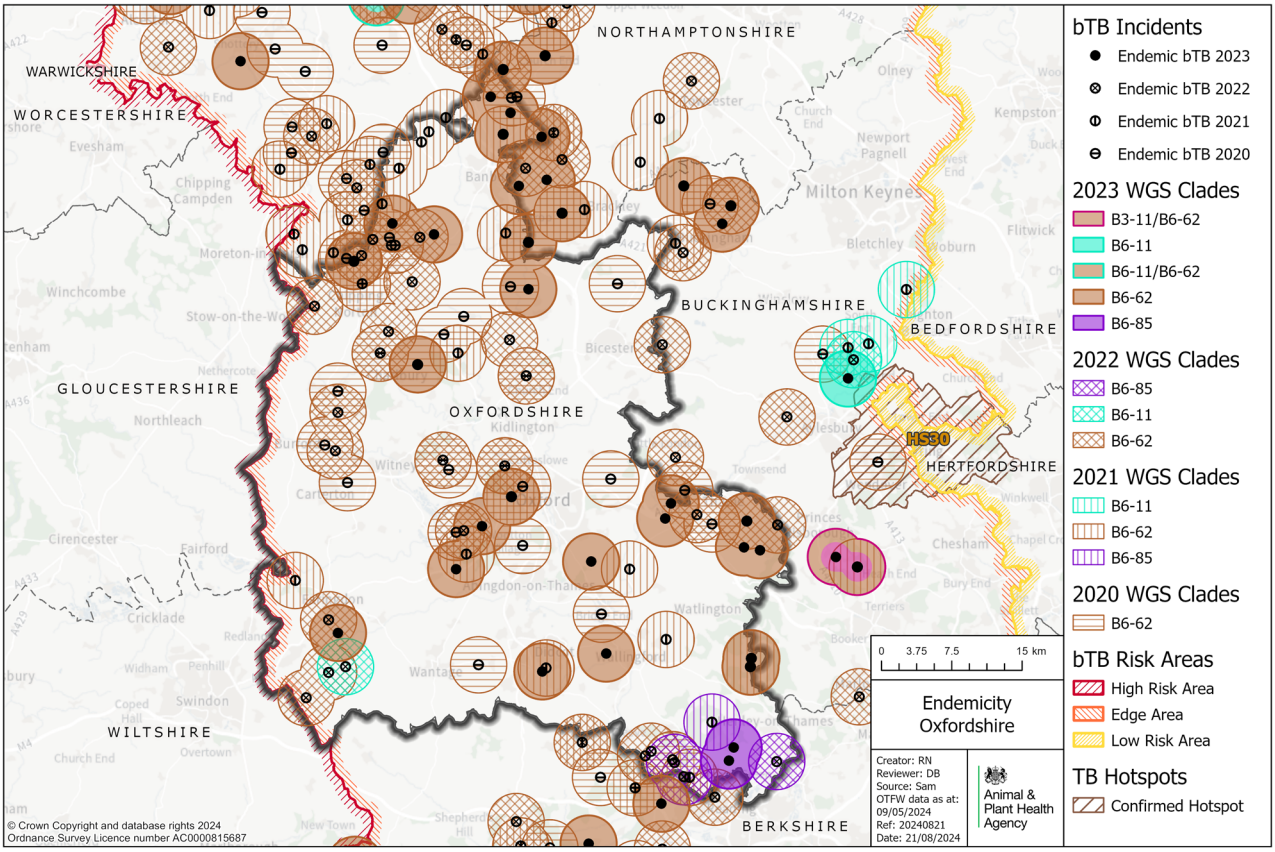


Figure 11: WGS clades of *M. bovis* detected in Oxfordshire between 2020 and 2023, where the WGS identified in the infected herd was within 3 SNPs of another TB incident in the past 4 years and 9km (OTF-W incidents only).

Figure 11 description: Map of Oxfordshire showing the WGS clades of *M. bovis* detected in Oxfordshire between 2020 and 2023, where the WGS identified in the infected herd was within 3 SNPs of another OTF-W incident in the past 4 years and within 9km of it. Clades are shown as circles on the map with each clade represented by a different colour. The year from which the clade was identified is shown by either having the colour be solid (2023) or different types of hash (2022 to 2020). Further detail is provided in the text.

Forward look

The number of herd incidents of TB per year in Oxfordshire remained high over the last 5 years with a decreasing trend in 2021 and 2022, before reverting in 2023 to the same levels as seen in 2020. The epidemiological picture has become more complex in recent years with multiple clusters, some of which have only recently become apparent. This does not favour the long-term objective of reducing OTF-W incidence to less than 1% in Oxfordshire by 2038.

Early detection of infection through more frequent surveillance testing of cattle herds, alongside the use of mandatory IFN-γ testing on all OTF-W incidents, is essential to reduce the spread of TB within herds and should not be limited. IFN-γ testing alongside

other Defra approved ancillary testing should also be explored by informed case management, as lack of sensitivity to current tests may become an issue.

As shown in this report, APHA have identified a number of ‘clusters’ of TB infection in Oxfordshire. To tackle these areas of genetically-linked infection, Defra have launched the ‘Oxfordshire Cluster Project’, starting in 2 areas (North-West Oxfordshire and Thame-Chinnor), formally from 1 October 2022. The project aims to give local farmers, veterinary practices, and other stakeholders the responsibility for design and delivery of locally tailored supplementary TB control measures in their area. It is supported, facilitated, and funded by Defra and will draw on previous, similar projects’ successes.

This project has highlighted the lack of wild deer surveillance, which it is trying to improve via targeted training of farmers and stalkers, facilitating reporting of suspected tuberculous deer carcasses, gathering information on wild deer populations, and potentially estimating the prevalence of TB in such populations in the future. Cattle contact with wild deer as well as badgers has been reported in some clusters supported by camera surveillance and increase in numbers.

Wildlife control in the form of badger culling is under way in parts of Oxfordshire. This will need to be supported by other intervention measures such as badger vaccination, deer management and increased biosecurity with TB health plans tailored to each farm working alongside farmers and local vets. Extended TB Advisory Service inspections could fill this gap. Defra will assess the project after each year. If it proves effective and the interest and involvement of stakeholders is retained in the area, it is likely to continue for up to 5 years. Ultimately, Defra would like to assess if this approach is replicable in different areas of the country with other genetically-linked clusters.

Increased knowledge and implementation of on-farm biosecurity, better informed purchasing of cattle, continued cattle surveillance, and continued wildlife interventions are paramount to stop the spread of TB within Oxfordshire and across into neighbouring counties and the LRA over the next few years.

Appendix 1: cattle industry demographics

Table 1: Number of cattle herds by size category in Oxfordshire as of 31 December 2023 (RADAR data on number of holdings in the report year)

Size of herds	Number of herds in Oxfordshire
Undetermined	3
1 to 50	174
51 to 100	92
101 to 200	79
201 to 350	43
351 to 500	22
Greater than 500	26
Total number of herds	439
Mean herd size	137
Median herd size	73

Table 2: Number (and percentage of total) of animals by breed purpose in Oxfordshire as of 31 December 2023

Breed purpose	Number (and percentage of total) cattle in Oxfordshire
Beef	45,085 (74%)
Dairy	12,171 (20%)
Dual purpose	3,026 (5%)
Unknown	2 (0.003%)
Total	60,284

Appendix 2: summary of headline cattle TB statistics

Table 3: Herd-level summary statistics for TB in cattle in Oxfordshire between 2021 and 2023 (Sam data showing the number of herds flagged as active at the end of the report year)

Herd-level statistics	2021	2022	2023
(a) Total number of cattle herds live on Sam at the end of the reporting period	531	517	511
(b) Total number of whole herd skin tests carried out at any time in the period	822	814	809
(c) Total number of OTF cattle herds having TB whole herd tests during the period for any reason	407	430	422
(d) Total number of OTF cattle herds at the end of the report period (herds not under any type of TB movement restrictions)	454	446	438
(e) Total number of cattle herds that were not under restrictions due to an ongoing TB incident at the end of the report period	475	469	452
(f.1) Total number of new OTF-S TB incidents detected in cattle herds during the report period	25	25	28
(f.2) Total number of new OTF-W TB incidents detected in cattle herds during the report period	32	31	41
(g.1) Of the new OTF-W herd incidents, how many can be considered the result of movement, purchase or contact from or with an existing incident based on current evidence?	3	5	7
(g.2) Of the new OTF-W herd incidents, how many were triggered by skin test Reactors or twice-inconclusive reactors (2xIRs) at routine herd tests?	22	17	24

Herd-level statistics	2021	2022	2023
(g.3) Of the new OTF-W herd incidents, how many were triggered by skin test reactors or 2xIRs at other TB test types (such as forward and back-tracings, contiguous or check tests)?	10	14	17
(g.4) Of the new OTF-W herd incidents, how many were first detected through routine SLH TB surveillance?	2	1	5
(h.1) Number of new OTF-W incidents revealed by enhanced TB surveillance (radial testing) conducted around those OTF-W herds	0	0	0
(h.2) Number of new OTF-S incidents revealed by enhanced TB surveillance (radial testing) conducted around those OTF-W herds	0	0	0
(i) Number of OTF-W herds still open at the end of the period (including any ongoing OTF-W incidents that began in a previous reporting period)	35	30	34
(j) New confirmed (positive *M. bovis* culture) incidents in non-bovine species detected during the report period (indicate host species involved)	3	2	6
(k.1) Number of grazing approved finishing units active at end of the period	0	0	0
(k.2) Number of non-grazing approved finishing units active at end of the period	9	11	11
(k.3) Number of grazing exempt finishing units active at end of the period	0	0	0
(k.4) Number of non-grazing exempt finishing units active at end of the period	0	0	0

Table 4: Animal-level summary statistics for TB in cattle in Oxfordshire between 2021 and 2023

Animal-level statistics (cattle)	**2021**	**2022**	**2023**
(a) Total number of cattle tested with tuberculin skin tests or additional IFN-γ blood tests in the period (animal tests)	130,753	129,938	131,236
(b.1) Reactors detected by tuberculin skin tests during the year	320	362	367
(b.2) Reactors detected by additional IFN-γ blood tests (skin-test negative or IR animals) during the year	351	175	199
(c) Reactors detected during year per incidents disclosed during year	11.8	9.6	8.2
(d) Reactors per 1,000 animal tests	5.1	4.1	4.3
(e.1) Additional animals slaughtered during the year for TB control reasons (dangerous contacts, including any first time IRs)	34	12	11
(e.2) Additional animals slaughtered during the year for TB control reasons (private slaughters)	1	6	4
(f) SLH cases (suspect tuberculous carcasses) reported by Food Standards Agency (FSA) during routine meat inspection	11	18	15
(g) SLH cases confirmed by *M. bovis* PCR testing or bacteriological culture	8	12	7

Note (c) Reactors detected during year per incidents disclosed during year, reactors may be from incidents disclosed in earlier years, as any found through testing during the report year count in the table above.

Note (g) SLH cases confirmed by culture of *M. bovis*, not all cases reported are submitted for culture analysis. All cases reported are from any period prior to or during restrictions.

Appendix 3: suspected sources of *M. bovis* infection for all the new OTF-W and OTF-S incidents identified in the report period

In 2023, 16 out of 69 (23%) new TB incidents in Oxfordshire received a preliminary or final APHA veterinary investigation to identify the source of infection. Not all DRF investigations were carried out in 2023. This was due to the continued impact and diversion of field resource as part of the 2022 to 2023 avian influenza outbreak which continued into spring 2023, in addition to the Bluetongue virus outbreak from summer 2023 onwards.

Each TB incident could have up to 3 potential risk pathways identified. Each risk pathway is given a score that reflects the likelihood of that pathway bringing TB into the herd. The score is recorded as either:

- definite (score 8)
- most likely (score 6)
- likely (score 4)
- possible (score 1)

The sources for each incident are weighted by the certainty ascribed. Any combination of definite, most likely, likely, or possible can contribute towards the overall picture for possible routes of introduction into a herd. If the overall score for a herd is less than 6, then the score is made up to 6 using the 'Other or unknown source' option. Buffering up to 6 in this way helps to reflect the uncertainty in assessments where only 'likely' or 'possible' sources are identified.

Table 5 combines the data from multiple herds and provides the proportion of pathways in which each source was identified, weighted by the certainty that each source caused the introduction of TB. The output does not show the proportion of herds where each pathway was identified (this is skewed by the certainty calculation). WGS of *M. bovis* isolates can be a powerful tool in identifying a likely source of infection, however WGS clades are not determined for OTF-S herds. As a result of varying levels of uncertainty, only broad generalisations should be made from these data. A more detailed description of this methodology is provided in the explanatory supplement to the annual reports 2023.

Table 5: Suspected sources of *M. bovis* infection for the 16 incidents with a preliminary or a final veterinary assessment in Oxfordshire, in 2023

Source of infection	Possible (1)	Likely (4)	Most likely (6)	Definite (8)	Weighted contribution
Badgers	6	6	4	0	44.0%

Source of infection	Possible (1)	Likely (4)	Most likely (6)	Definite (8)	Weighted contribution
Cattle movements	4	3	0	0	13.7%
Contiguous	1	0	0	0	0.8%
Residual cattle infection	3	3	2	0	21.9%
Domestic animals	0	0	0	0	0.0%
Non-specific reactor	0	0	0	0	0.0%
Fomites	0	0	0	0	0.0%
Other wildlife	2	3	1	0	15.1%
Other or unknown source	0	0	0	0	4.4%

Each TB incident could have up to 3 potential pathways so totals may not equate to the number of actual incidents that have occurred.

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

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