



Animal &
Plant Health
Agency

**Bovine TB in cattle: badger control areas
monitoring report
For the period 2013 – 2019**

October 2020



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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.

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Purpose of this report

This report provides the annual bovine tuberculosis (TB) monitoring data for each of the badger control licenced areas that have been exposed to at least one period of culling and at least one year of follow-up ending during 2019. The report shows changes over time in TB in cattle in areas subject to badger control but these data alone cannot demonstrate whether the badger control policy is effective in reducing bovine TB in cattle. Evaluation of the effect of the badger control policy requires consideration of other factors that could affect cattle TB incidence in addition to culling and has been subject to separate analytical studies (Brunton et al., 2017; Downs et al., 2019)

Please note that all of the data presented in this report are available in an accessible format in the accompanying Excel spreadsheet.

Introduction

The badger control policy was implemented in England to reduce the population of badgers where bovine tuberculosis (TB) is endemic. The aim is to reduce the potential for transmission of *Mycobacterium bovis*, the bacterium that causes TB, between badgers and cattle, and hence reduce the incidence of TB in cattle. The policy is based upon evidence generated by the Randomised Badger Culling Trial (RBCT) conducted in England between 1998 and 2005. This trial indicated that the incidence of confirmed TB in cattle could be reduced by 23.2% (95% CI: 12.4% to 32.7%) over a four year period if badger culling was performed systematically over large areas and sustained for at least four years (Donnelly et al., 2007). Culling badgers was found to be associated with both reductions in TB incidence in cattle in the cull areas, which were sustained for an average of 2.5 years post-culling, and transitory increases in TB incidence in the surrounding 2 km buffers (Jenkins et al., 2010).

The current badger control policy includes the licencing of industry-led badger culling (DEFRA, 2018) from 2013 and provision of biosecurity advice to farmers in licenced areas since 2014. From April 2017 where badger control operations have been conducted during a minimum of two years, interferon-gamma testing of cattle during TB incidents has been introduced in addition to tuberculin skin testing.

In 2013, two licences were issued under the Protection of Badgers Act 1992 by Natural England (NE), to groups of farmers and landowners in Gloucestershire and Somerset in the High Risk Area (HRA) for TB in England. A further licence was issued in Dorset, also in the HRA, in 2015. Seven licences were issued in 2016 and

11 in each of 2017, 2018 and 2019. The majority of areas are located in the HRA, but six straddle the HRA and Edge Area and one is located in the Low Risk Area (LRA) for TB in England.

APHA is commissioned by Defra to monitor the incidence of TB in cattle in the areas that have been issued licences for badger control. To address this requirement APHA publishes monitoring results showing the frequency of TB infection in cattle herds in the badger control areas that have been exposed to at least one period of culling and for which there is at least one year of follow-up since culling was started. Culling is initiated in the autumn and generally continues for a period of around six weeks until badger removal targets are met.

In addition, APHA has undertaken analytical studies to assess whether there is any association between badger control and cattle TB incidence. To date these have been conducted using multivariable analyses comparing TB incidence rates in areas subject to badger control to TB incidence rates in areas not subject to the badger control whilst controlling for differences between the areas which are related to the risk of TB (Brunton et al., 2017; Downs et al., 2019). Further evaluation of effects will require a different design because of the loss of potential comparison area land to new cull areas. The loss of buffer land to new cull areas has also considerably reduced the utility of data from these areas in measuring effects on land surrounding cull areas.

Changes from earlier monitoring reports

Review of information requests for data about cull areas, the impact of new cull licenses on existing areas and new reporting requirements have led to the following changes and additions:

1. Data for TB incidence rates and prevalence in the central and buffer areas are now provided by calendar year, January 1st to December 31st, as well as cull year, which runs autumn to autumn with the exact date varying by intervention area.
2. The follow-up period prior to culling starting in an area has been extended from three to four years to extend the provision of historical background information.
3. Any changes to the original size of an area licenced for culling by NE that have occurred since culling started in the area are reported.
4. The presentation of the information in the report has been revised to improve data accessibility. All data are accessible within a Microsoft Excel workbook (available at: <https://www.gov.uk/government/publications/bovine-tb-incidence-of-tb-in-cattle-in-licenced-badger-control-areas-in-2013-to-2019>).

5. Area data for reactors to the tuberculin skin test, reactors to the interferon gamma test, TB incidents, TB incidence rates and TB prevalence are reported in the Excel tables as opposed to within the body of the main report.
6. TB incidence and prevalence data for buffer areas by cull years are reported in the Excel tables but are no longer plotted in graphs.

In addition:

1. In previous reports, herds in existence (HIE) was calculated as the number of herds active in the most recent year that were also active in each year of the follow-up. HIE should have been calculated as the number of herds recorded as active in each area in each year prior to the start of culling and each year of follow-up. This error has been corrected in the current report, which has led to small changes in the reported number of herds and the associated time at risk (TAR).
2. The algorithm for the calculation of TAR has been updated to take account of effects from moving from annual to six monthly surveillance testing in some Edge Area counties. Please note, however, due to earned recognition some herds in these counties will have reverted back to annual surveillance in 2019.

As with all monitoring reports published since 2018, no data from potential comparison areas are included because of the loss of potential comparison area land to new cull areas.

Monitoring Methods

Data source and quality

TB data for the report are extracted from Sam, the APHA database, which records the results from TB tests conducted in cattle herds throughout Great Britain.

These data are continually compiled and updated over time. Corrections may include a herd becoming inactive, revision to a herd geographical location or change of a herd incident (breakdown) from unconfirmed (OTF-S) infection to confirmed (OTF-W) designation because of new confirmatory information about the presence of *M. bovis* infection. Data corrections and routine validation can affect the counts of incidents and the calculated time at risk and are revealed in minor differences in statistics between annual reports. The most recently published report contains the most accurate new and historical data known to the project team. Where areas have changed size, this is indicated above the figures and tables for the relevant areas.

Badger control areas

Central areas

This is the area which is licenced by NE for badger control operations. The boundaries to these areas are defined and provided by NE to APHA each year. They remain broadly stable over time. However, there have been small changes to some boundaries over time made by NE. The APHA has no control over the location of boundaries and reports levels of TB for the population of HIE based on the most up-to-date information available for boundaries at the time of each annual report. The population of cohort herds is established in the year culling starts in an area and only changes with changes in activity of the herd e.g. loss of herds from farms that are no longer operating.

Buffer areas

Buffer areas are 2 km wide areas that immediately surround the central area. They are identified by the APHA project team using the central area boundary information provided by N.E. The size of available buffer varies between areas at the baseline (see guide to buffer area changes, page 48) and the proportion of buffer area that can be included in the analyses for the monitoring report has decreased over time as new areas have been licenced for badger control and existing areas have been extended. Monitoring data from herds in buffer areas that exist in the year of the

annual monitoring report are reported. The monitoring results from buffer areas are not always comparable between years because of large changes to the herd population. Additionally, only a handful of herds remain in some buffer areas because of the loss of buffer area land.

Each badger control area (central and buffer) is identified by a unique number which relates to when the area was licensed for badger culling and the county in which it is located.

Time period

The baseline date

Each area has an identified baseline date. This is the date of the start of the first cull in the particular area.

Monitoring herd groups

Cohort

Cohort herds are herds recorded as active in either central or buffer areas on the baseline date, when culling started. The central cohort are herds identified, using map reference data, as in the cull areas licenced by NE. The buffer cohort are herds identified, using map reference data, as being in the surrounding area on the baseline date.

TB data for cohort herds always relates to the original cohort of herds in the areas defined by the original licence, even if map reference data show that a herd is not in the area in non-baseline years. Over time some of the herds in a cohort may become inactive and are lost to follow-up. This means that the number of herds in the cohort can decrease between years. The number cannot, by definition, increase.

Cohort herds were all in existence on the baseline date and should be exposed to badger control operations for the full follow-up period whilst they remain active.

Herds in Existence (HIE)

HIE provides an annual snapshot of active herds that are located within central areas based on the area boundaries licenced by NE at the time data are compiled for the annual monitoring report. This group of herds will include active herds within the cohort and other herds recorded as active within the area before and after the baseline date, based on current herd location map reference data.

The annual count of HIE for the central areas recognises that there are new herds that come into existence, after the baseline date or existed prior to the baseline date. Inclusion of the HIE population should help address any bias due to the natural loss of herds from the cohort due to changes in business activity. However, it is important to note that herds reported on in this group were not all in existence on the baseline date when culling started and therefore may not have not been exposed to badger control operations for the entire follow-up period.

HIE are not compiled for the buffer areas.

Individual area monitoring data

The figures in this report plot TB incidence rates and TB prevalence **by cull year** in the central areas subject to at least one period of culling and one year of follow-up. The figures show TB incidence rates and prevalence for both cohort herds and HIE for the periods before and after the baseline date when culling started in each area. Data for buffers have not been plotted but are available in a Microsoft Excel appendix. The appendix contains data for TB incidents, herds, herd years at risk and numbers of reactors **by cull and calendar year** for both central and buffer areas.

Glossary of definitions for TB incidence tables and figures

New incidents

The total number of new incidents is the sum of Officially Tuberculosis Free – Withdrawn (OTF-W) and Officially Tuberculosis Free – Suspended (OTF-S) incidents detected throughout the reporting period (cull year or calendar year). Both OTF-W and OTF-S are new incidents (may also be referred to as breakdowns) of TB in a herd that have been disclosed by surveillance but in OTF-W incidents, *M. bovis* infection has been confirmed through post-mortem tests in at least one animal from the herd.

Number of herds

The number of herds shown in the incidence tables refers to the number of herds in the area for each group (cohort or HIE) at the start of each reporting period (cull year or calendar year).

Time at risk (TAR)

The TAR is the total period of time the herds in an area were considered at risk of TB infection (Downs et al., 2013). Herds are considered to be at risk of infection when they are not under trading restrictions because of TB infection (i.e. a breakdown) in the herd. The TAR is reported in years.

OTF-W incidence rate

The OTF-W incidence rate is the rate of occurrence of new OTF-W incidents (may also be referred to as breakdowns). The rate is calculated as the number of OTF-W breakdowns per 100 herd years at risk (National Statistics, 2015). This is the number of new OTF-W incidents detected in the area during the time period of interest divided by the total years herds in the area were at risk of infection and multiplied by 100. The incidence of OTF-W breakdowns is used as the primary outcome for monitoring rather than total TB incidence because stronger associations have been shown between OTF-W incidence and culling than with total TB incidence (Donnelly et al., 2007).

95% Confidence interval

The lower and upper limits of a 95% confidence interval for the OTF-W incidence rate are given. The confidence interval gives an indication of the range of uncertainty around the reported central estimates. If data were collected and the 95% confidence interval were calculated independently multiple times, we would expect the true incidence rate to be found within 95% of these confidence intervals. A wider confidence interval indicates greater uncertainty about the true underlying incidence rate or prevalence.

Skin test reactors

Skin test reactors are cattle that reacted to the Single Intradermal Comparative Cervical Tuberculin (SICCT) test, which is a diagnostic test for TB. The test measures an animal's reaction to injection(s) of tuberculin carried out in line with Council Directive 64/432/EEC. Reactors are detected in both OTF-W and OTF-S incidents. This group does not include any cattle removed as "Dangerous Contacts" but includes two times inconclusive reactors (2xIRs) and one times IRs (1xIRs) removed by APHA for TB control and are found to have visible lesions at slaughter or have a positive culture for *M. bovis*. Inconclusive reactors are cattle, which have a smaller reaction to the SICCT test than standard reactors.

IFN gamma reactors

IFN gamma reactors are cattle that tested positive to the Interferon (IFN) gamma assay, which is a rapid (24-hour) whole blood in-vitro assay to detect immune response to *M. bovis* infection for the diagnosis of bovine TB. Any reactors to both SICCT and IFN gamma assay are included within the skin reactors group but are not included within the IFN gamma reactors group. Mandatory IFN gamma testing was introduced in 2017 for herds with a TB incident in areas that had been subject to two or more years of culling.

Baseline date

The baseline date is the point the cull started in the central area named, which is indicated by a black dashed line in the associated figures.

Glossary of definitions for TB prevalence tables and figures

Herds under restriction

Herds under restriction are herds under TB-related trading restrictions on the last day of the reporting period (cull year or calendar year), as a result of any breakdown. Also shown in the tables are the number of herds under trading restrictions on the last day of the reporting period (cull year or calendar year) due to an OTF-W incident (breakdown).

Herds

The number of herds displayed in the tables are the number active in the area at the end of each reporting period.

OTF-W prevalence

The OTF-W prevalence is a point prevalence estimate indicating the proportion of herds with an OTF-W breakdown on a particular date, which is the last day of each reporting period. It provides an indication of the burden of disease in an area. The OTF-W prevalence can also be described as the number of herds under trading restrictions on the last date of each period due to an OTF-W incident (may also be referred to as a breakdown) per 100 herds on the same date.

95% confidence interval

This calculated interval gives an indication of the range of uncertainty around the central estimate of OTF-W prevalence (see also glossary of definitions for TB incidence tables and figures).

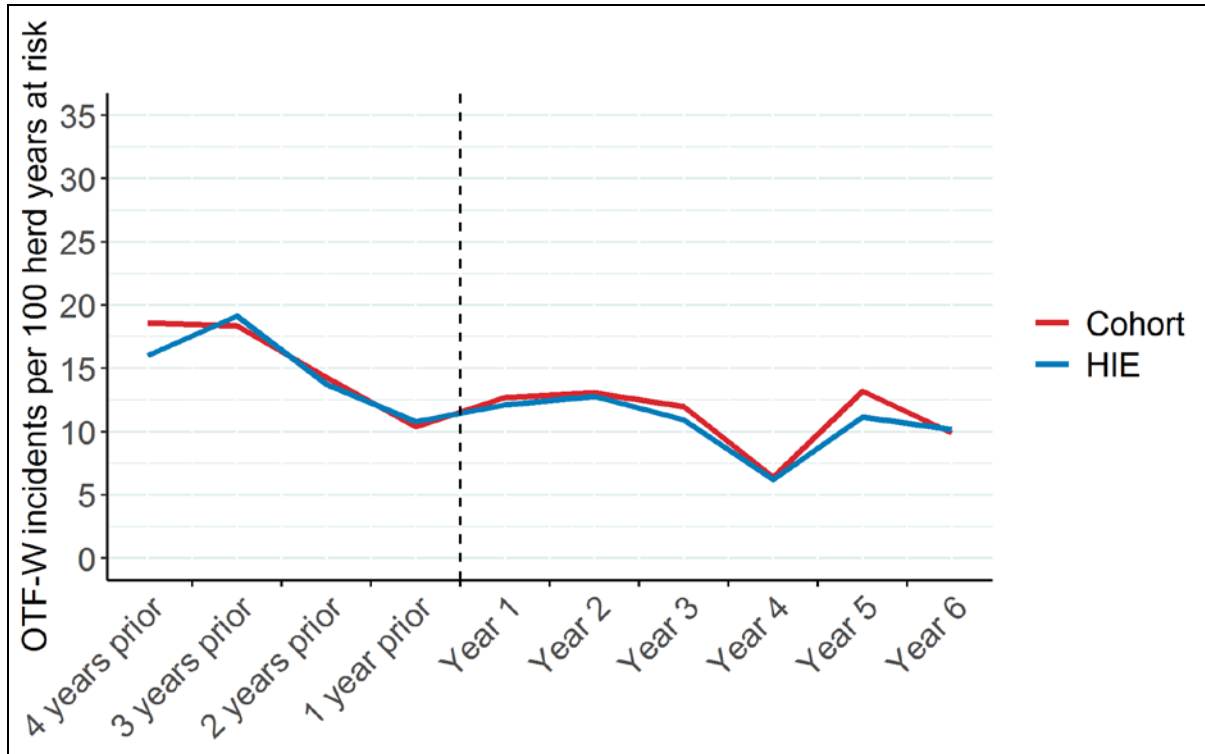
Baseline date

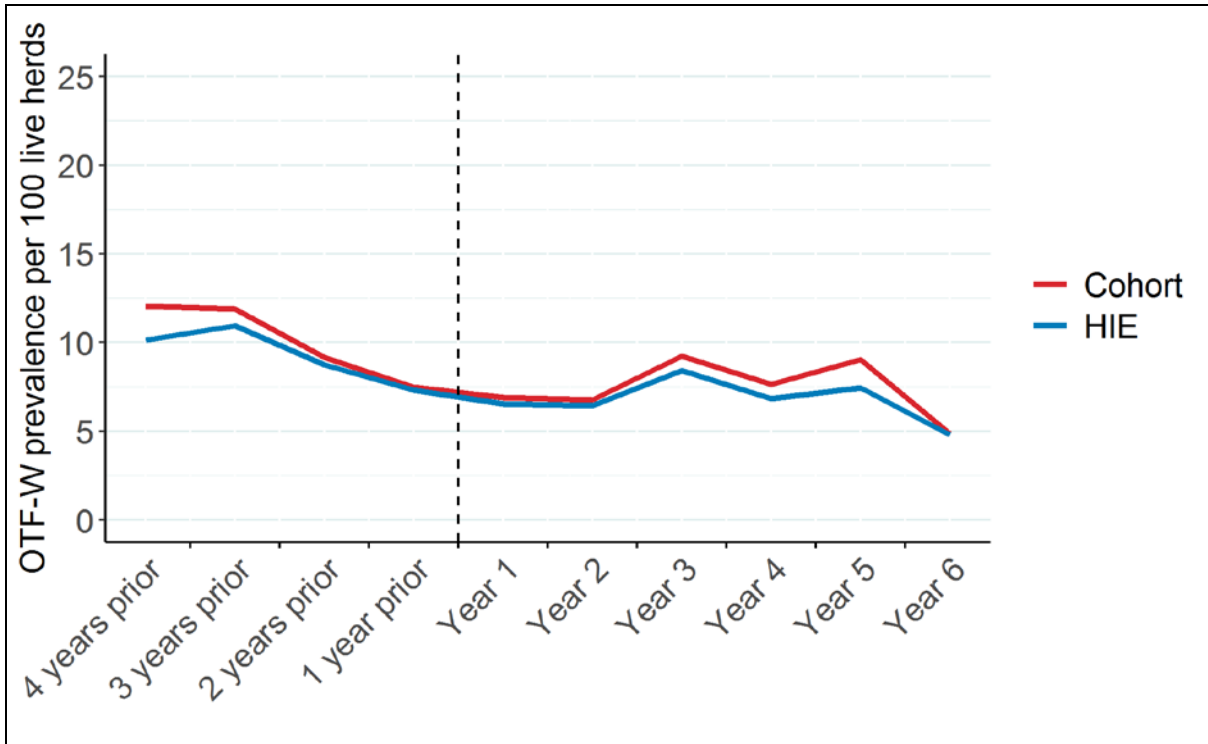
See glossary of definitions for TB incidence tables and figures.

TB incidence and prevalence figures

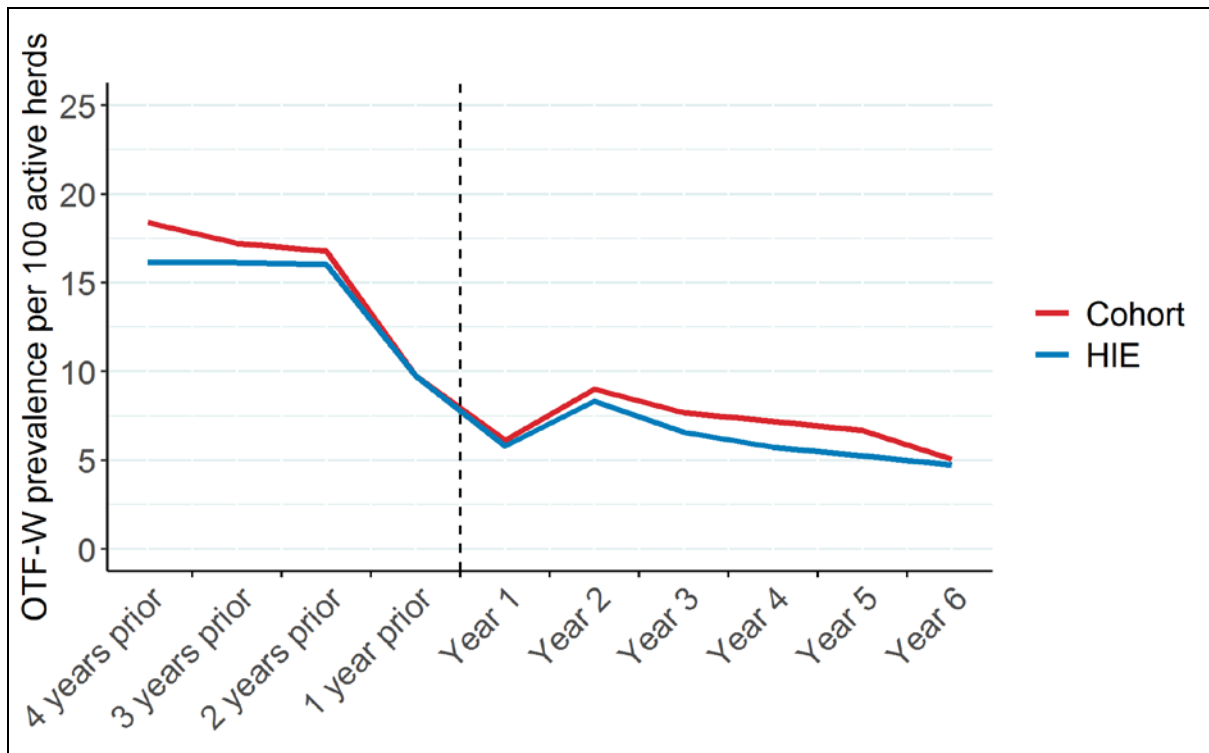
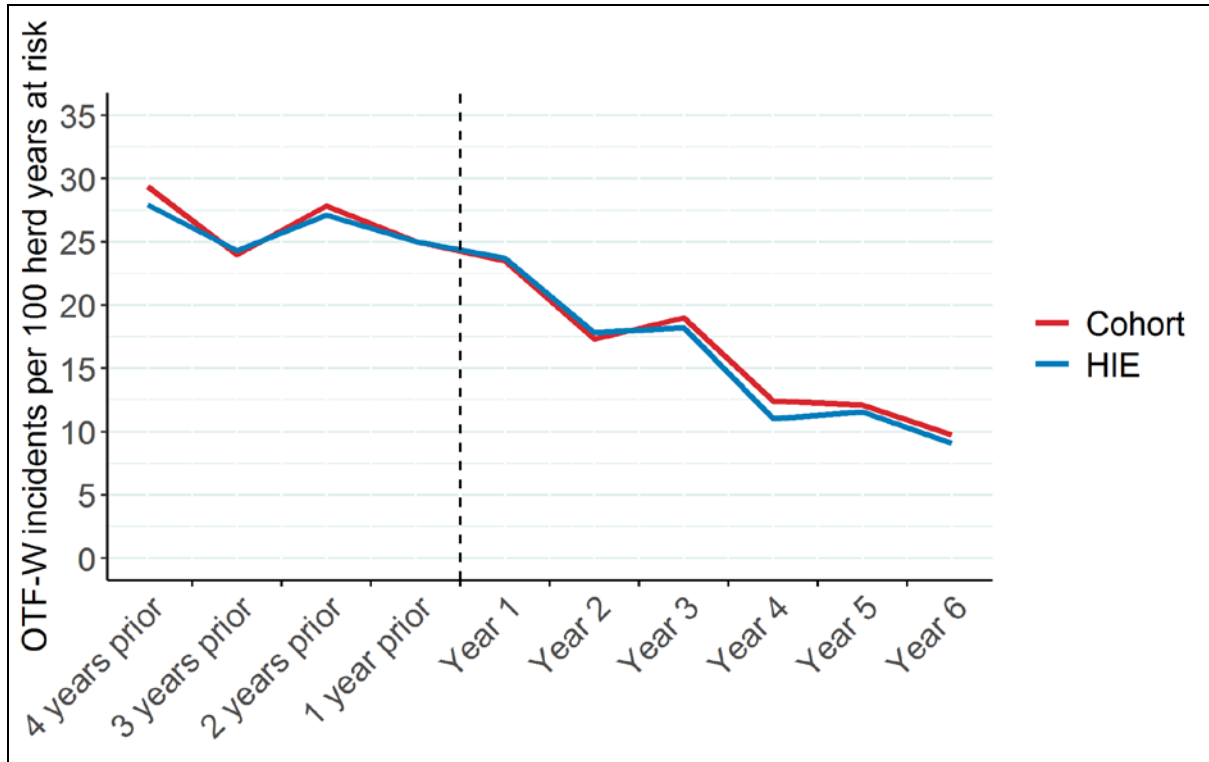
Areas where the cull commenced in 2013

Area 01 - Gloucestershire central



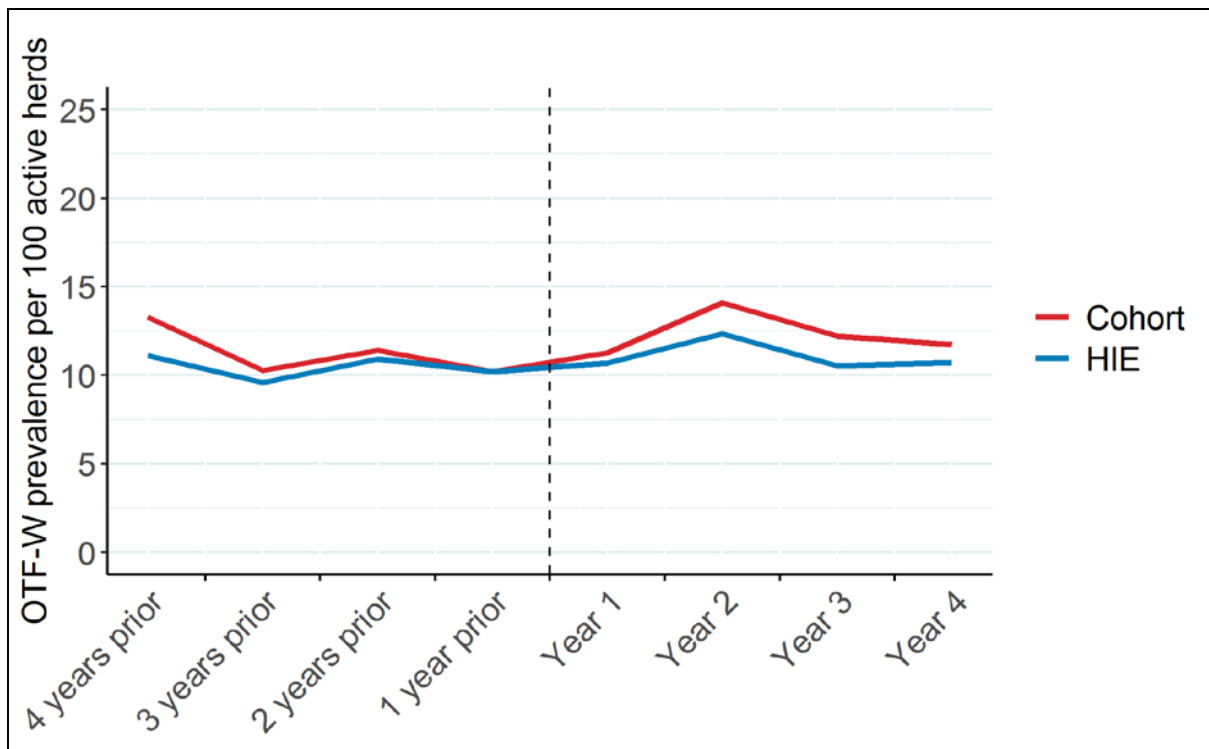
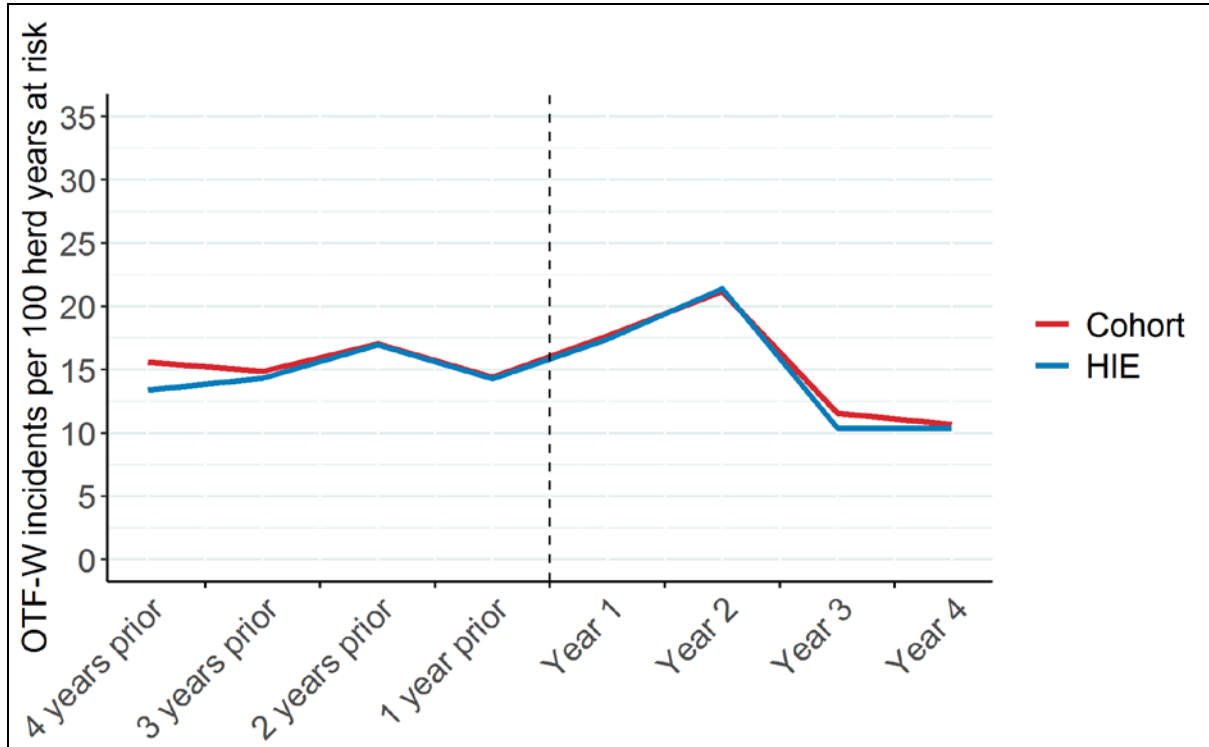


Area 02 - Somerset central



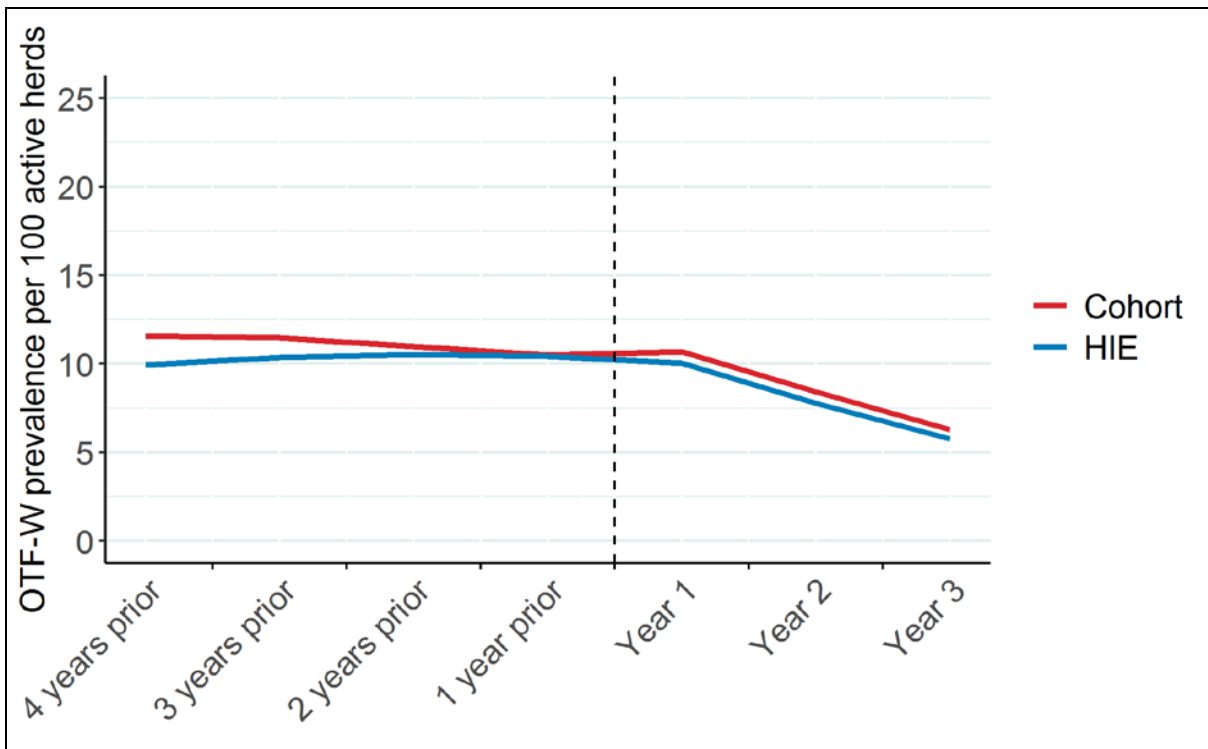
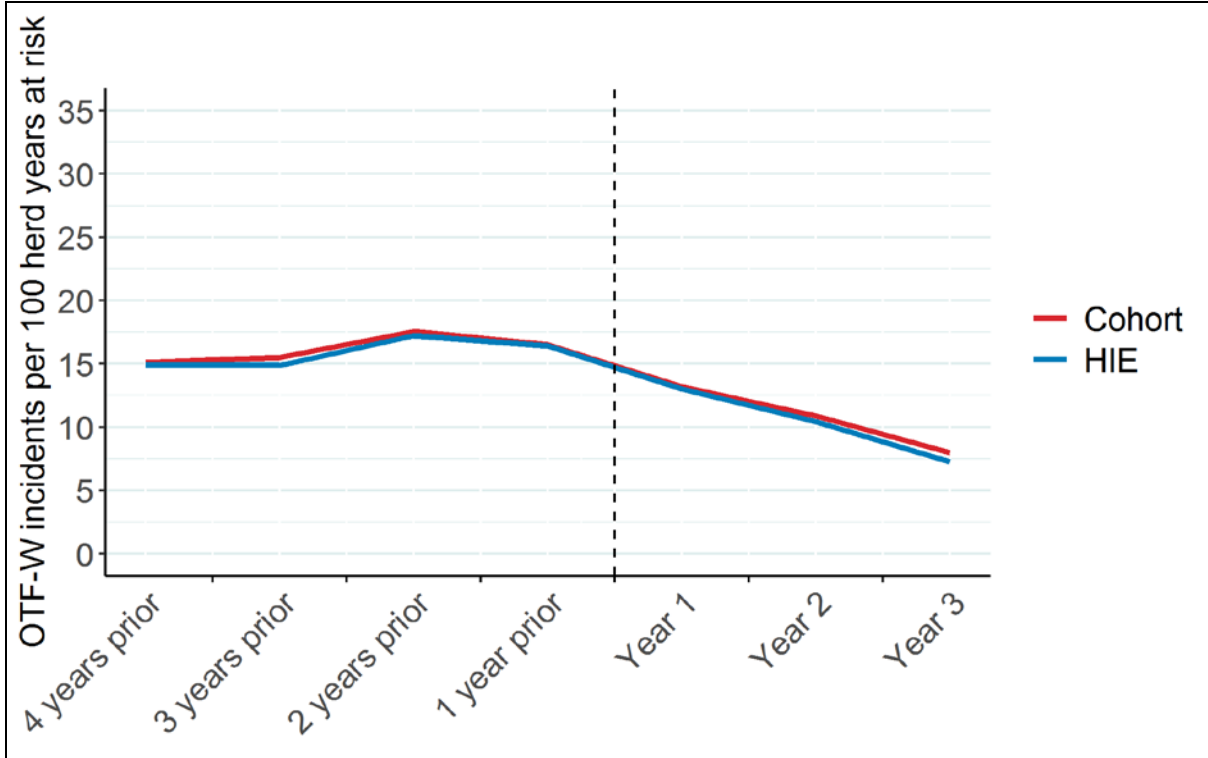
Areas where the cull commenced in 2015

Area 03 - Dorset central

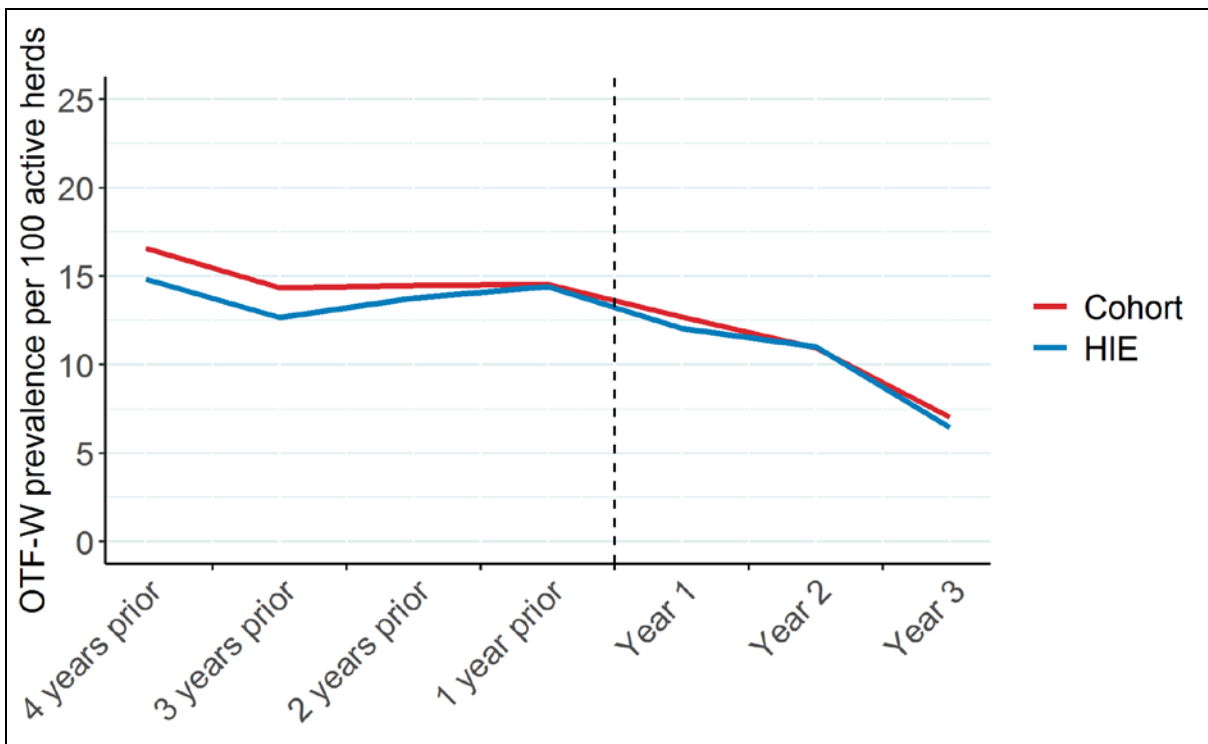
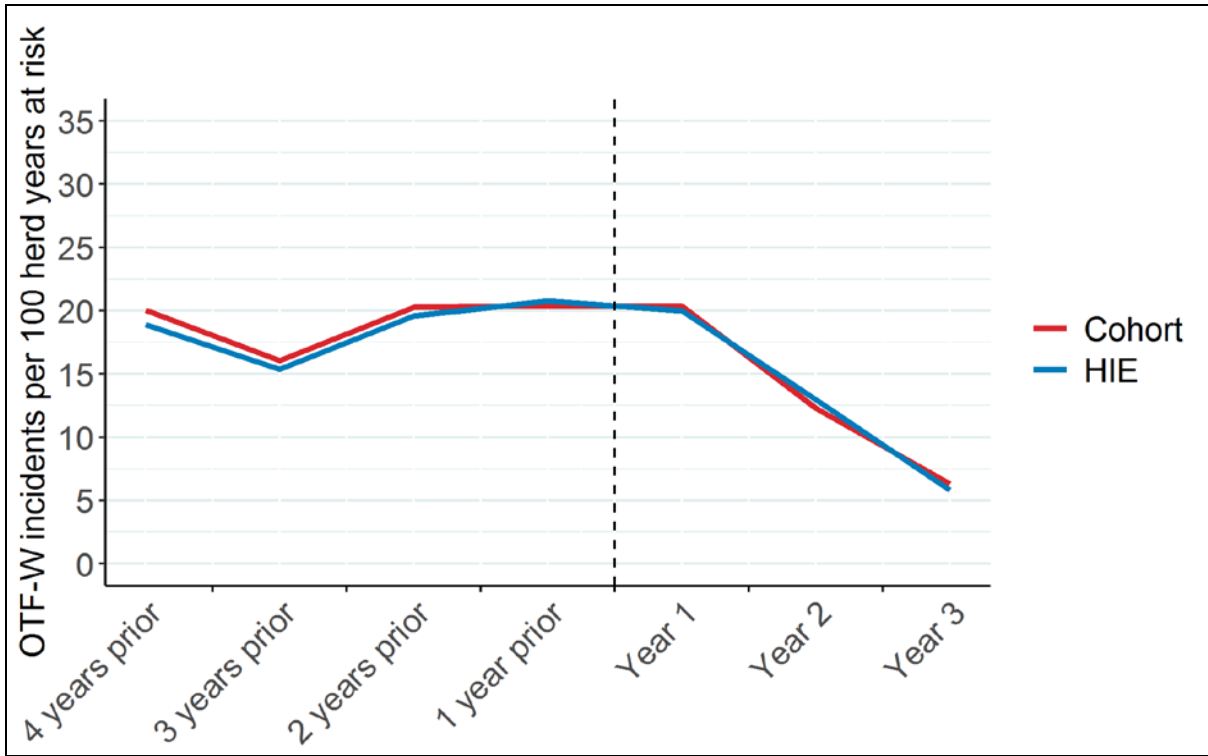


Areas where the cull commenced in 2016

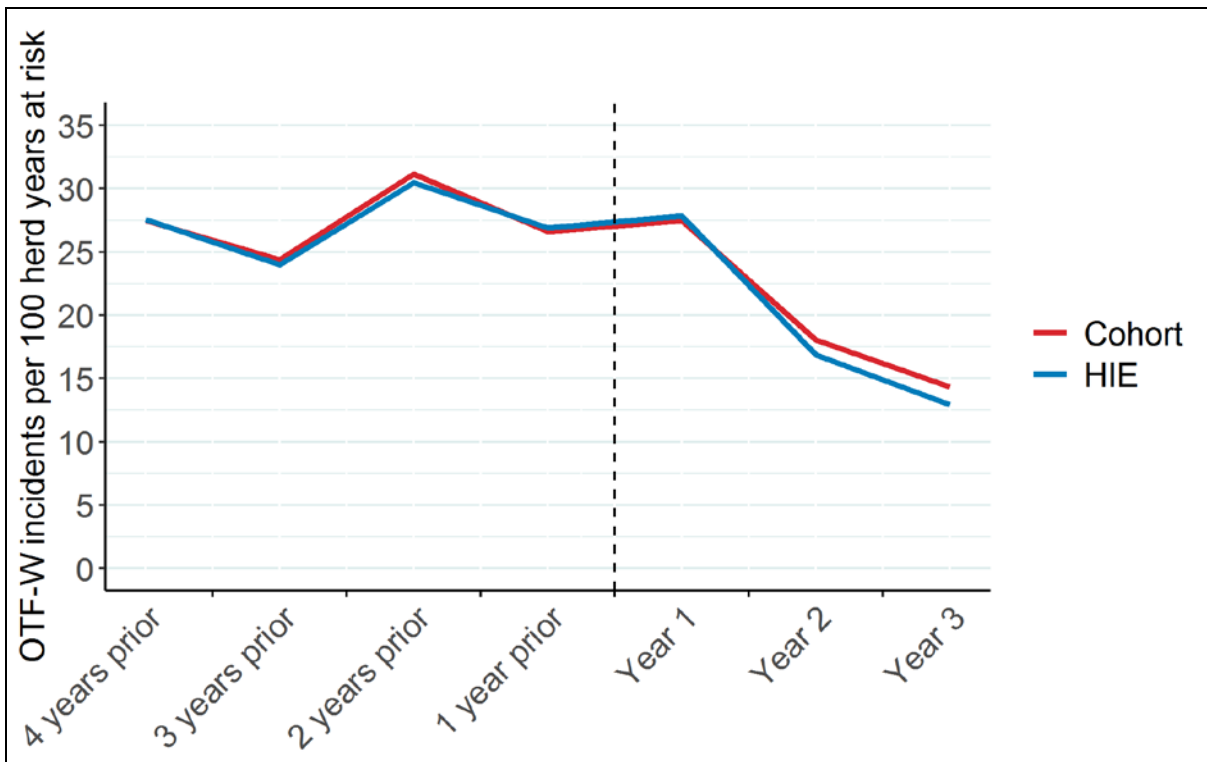
Area 04 - Cornwall central



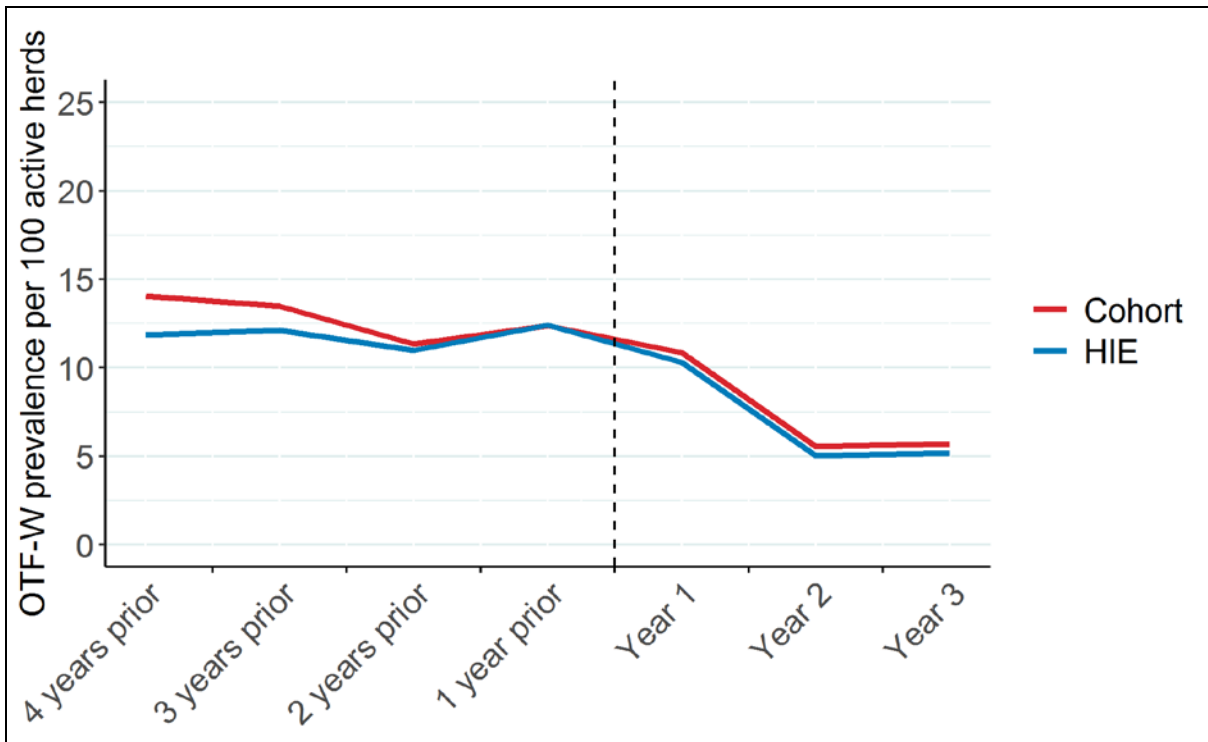
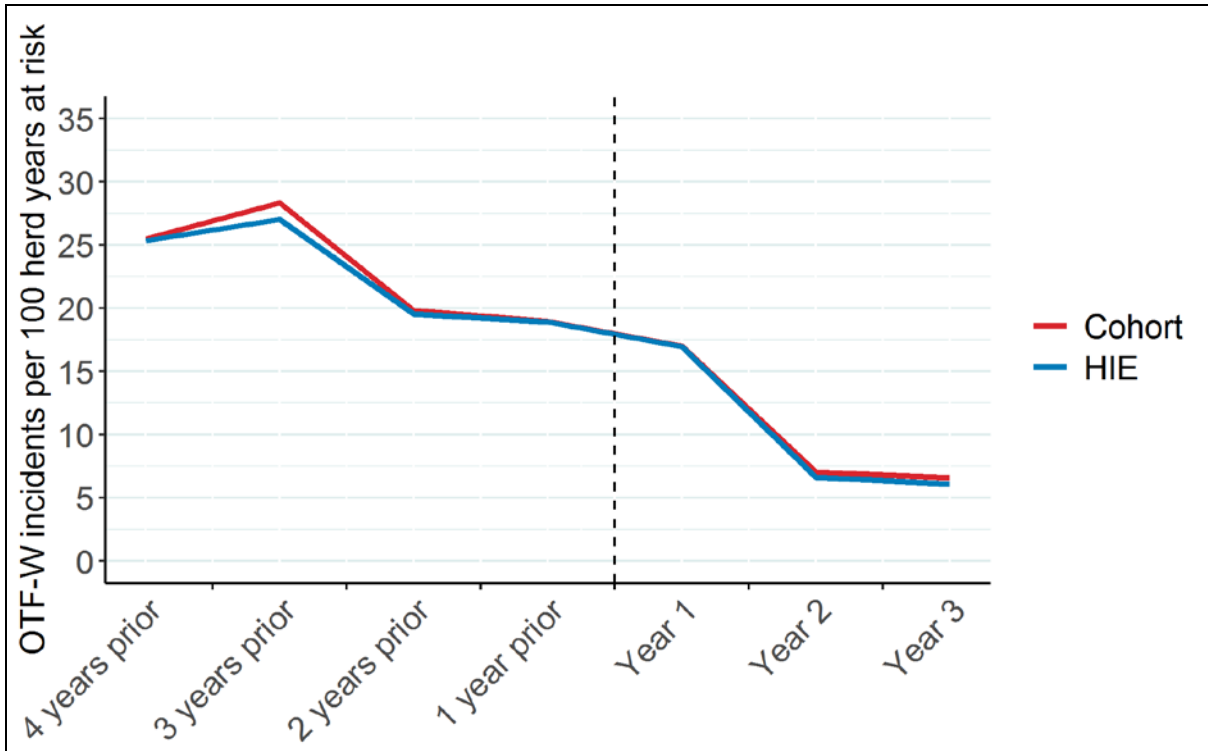
Area 05 - Cornwall central



Area 06 - Devon central

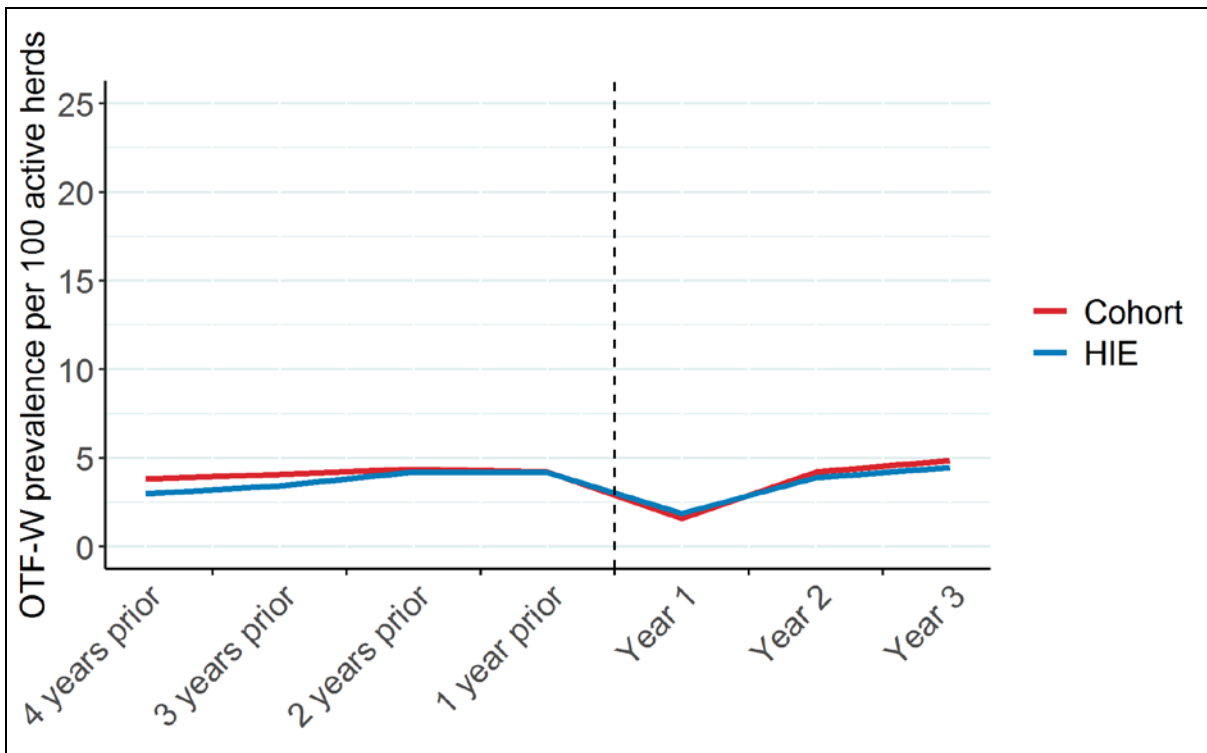
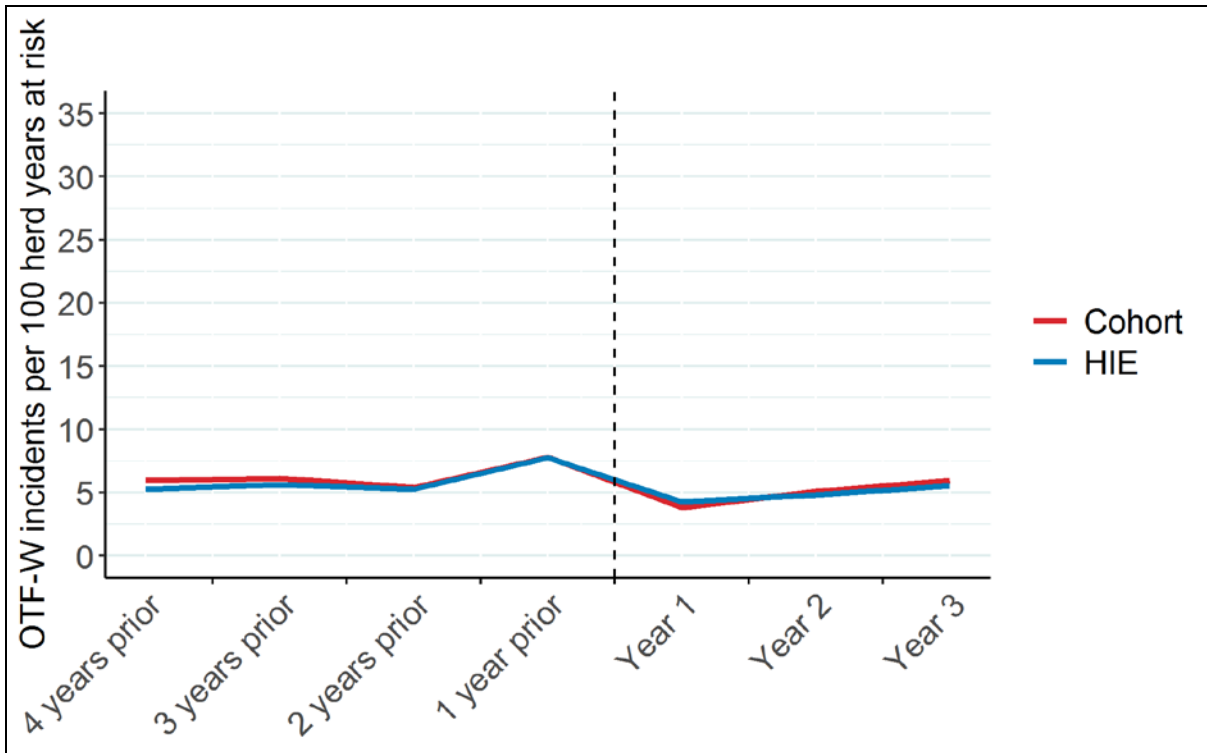


Area 07 - Devon central

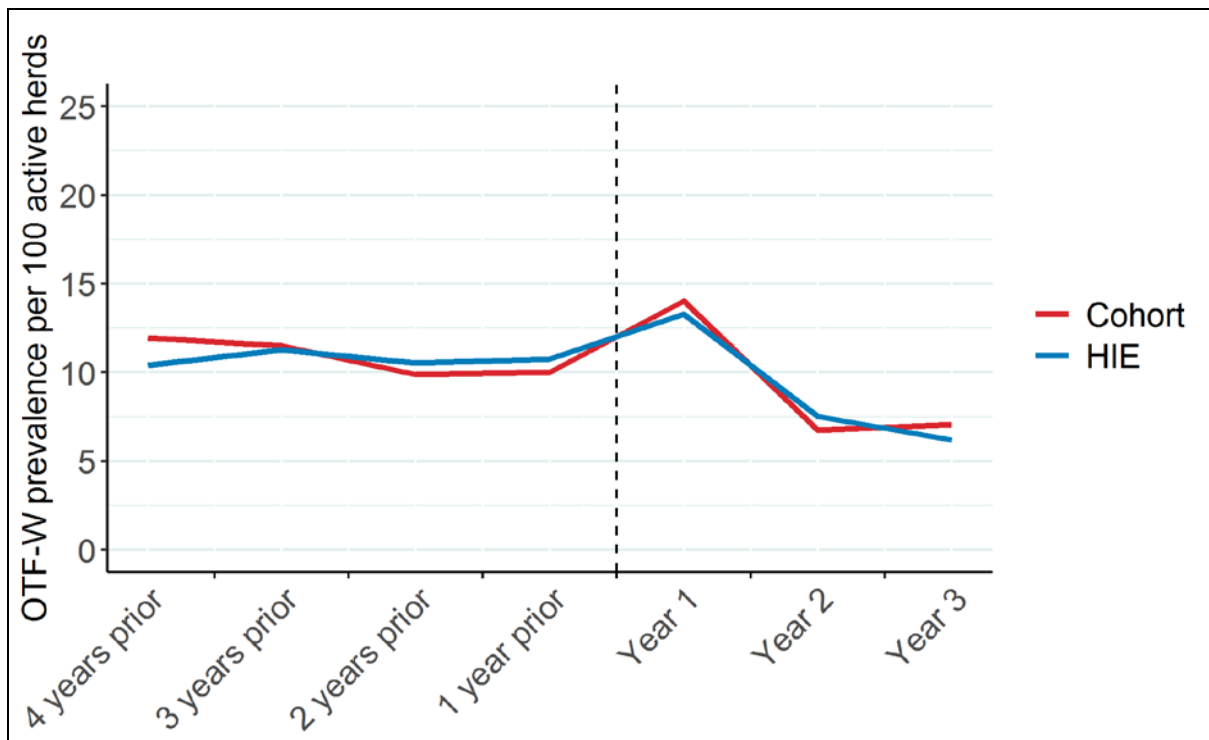
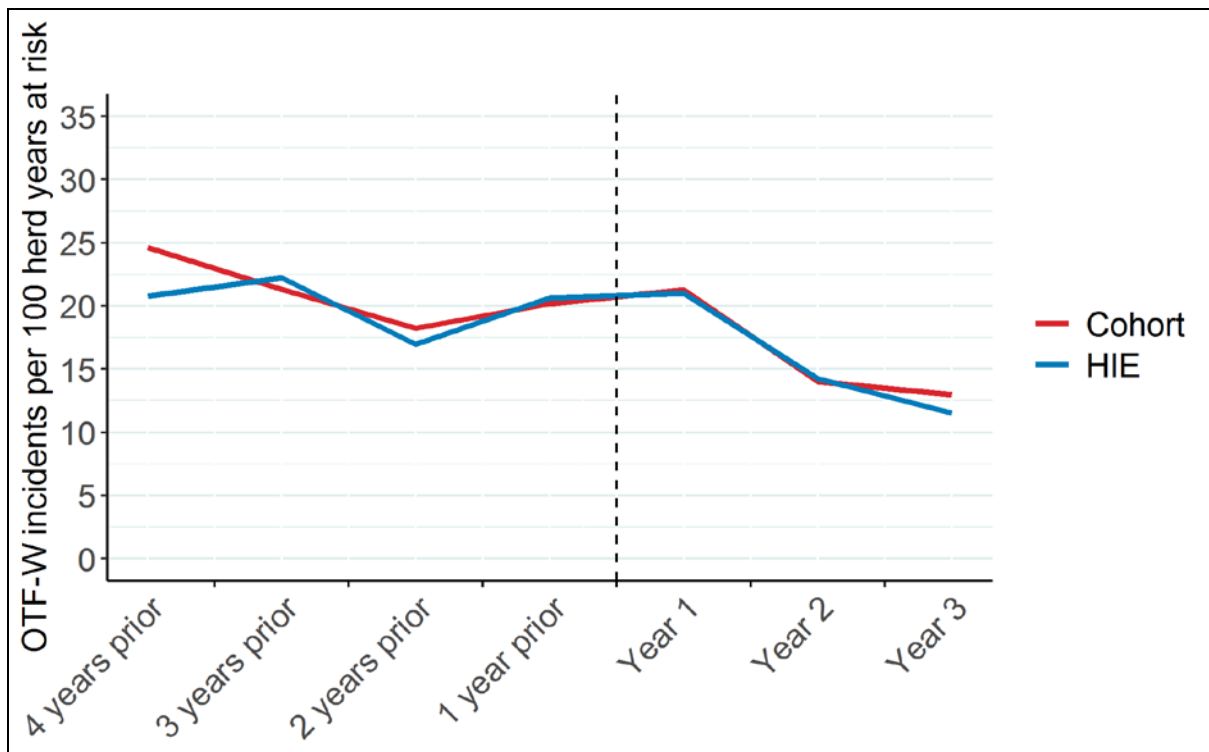


Area 08 - Dorset central

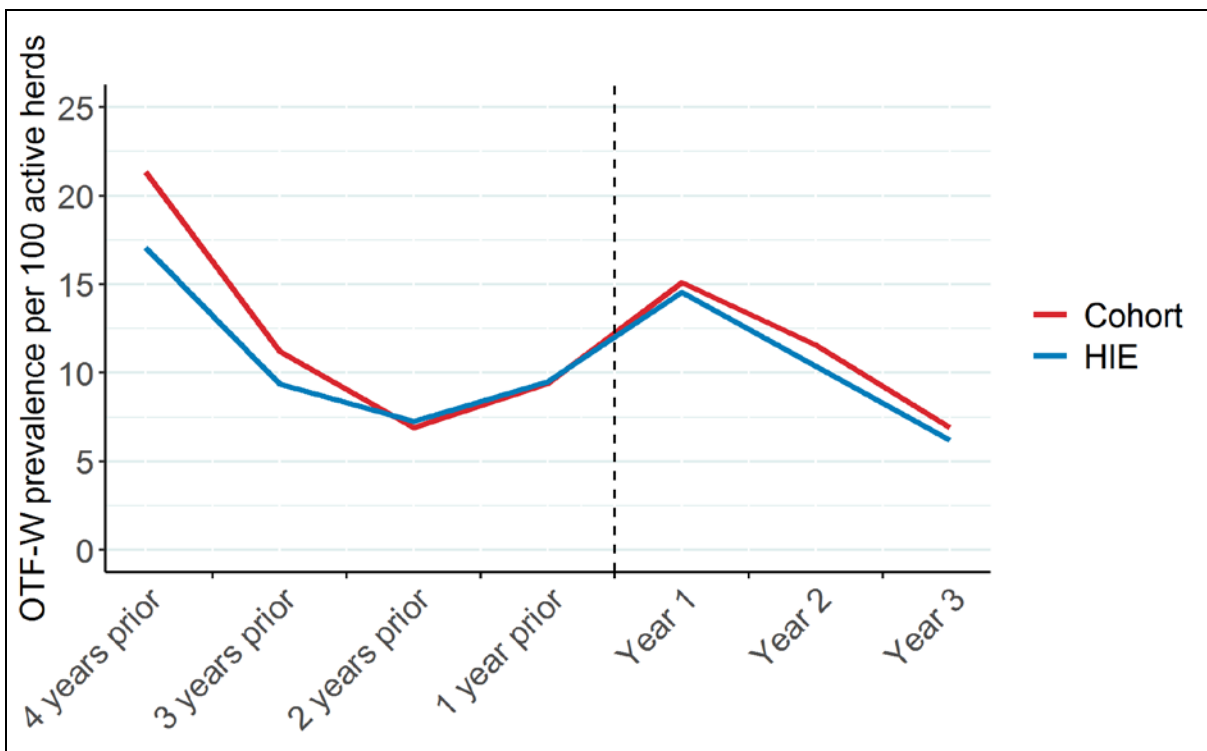
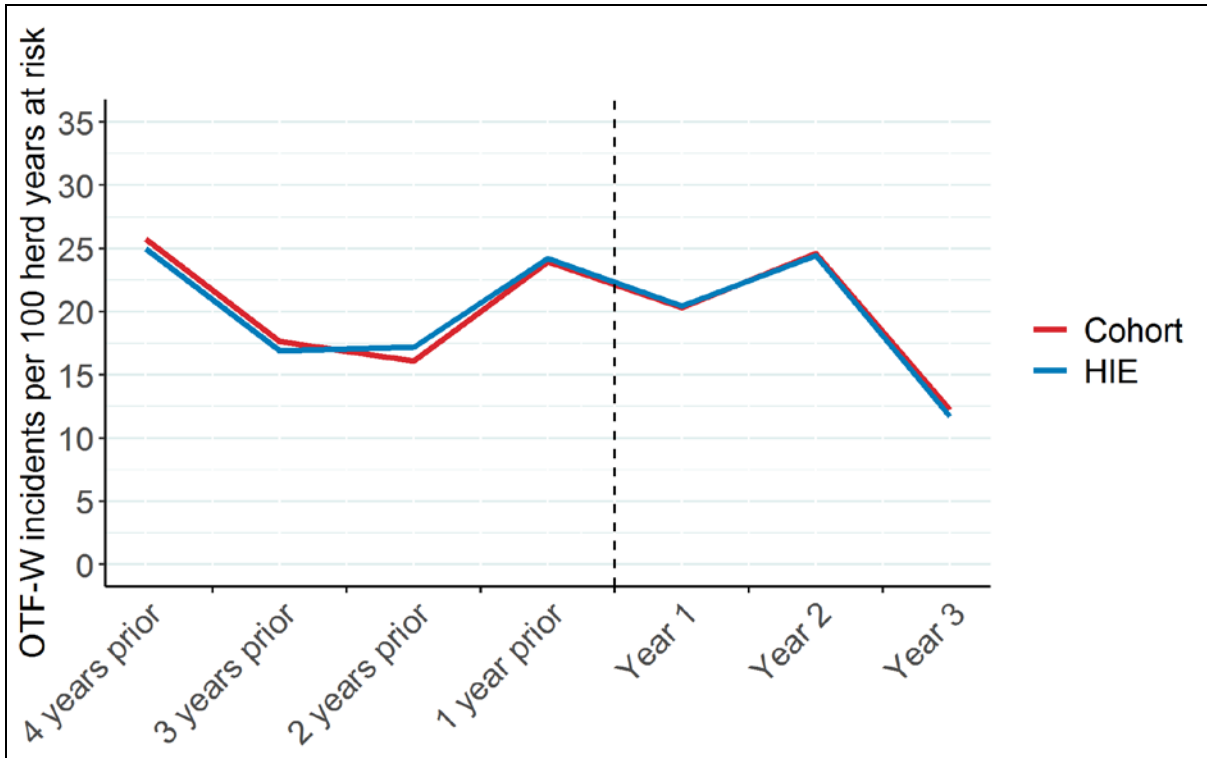
Area increased in size by 3.1% in April 2017



Area 09 - Gloucestershire central

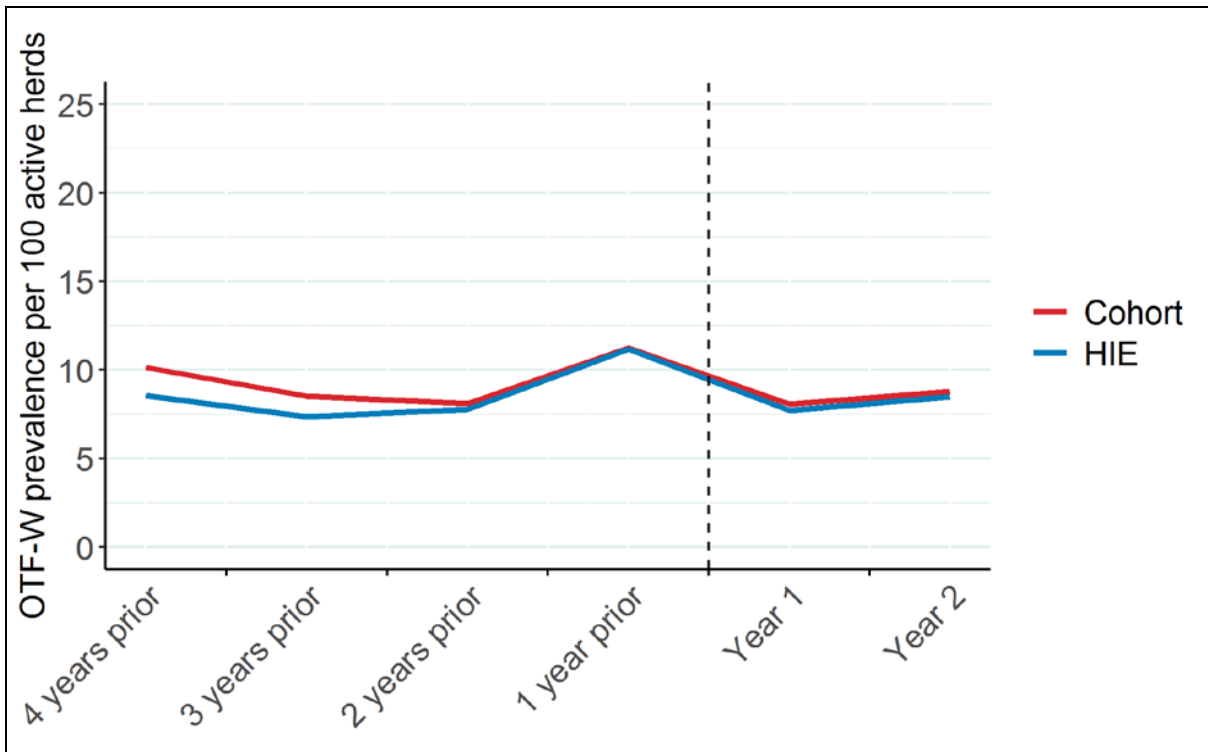
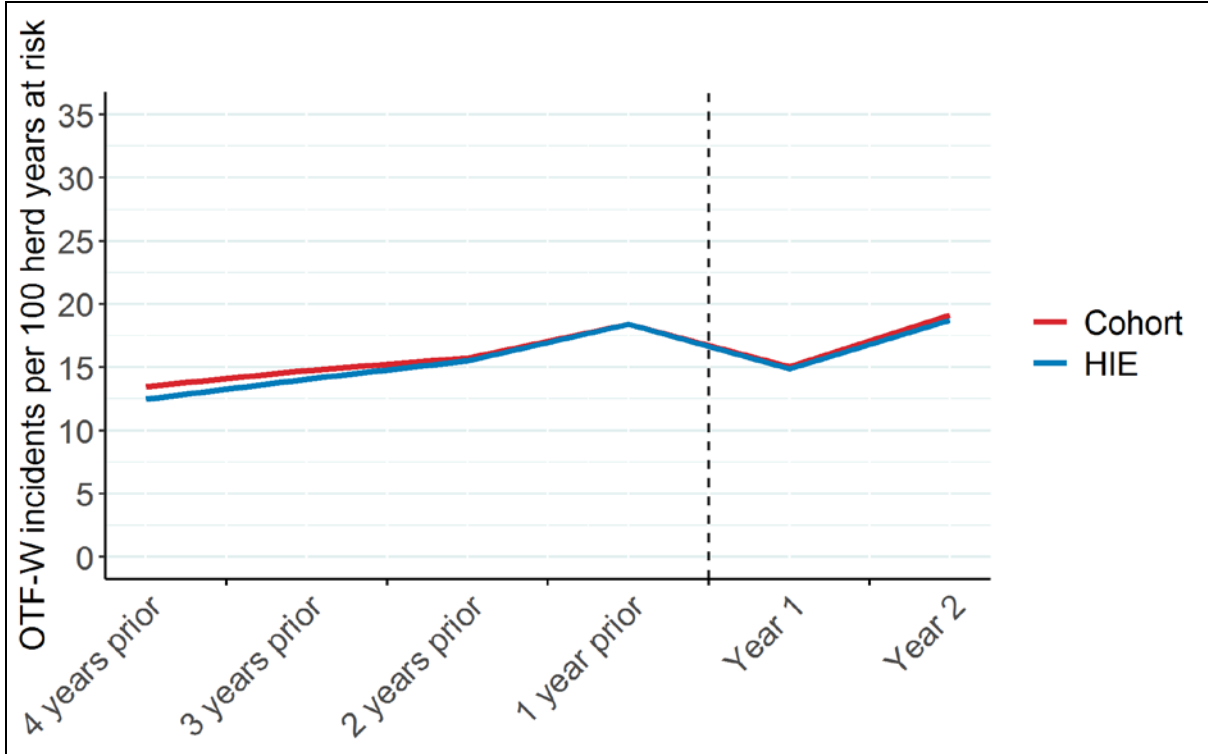


Area 10 - Herefordshire central

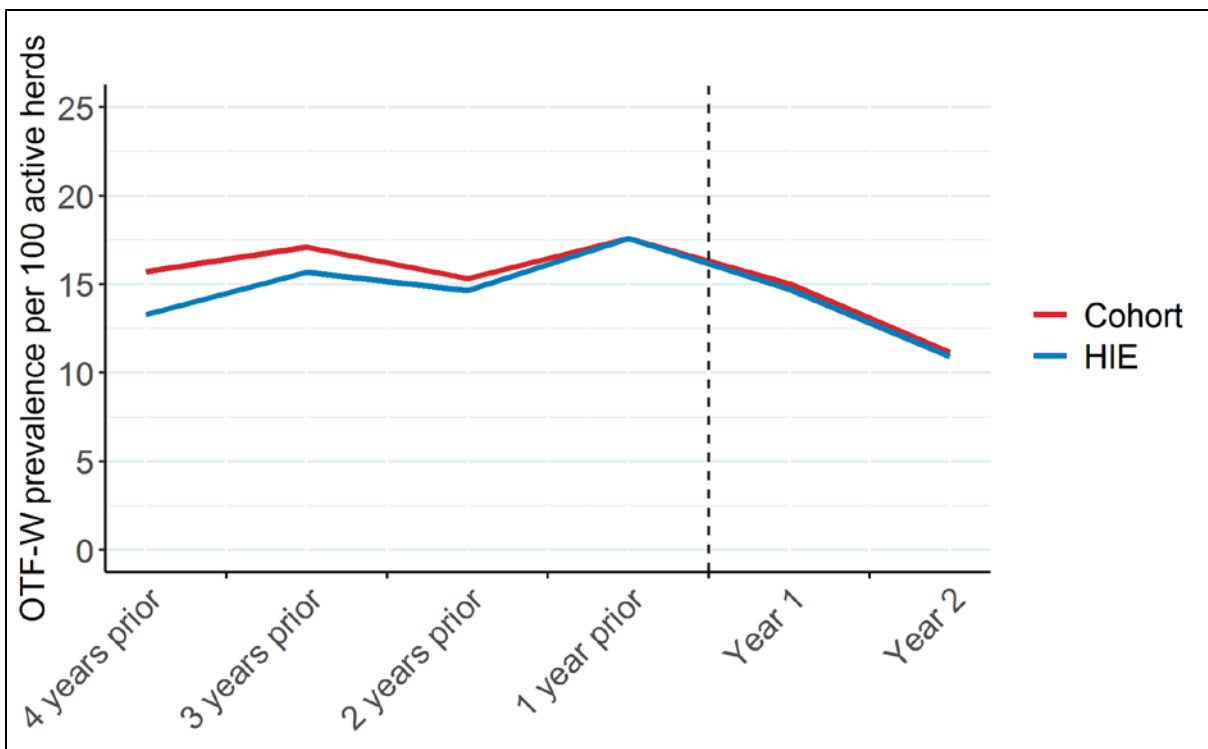
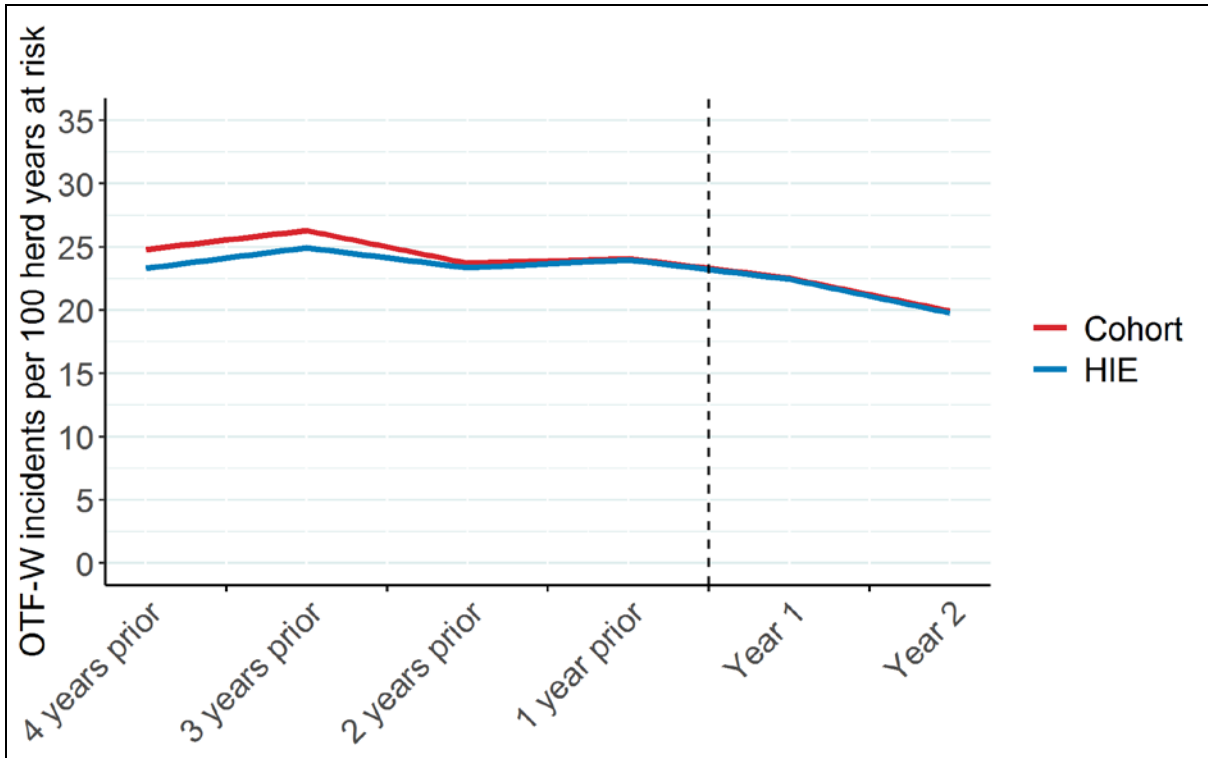


Areas where the cull commenced in 2017

Area 11 - Cheshire central

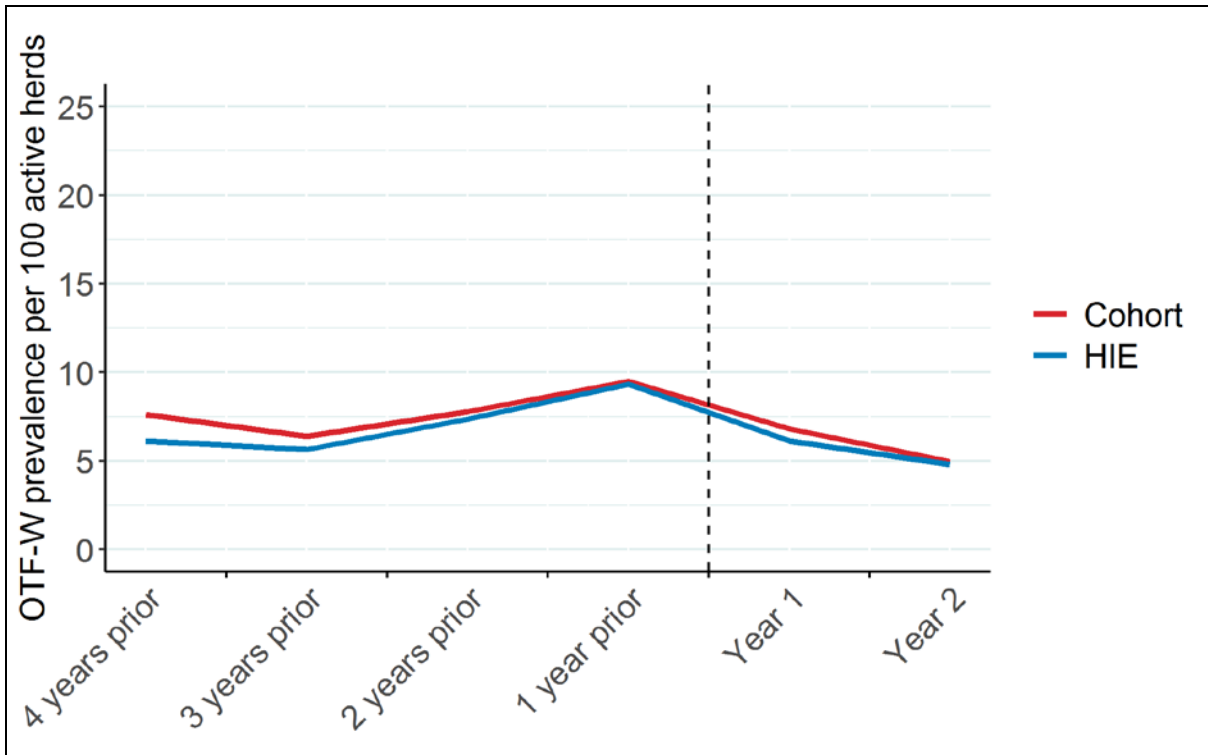
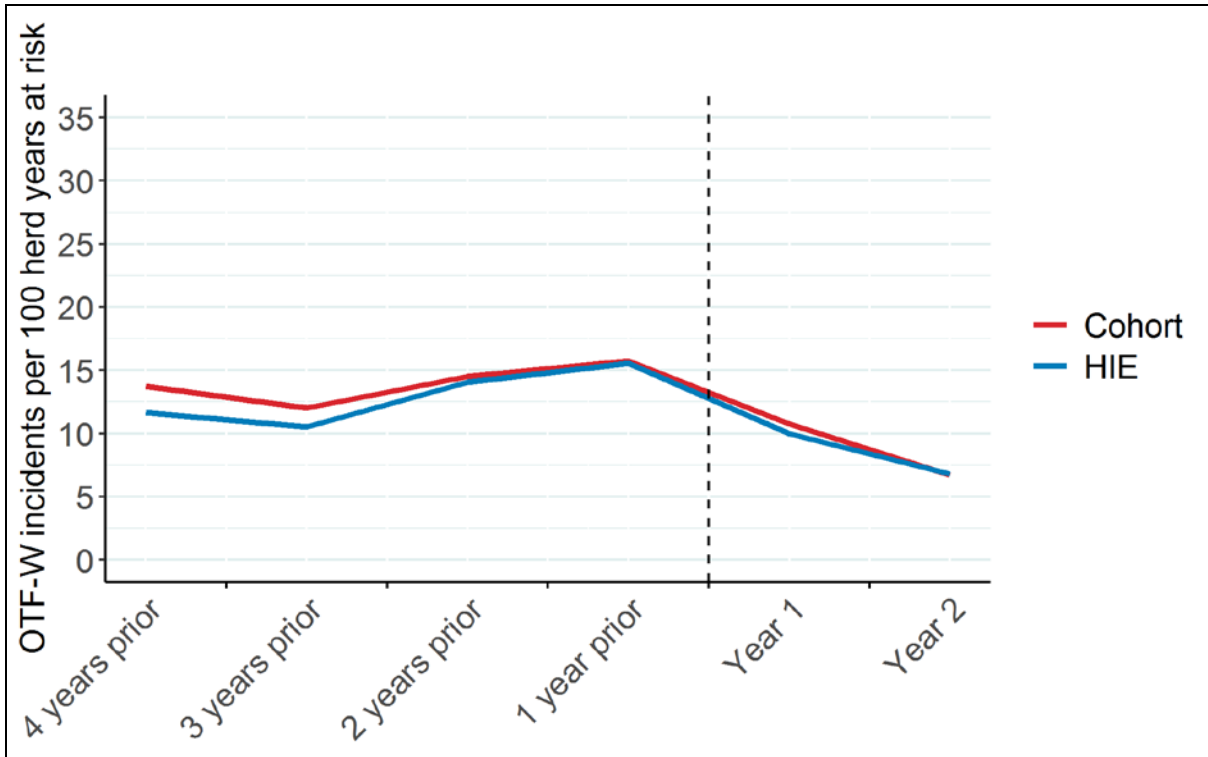


Area 12 - Devon central

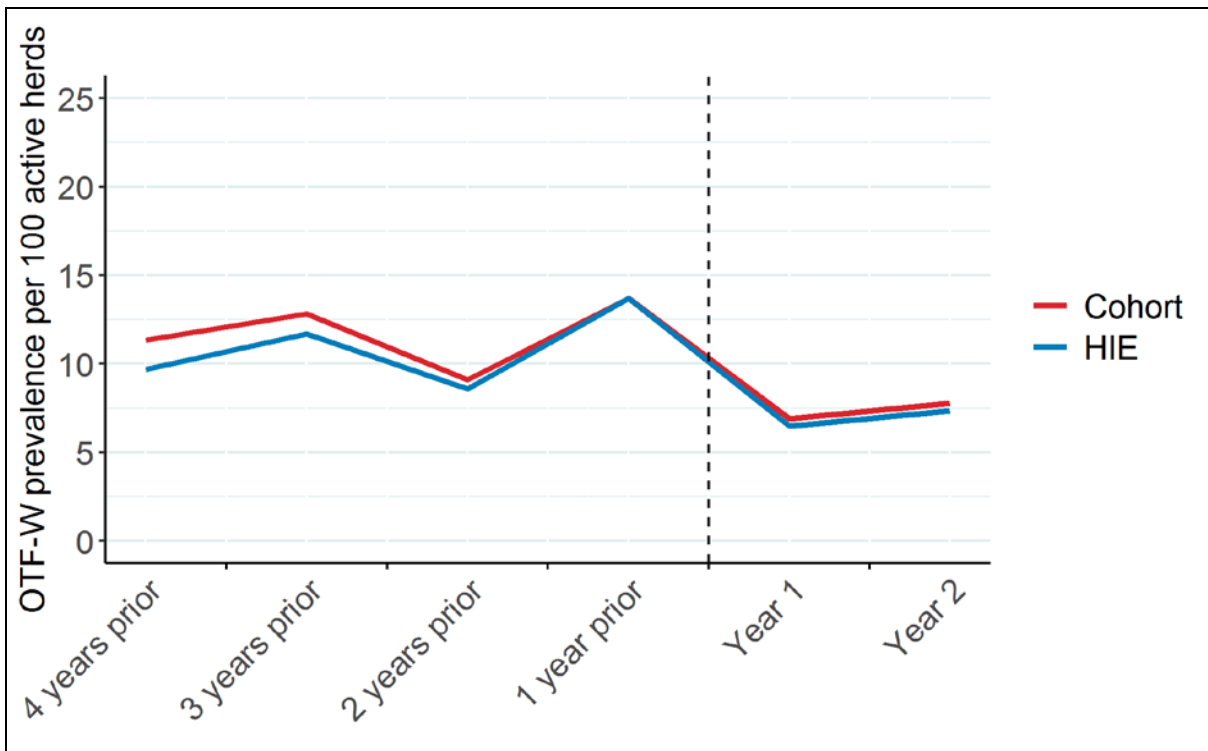
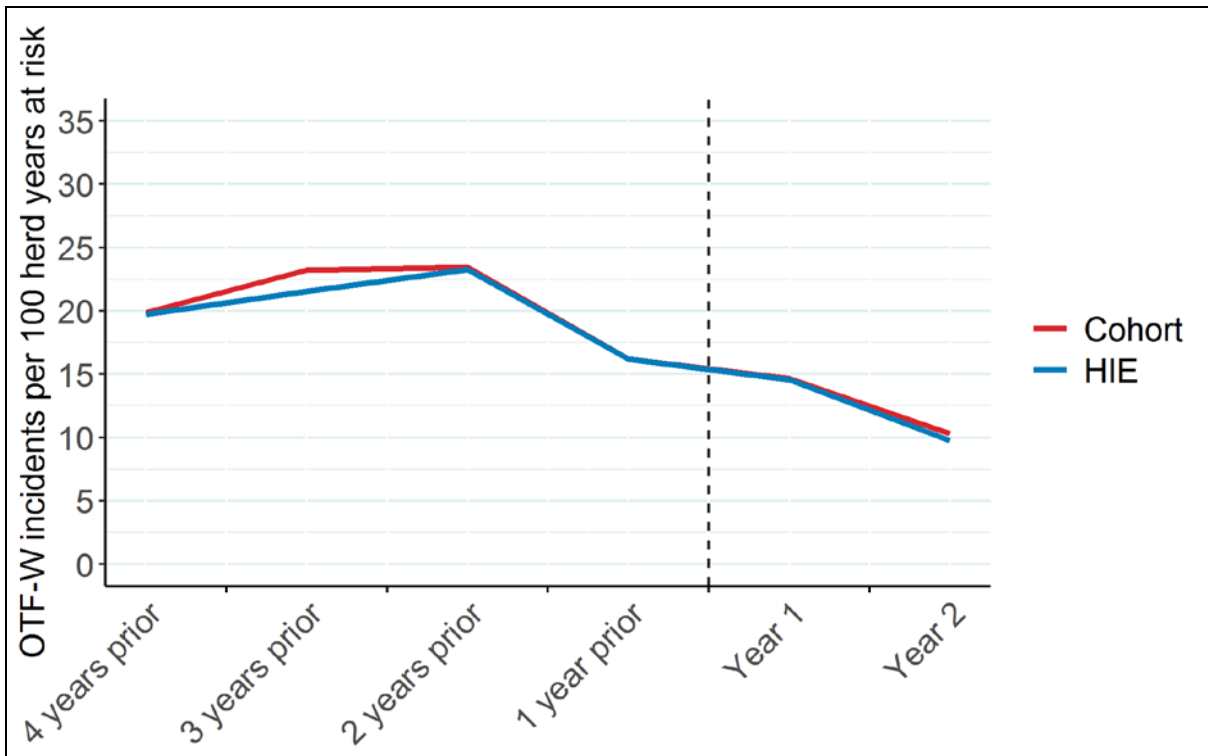


Area 13 - Devon central

Area increased in size by 3.1% in May 2018

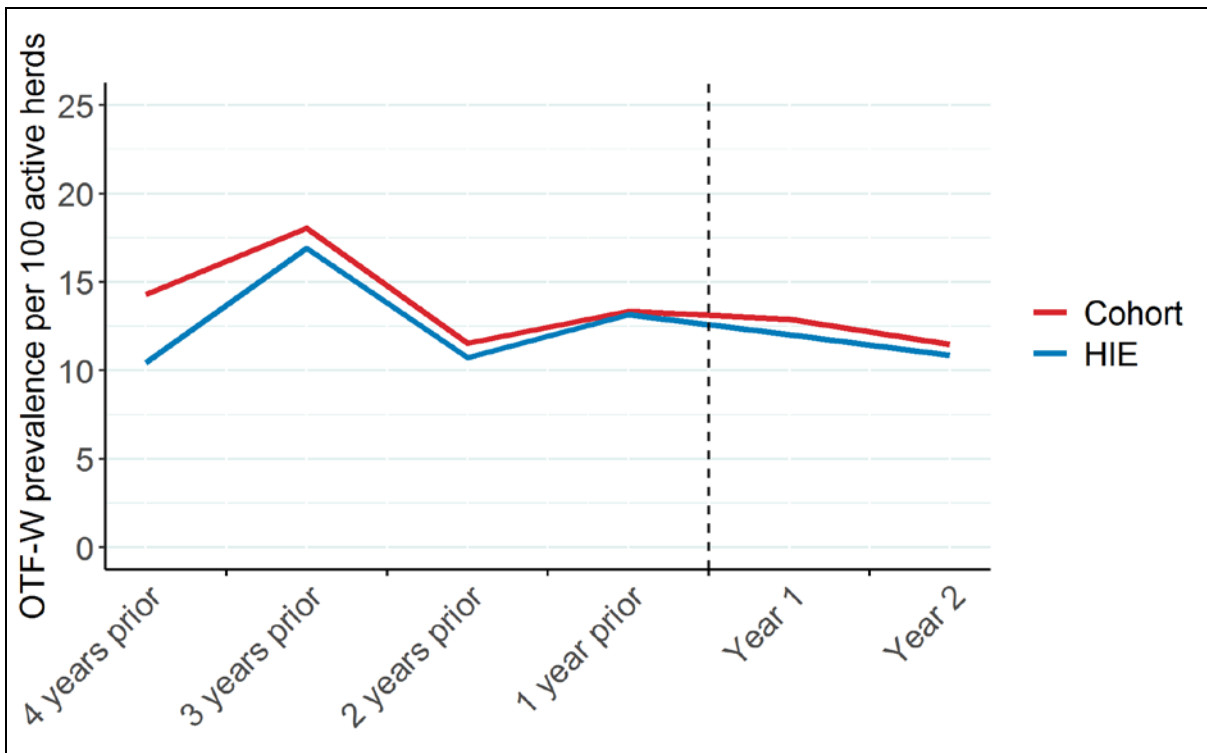
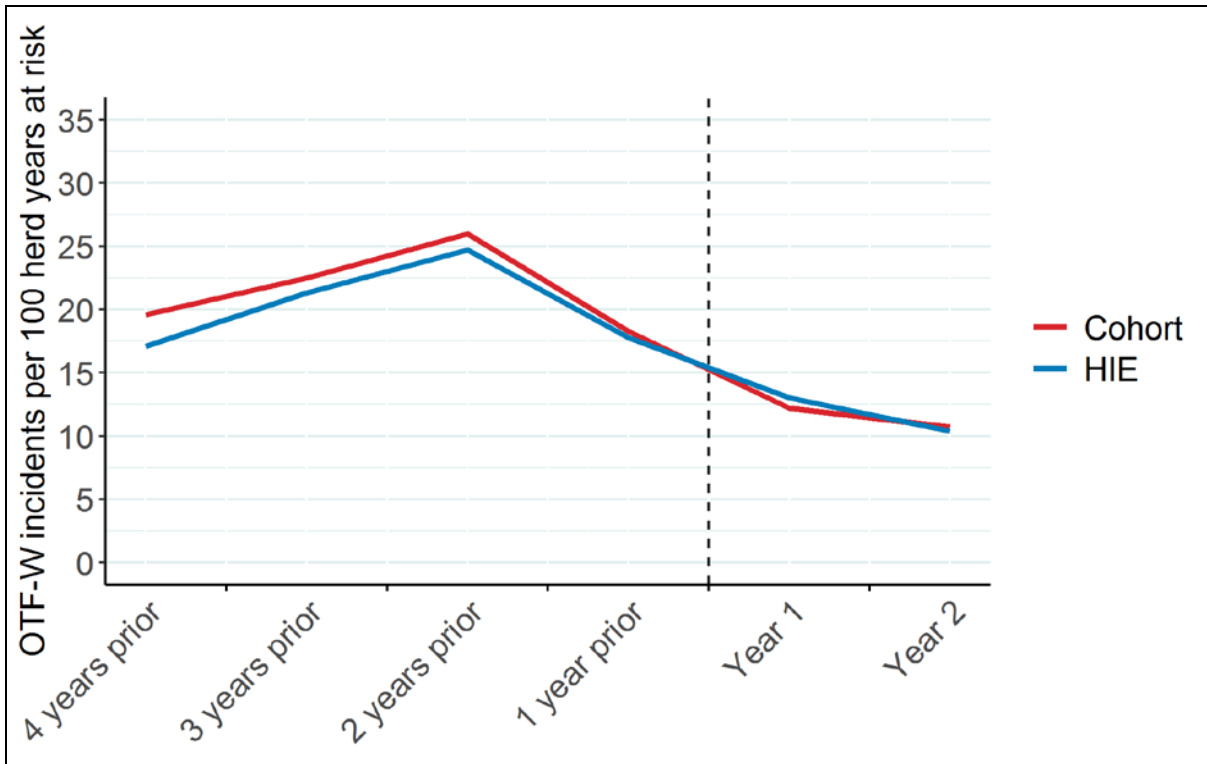


Area 14 - Devon central

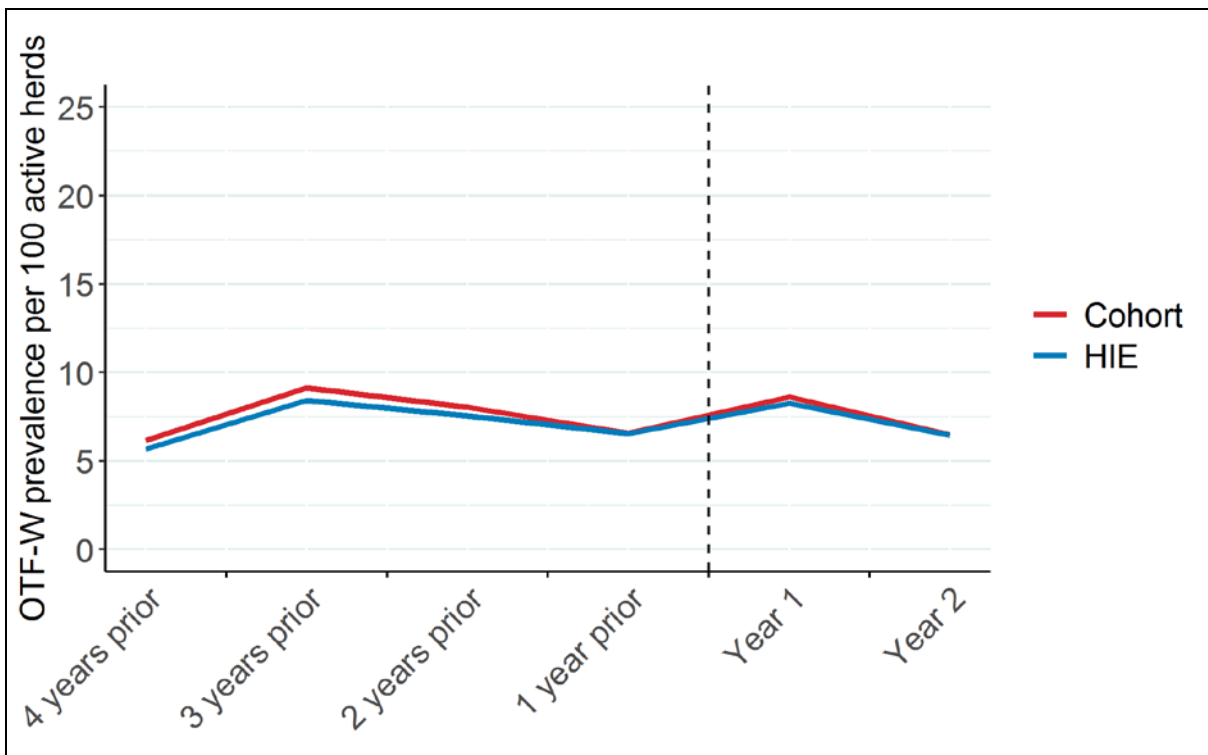
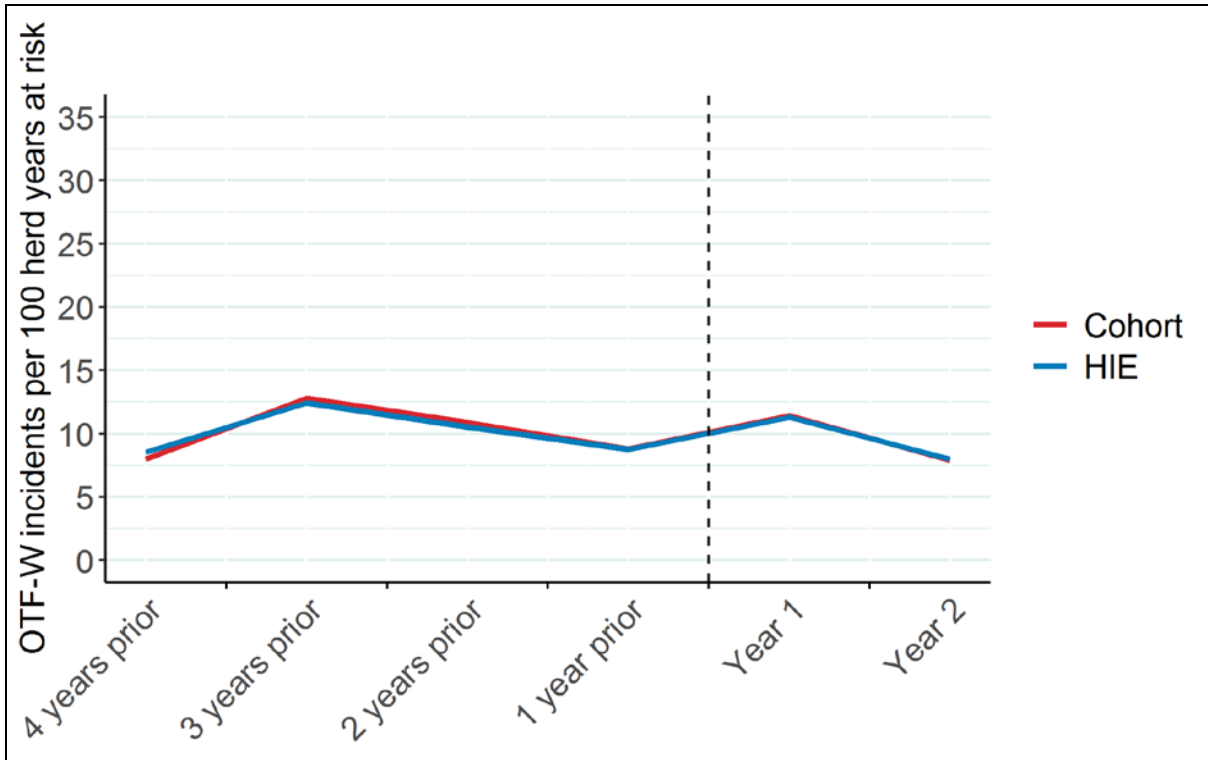


Area 15 - Devon central

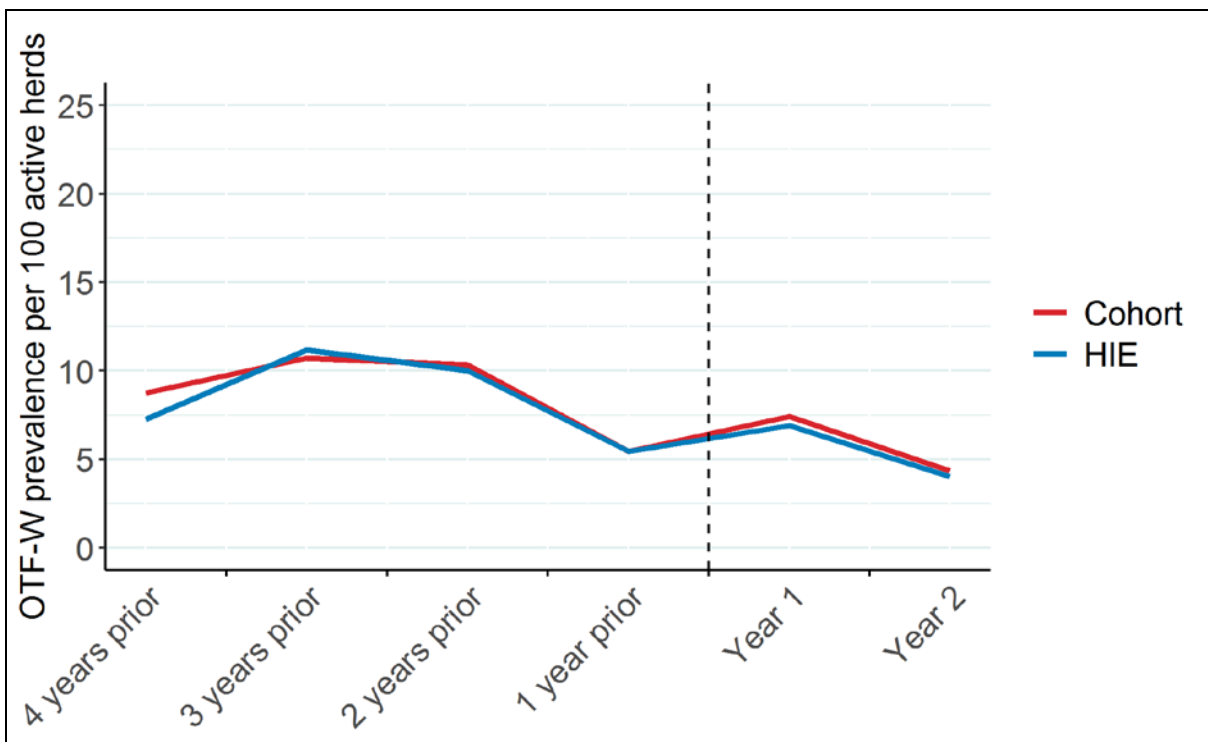
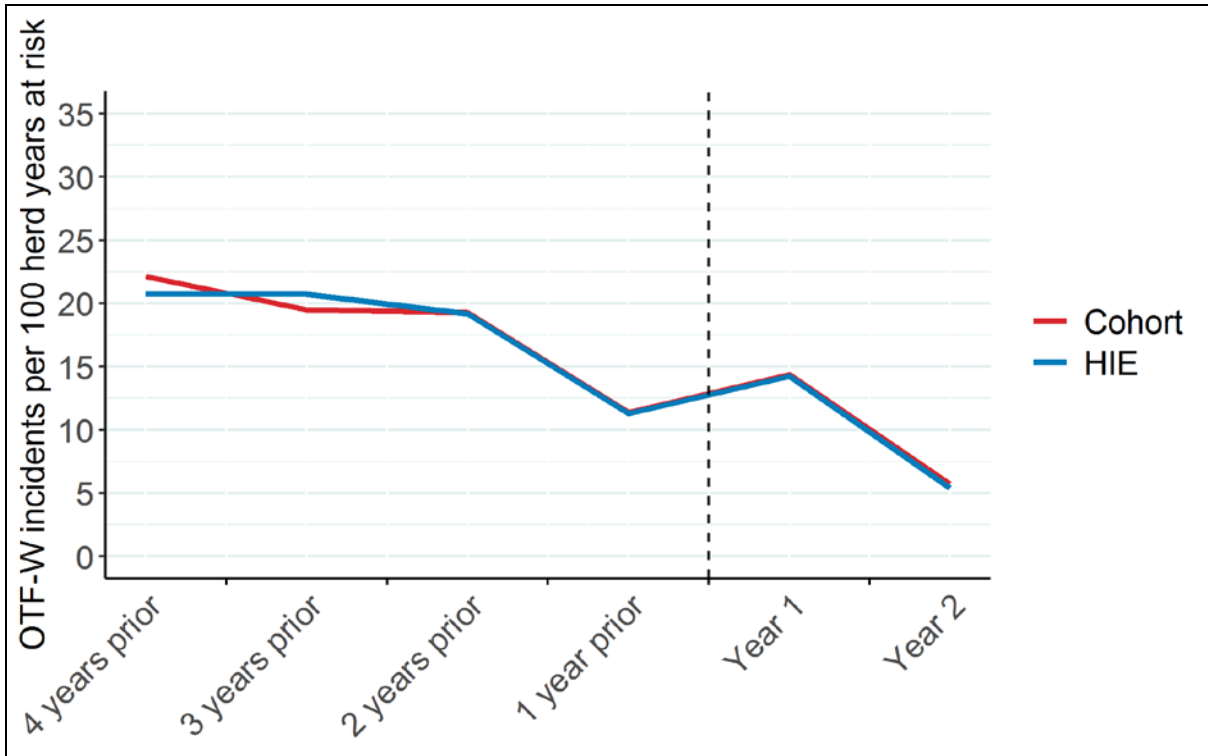
Area increased in size by 0.6% in May 2018



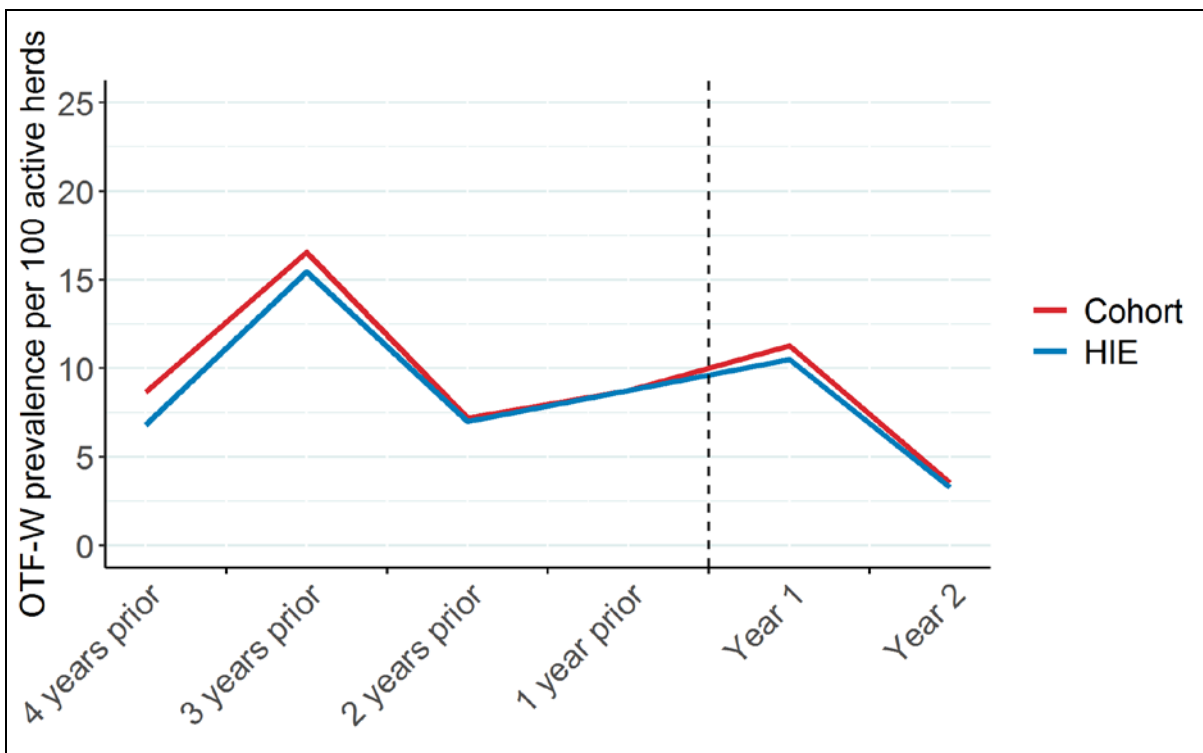
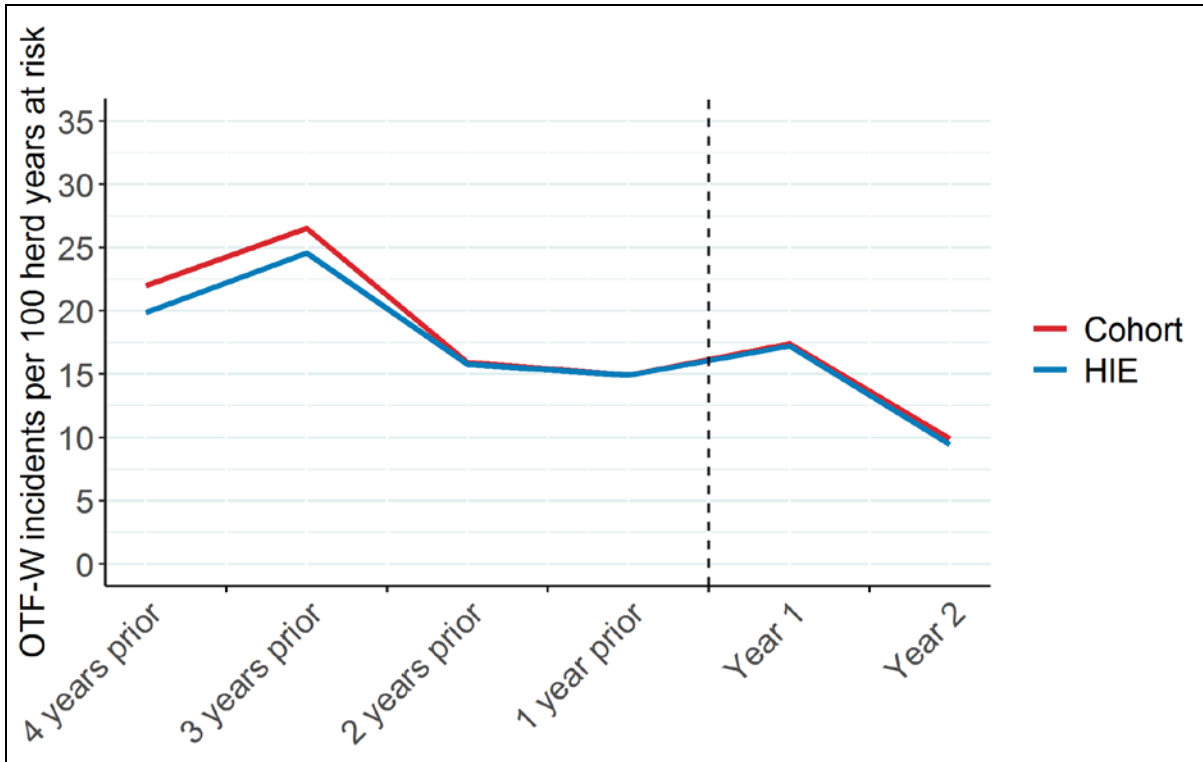
Area 16 - Dorset central



Area 17 - Somerset central

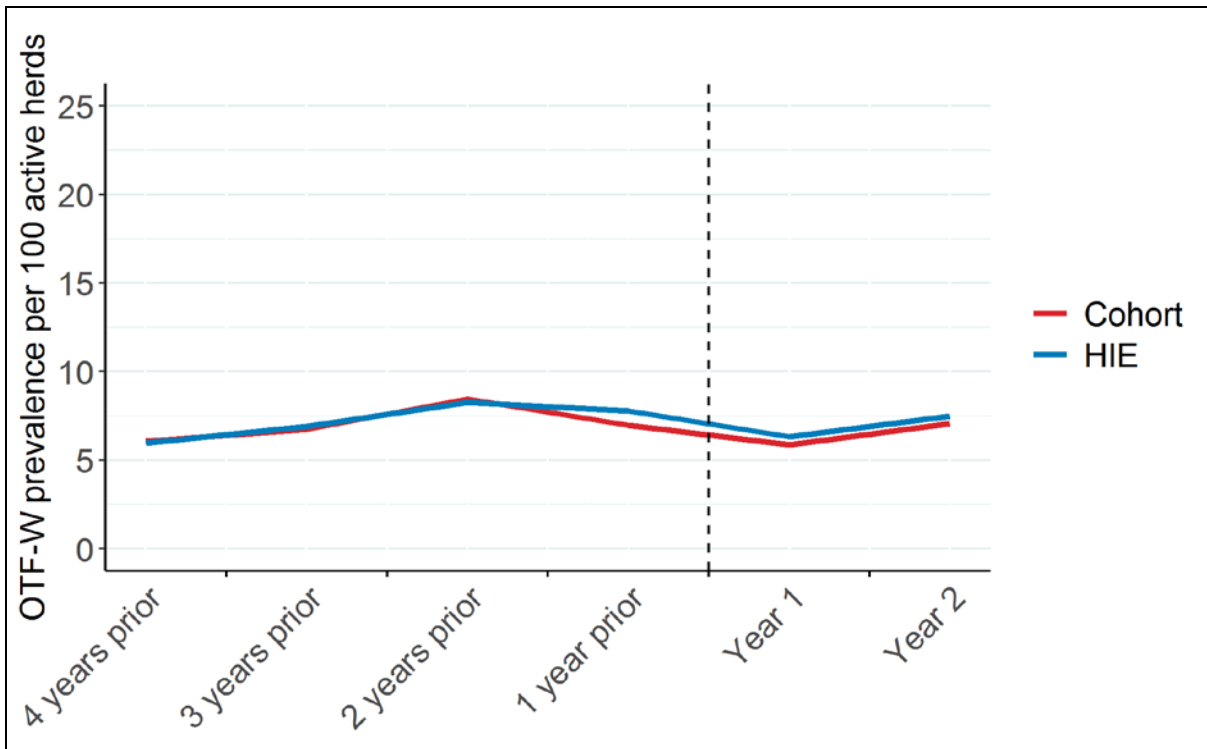
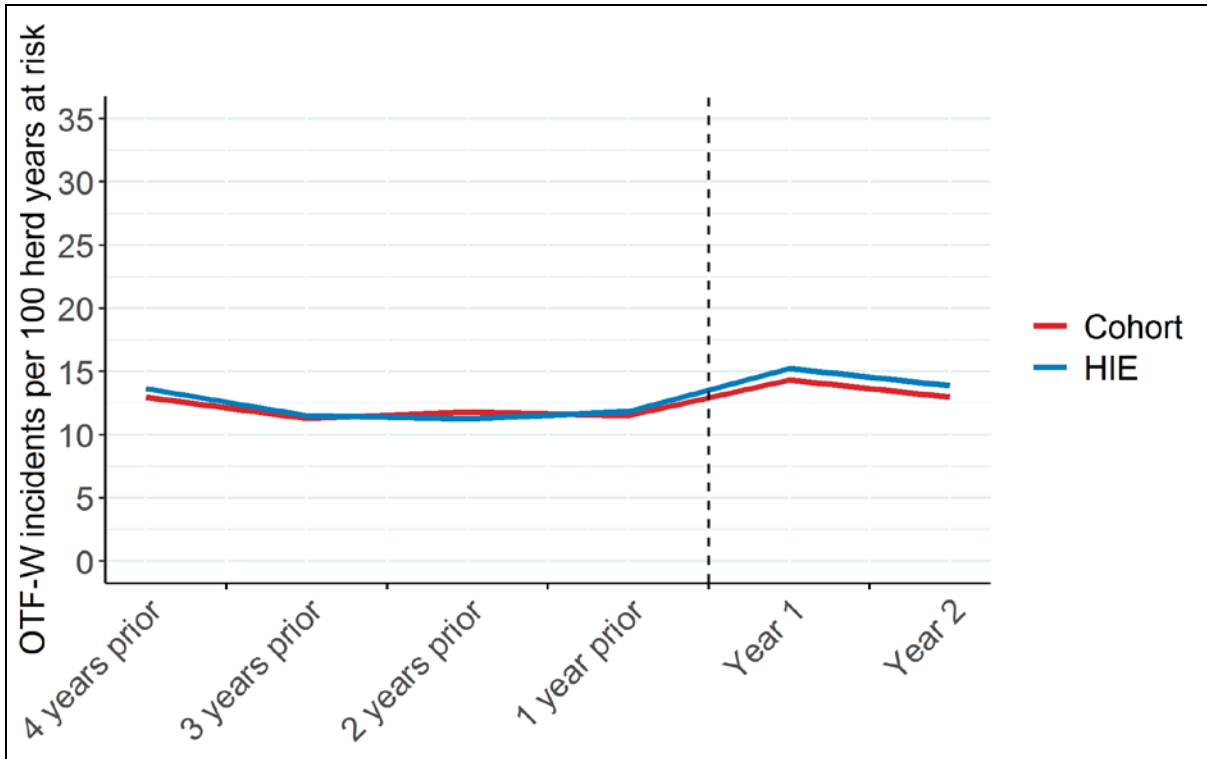


Area 18 - Somerset central



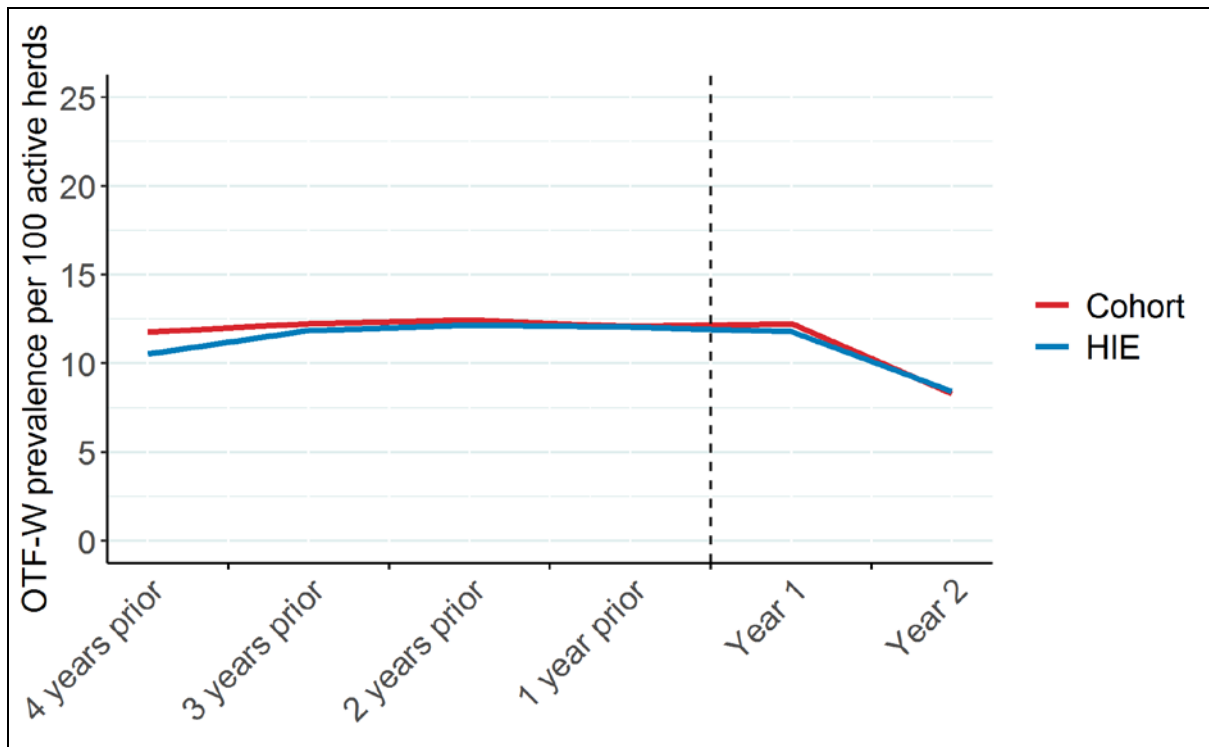
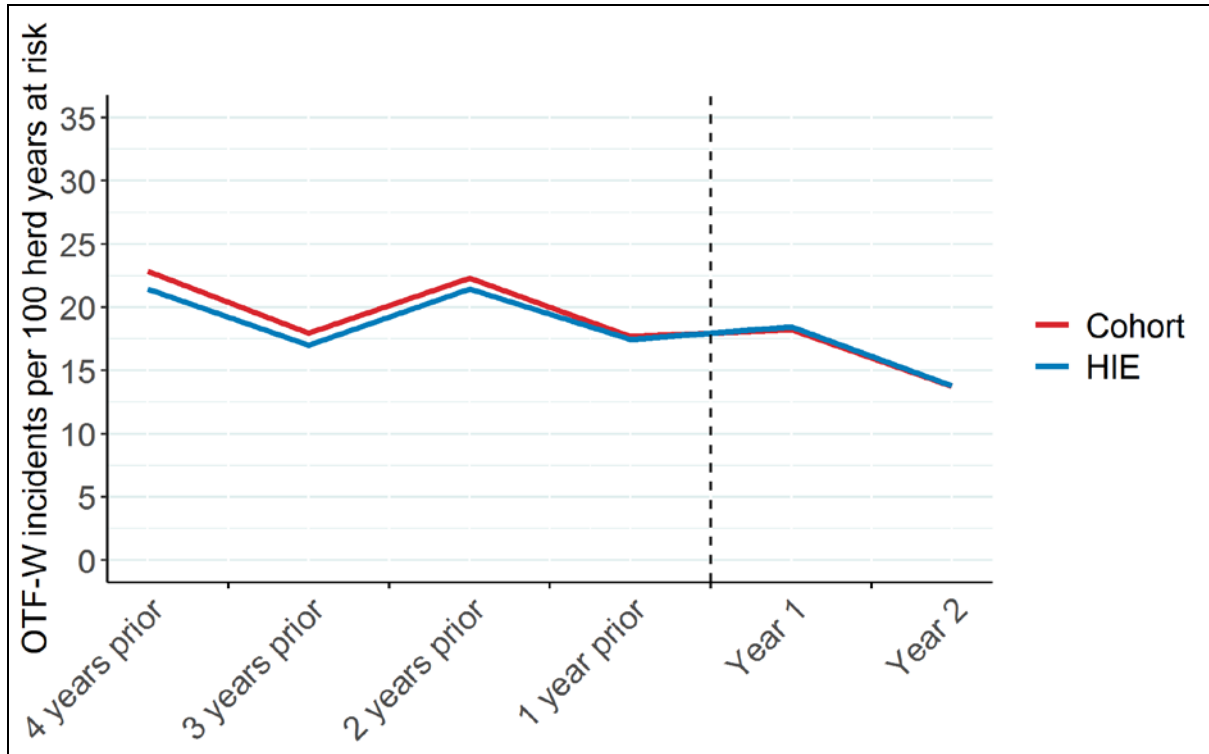
Area 19 - Wiltshire central

Area increased in size by 3.4% in May 2018

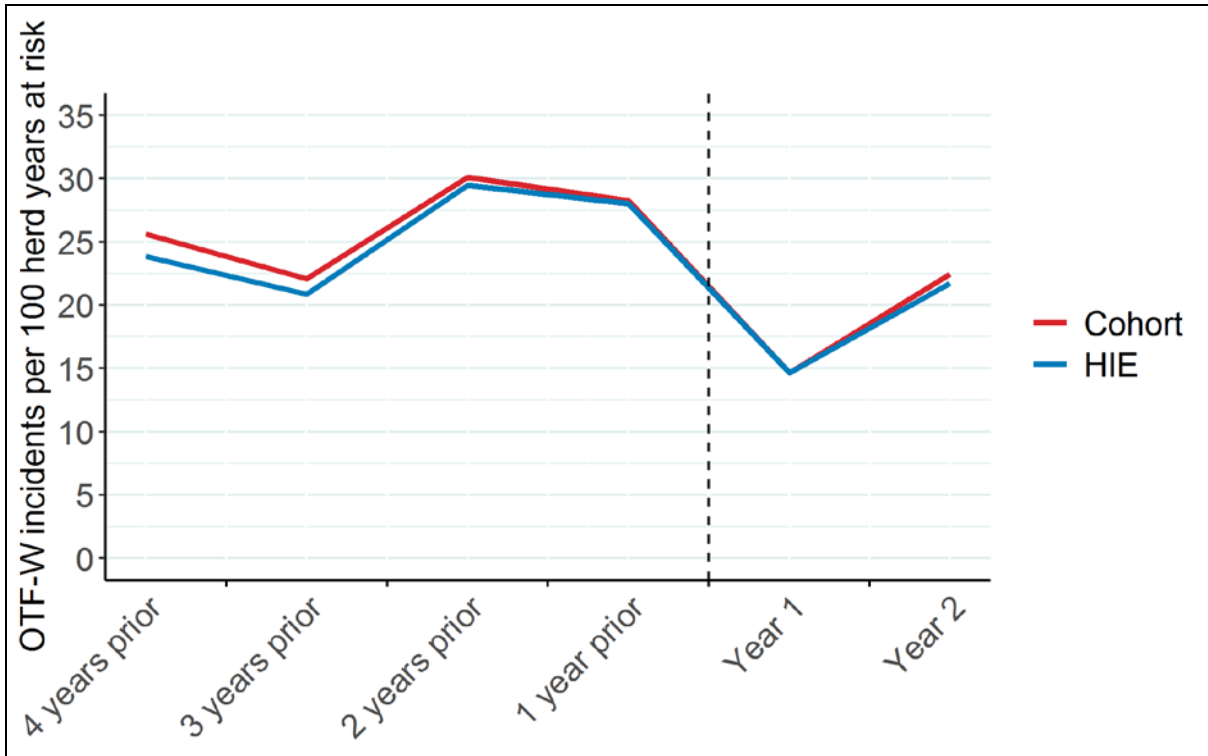


Area 20 - Wiltshire central

Area increased in size by 1.3% in May 2018

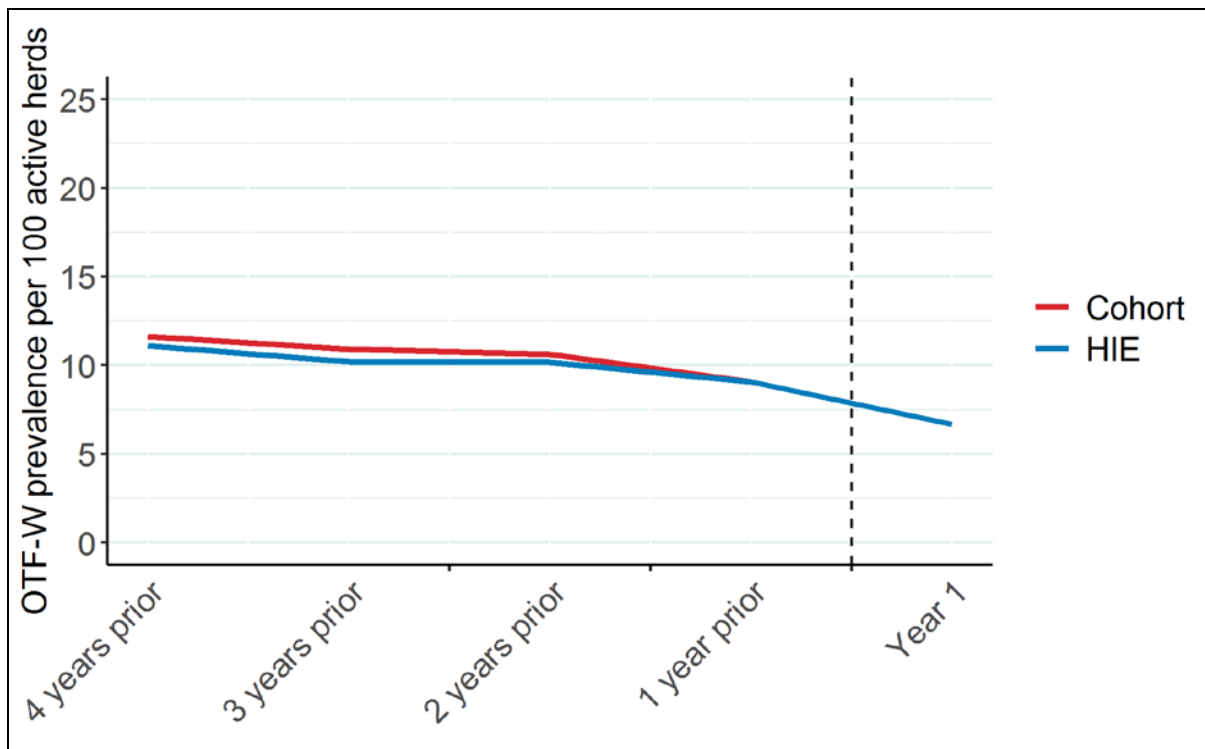
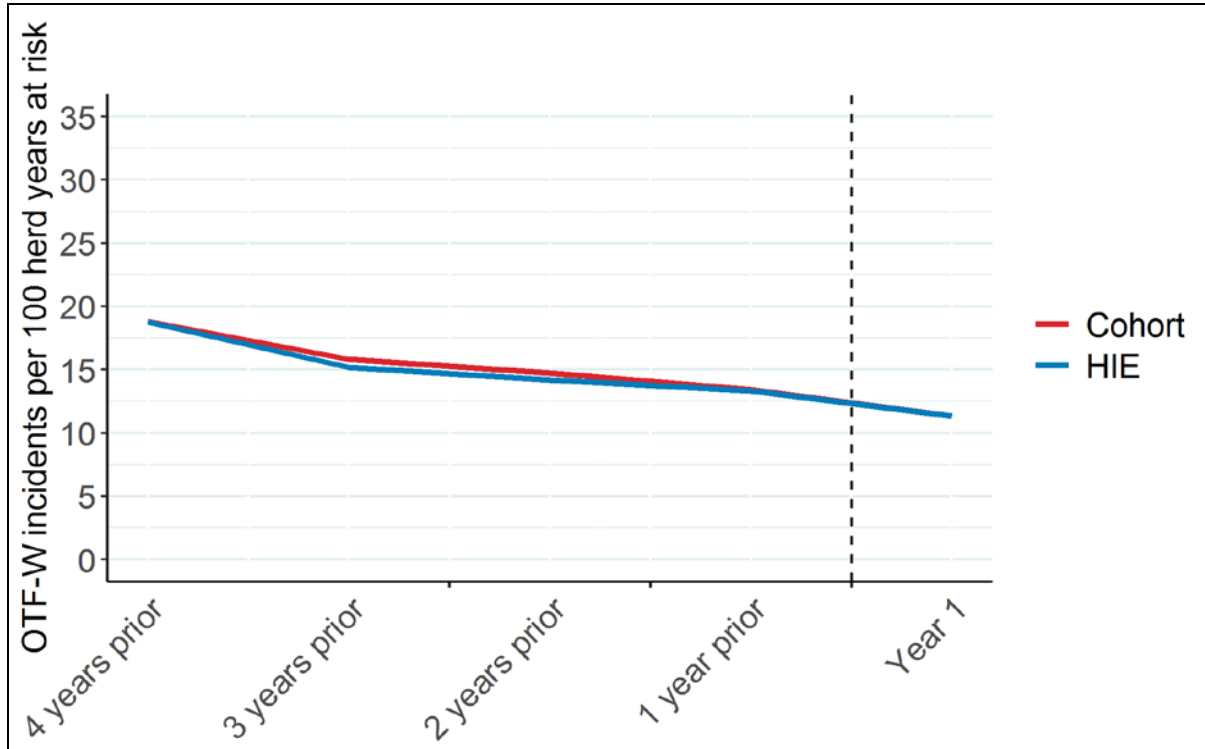


Area 21 - Wiltshire central

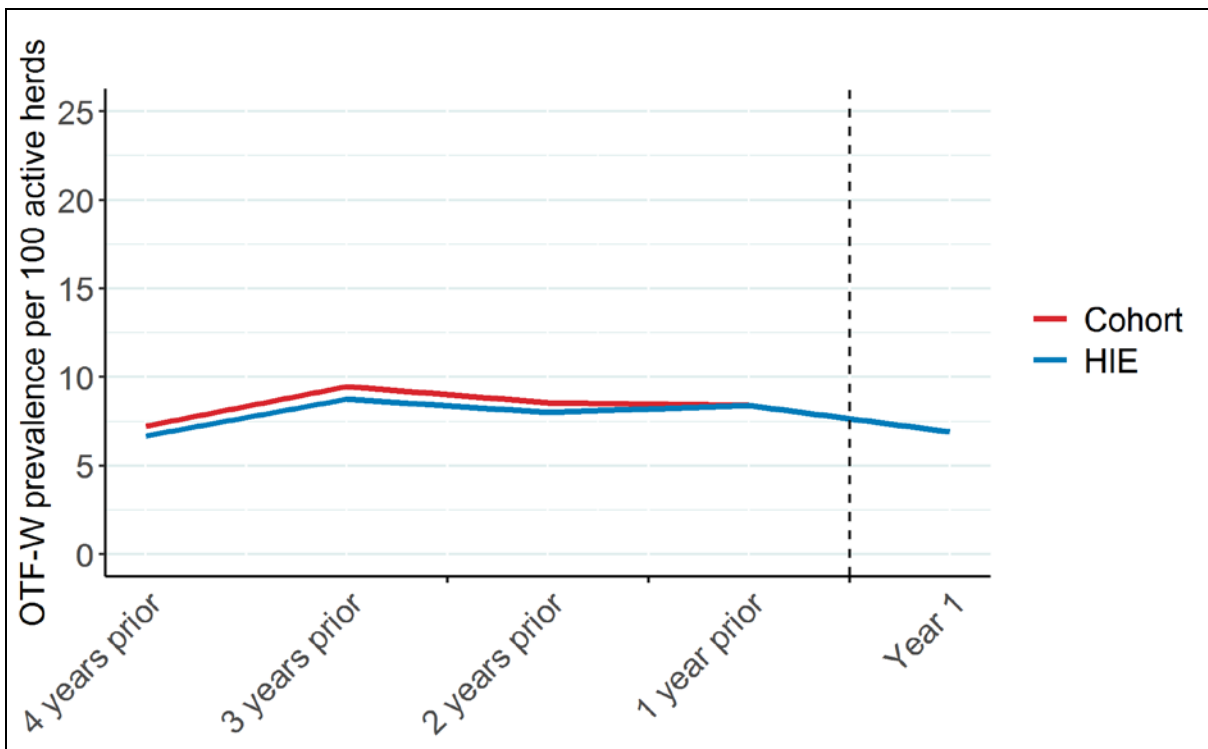
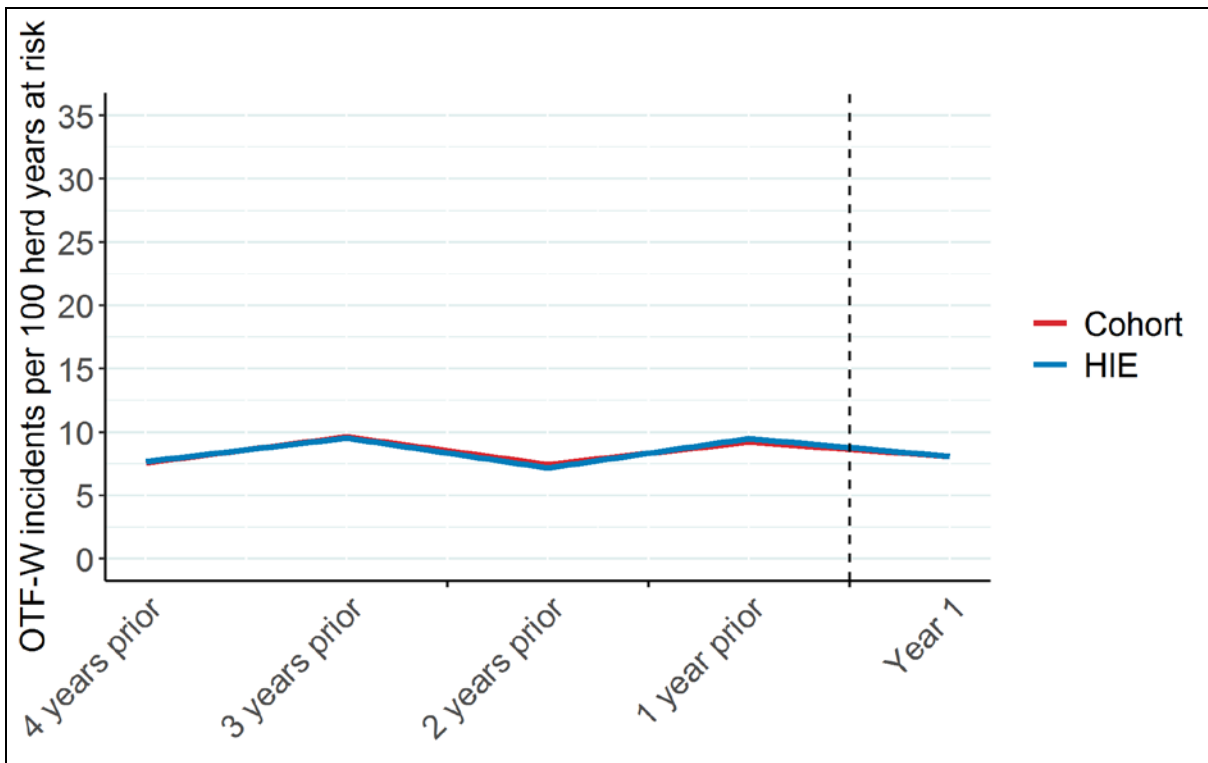


Areas where the cull commenced in 2018

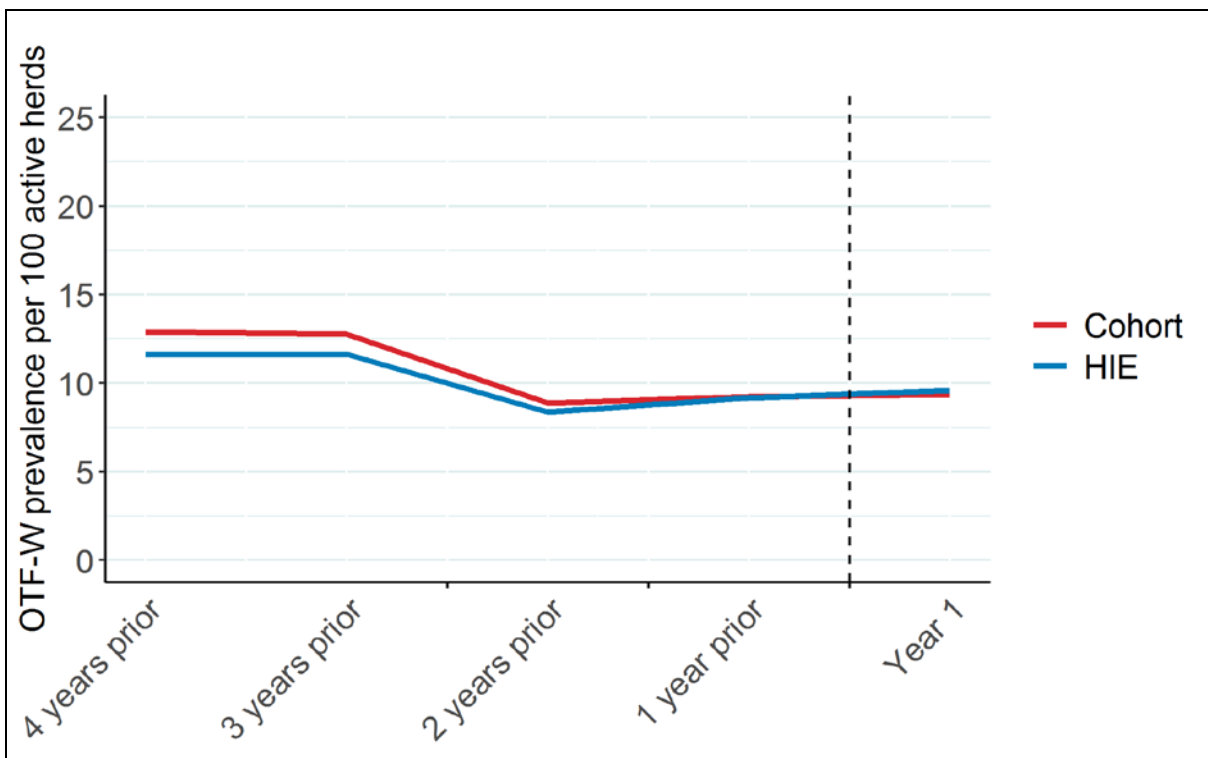
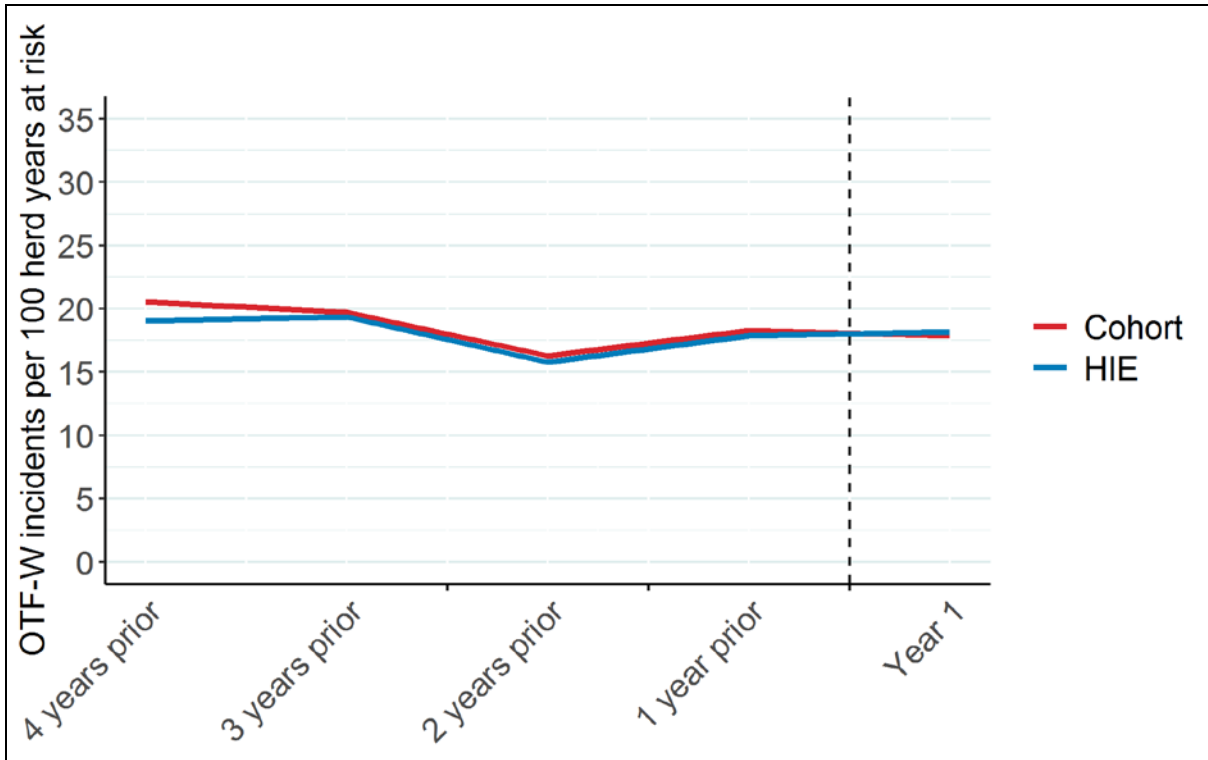
Area 22 - Cornwall central



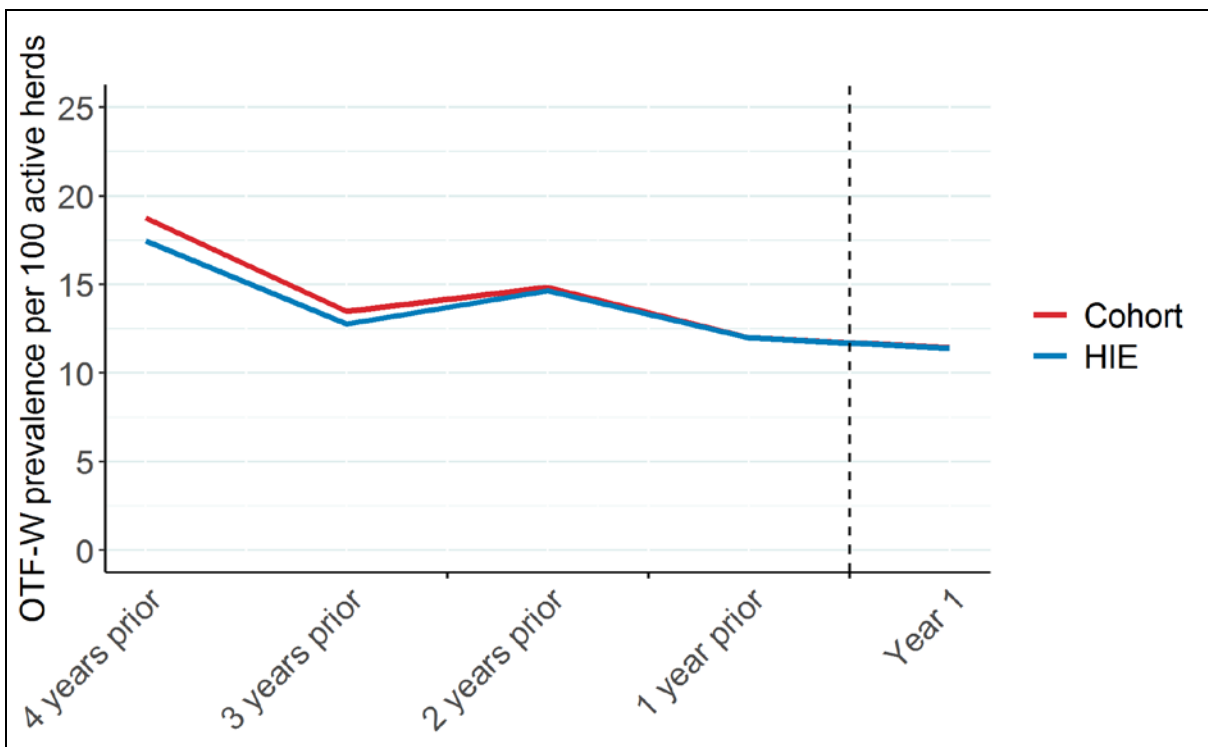
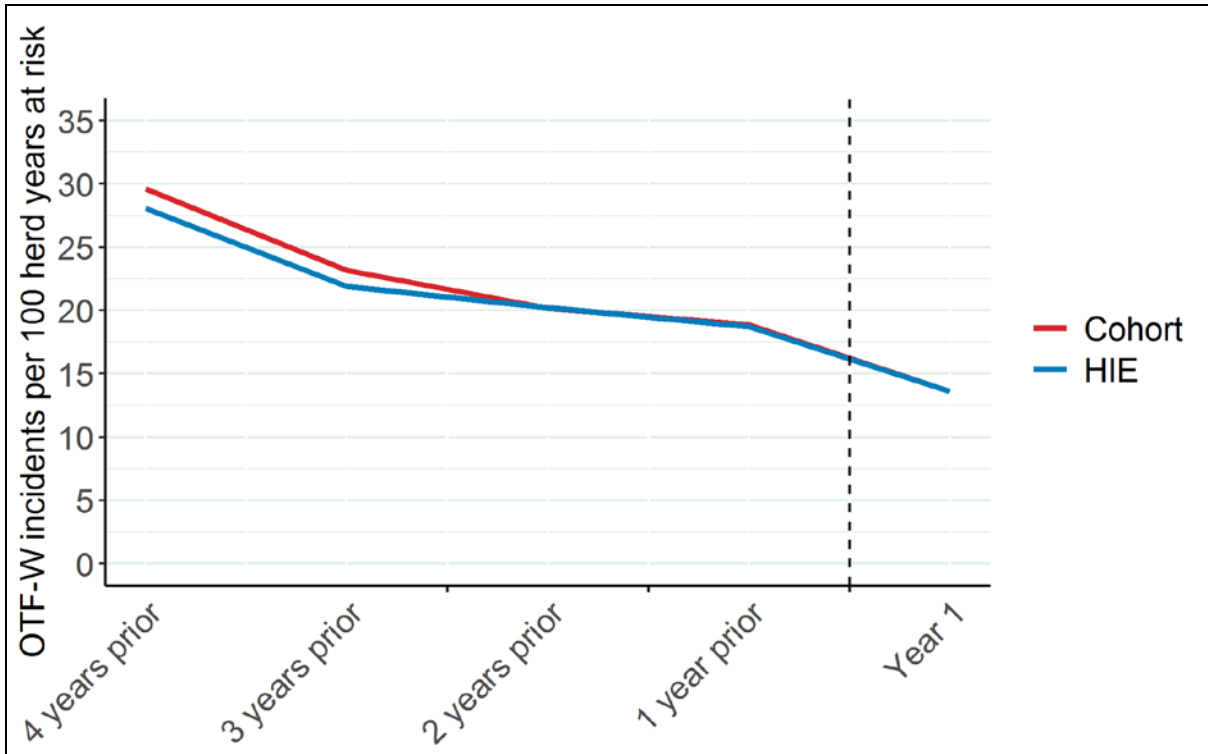
Area 23 - Devon central



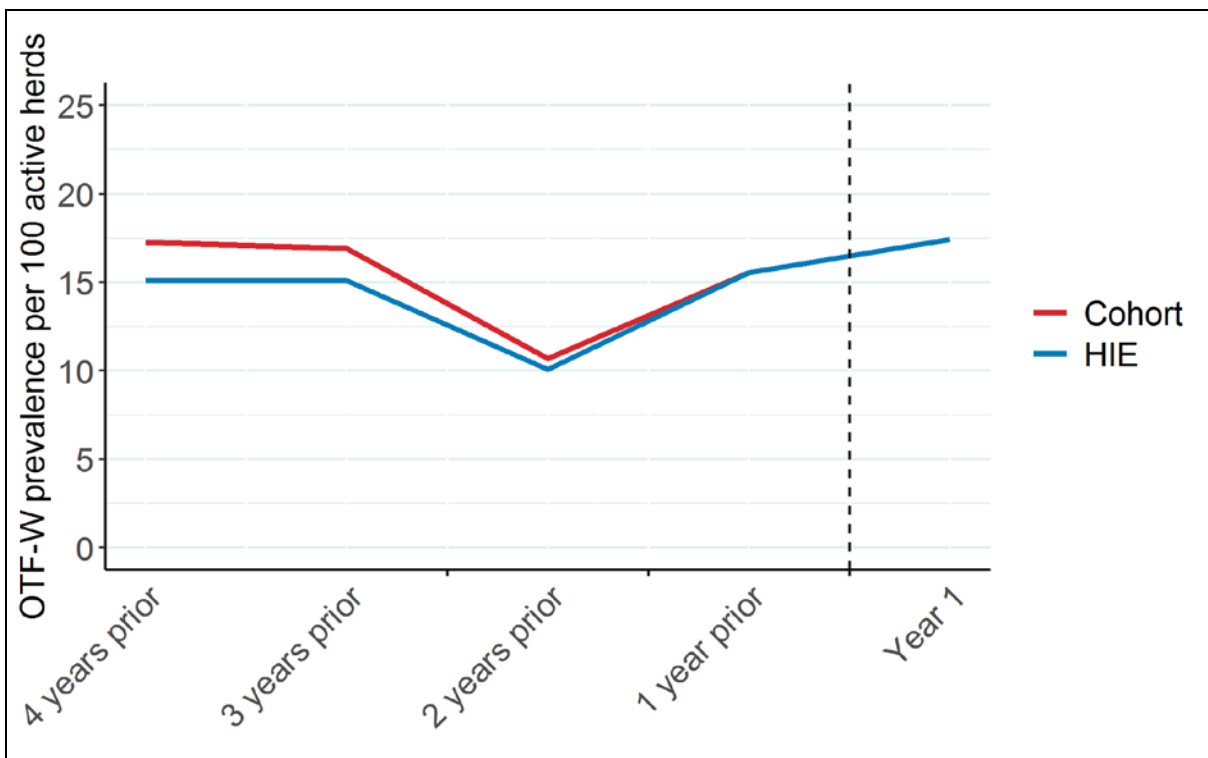
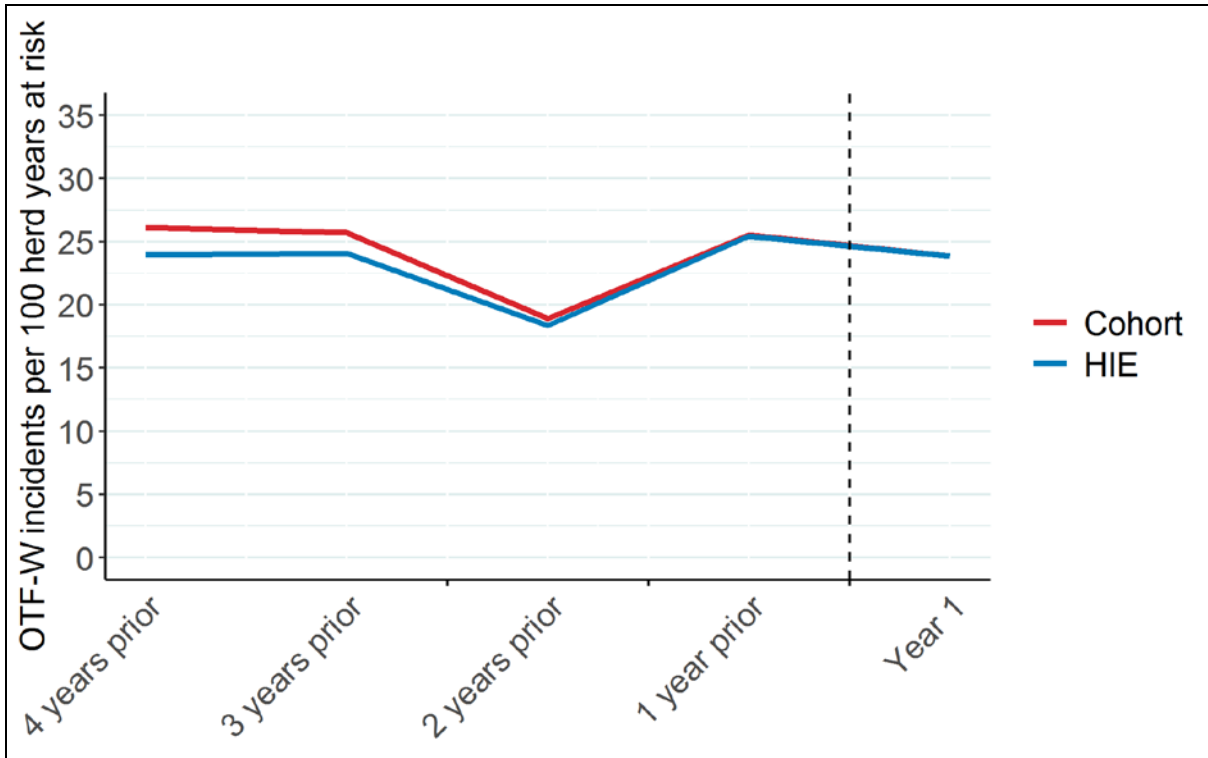
Area 24 - Devon central



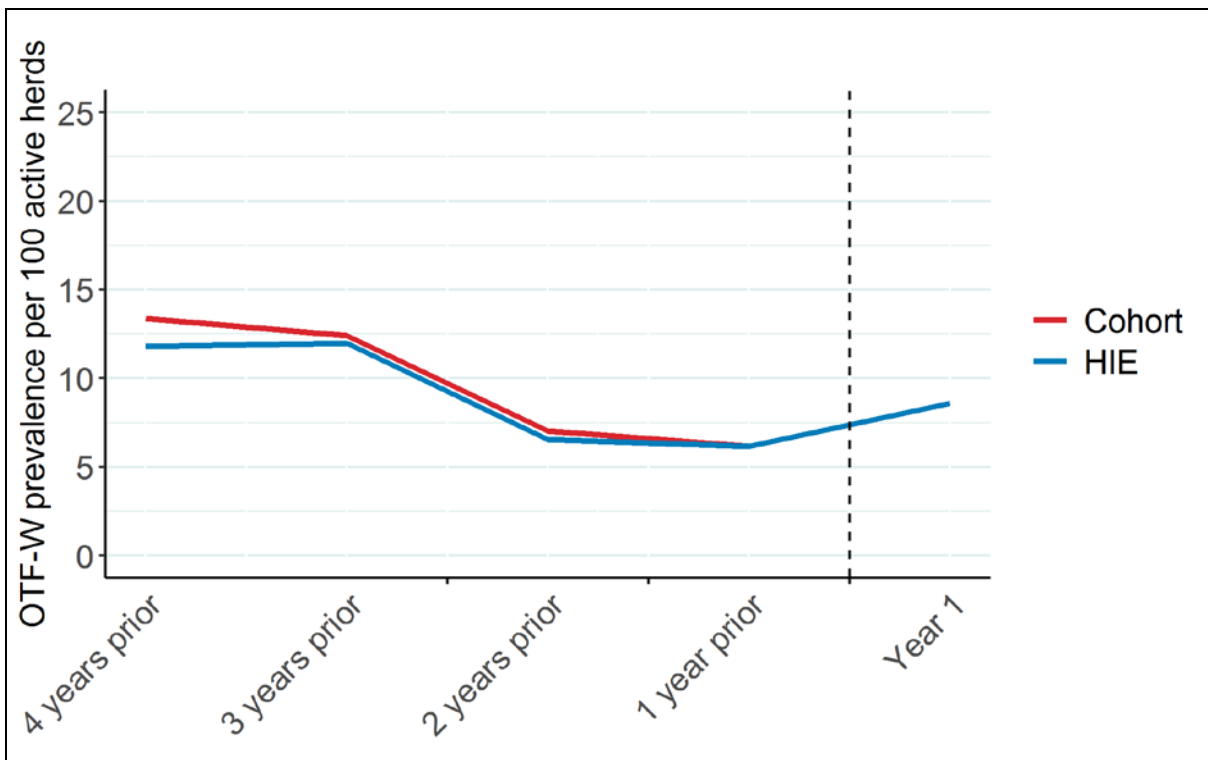
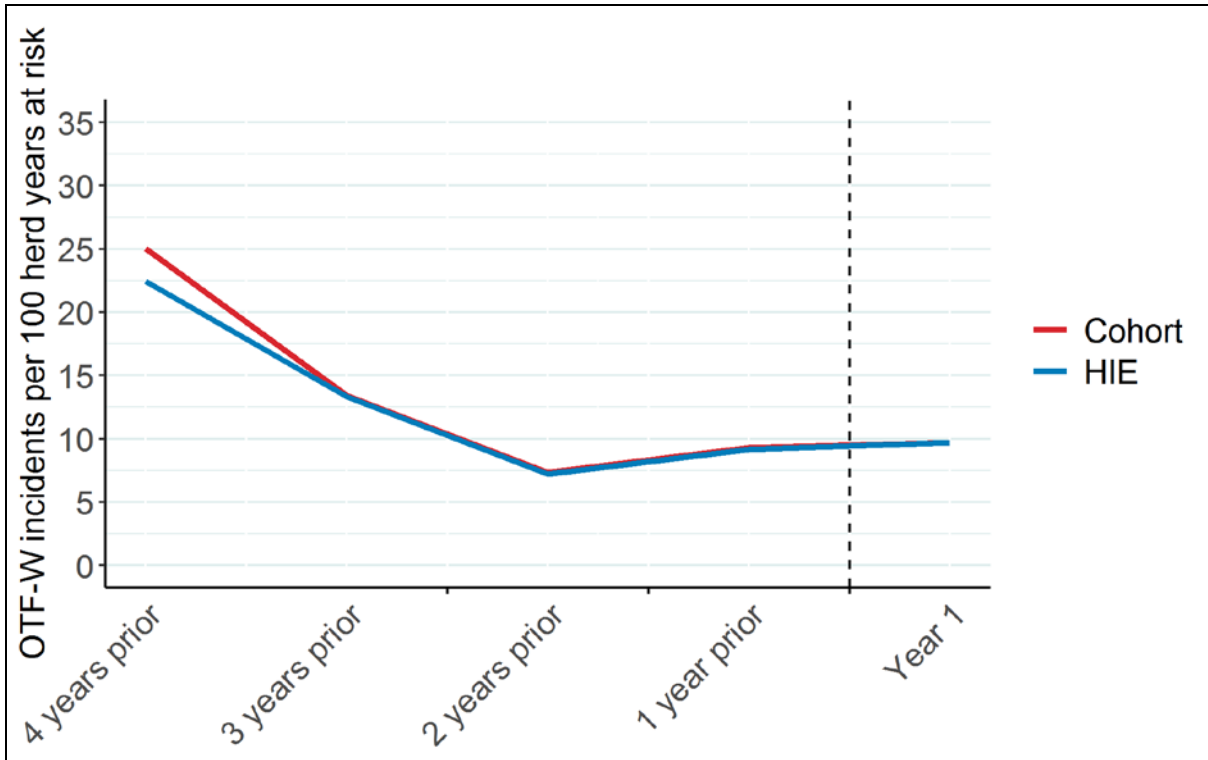
Area 25 - Devon central



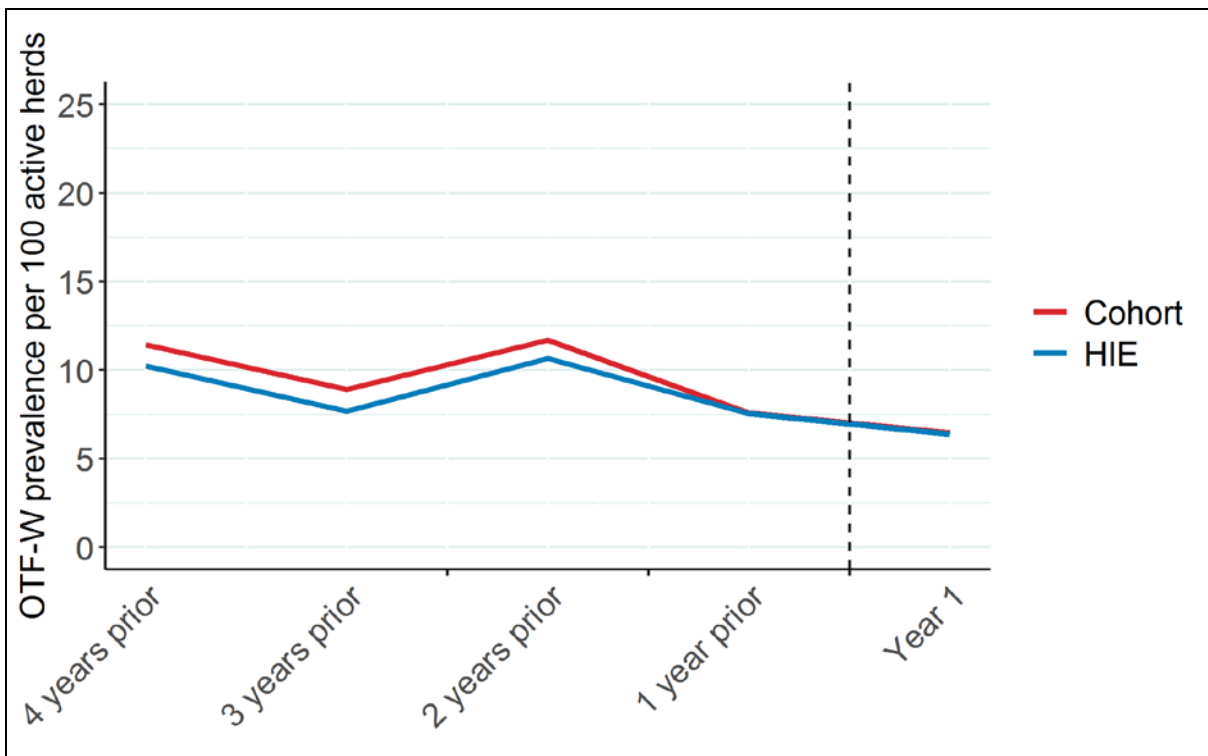
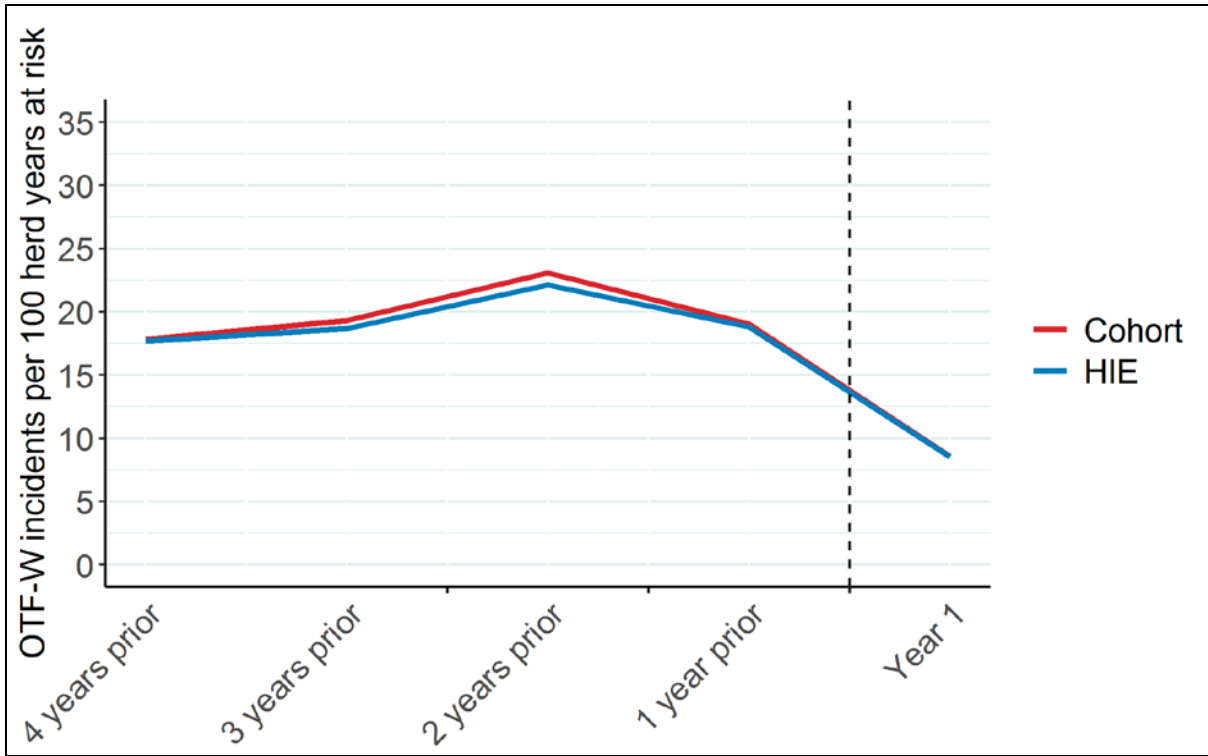
Area 26 - Devon central



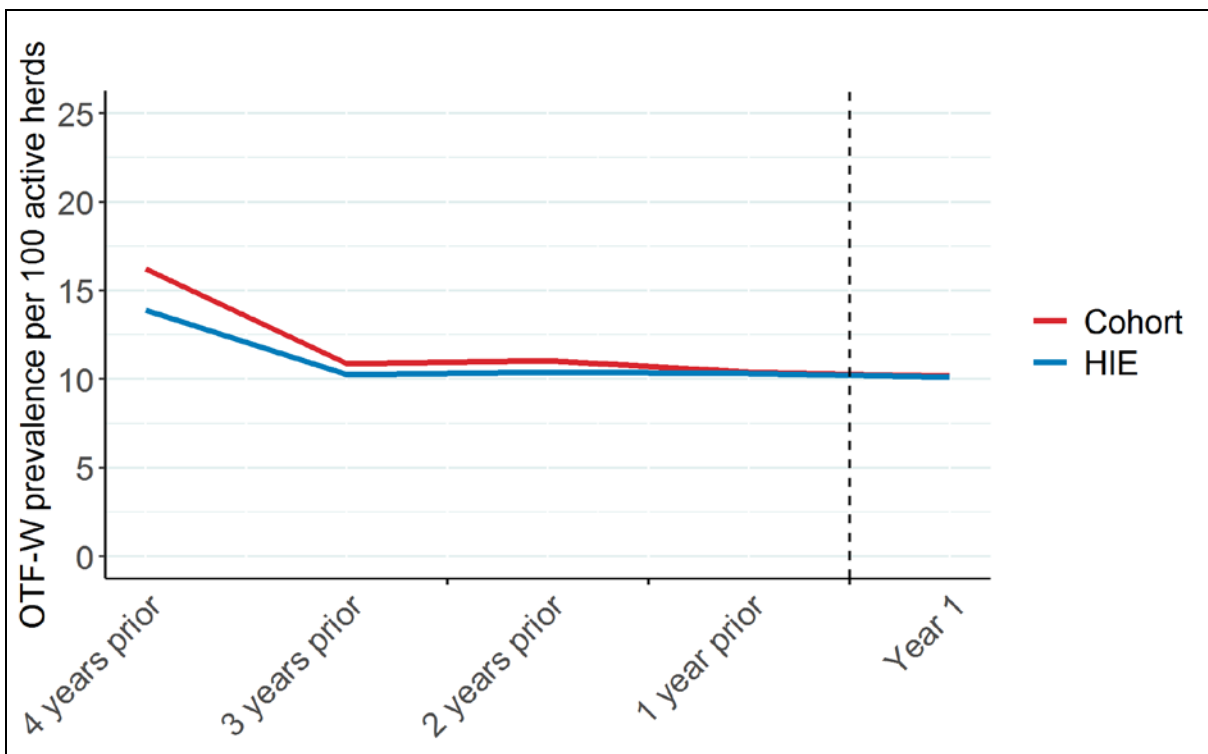
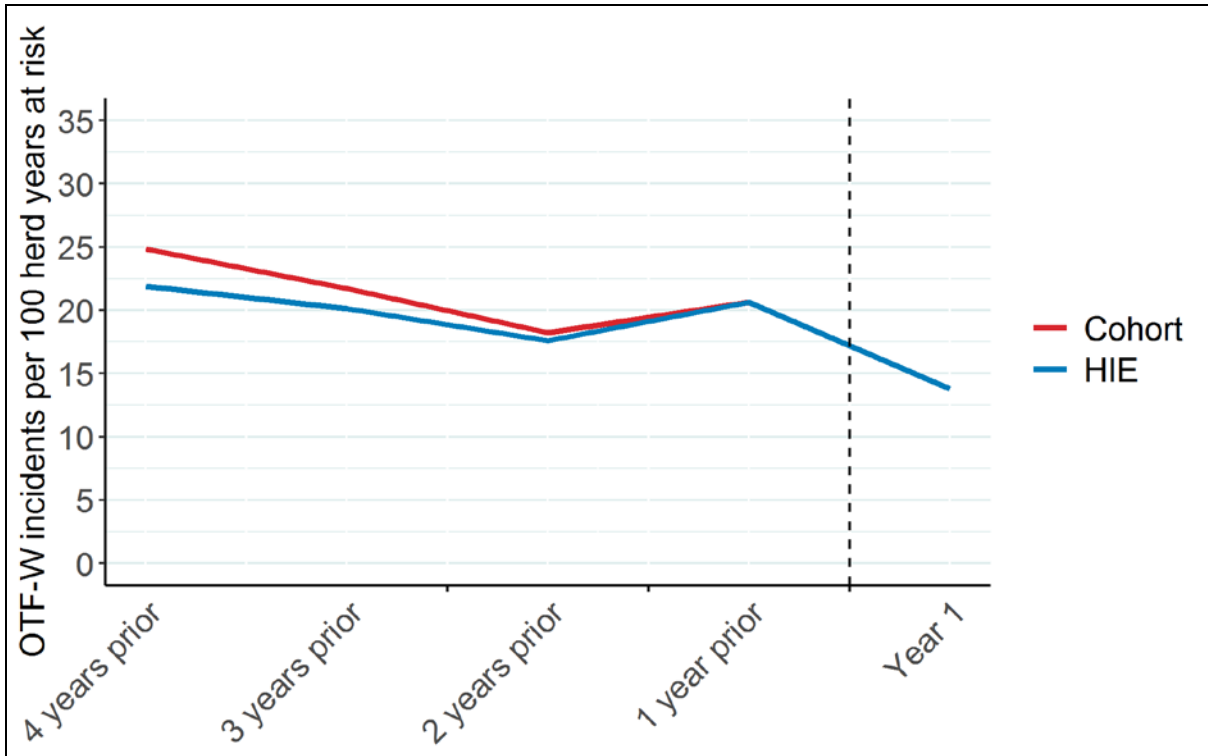
Area 27 - Devon central



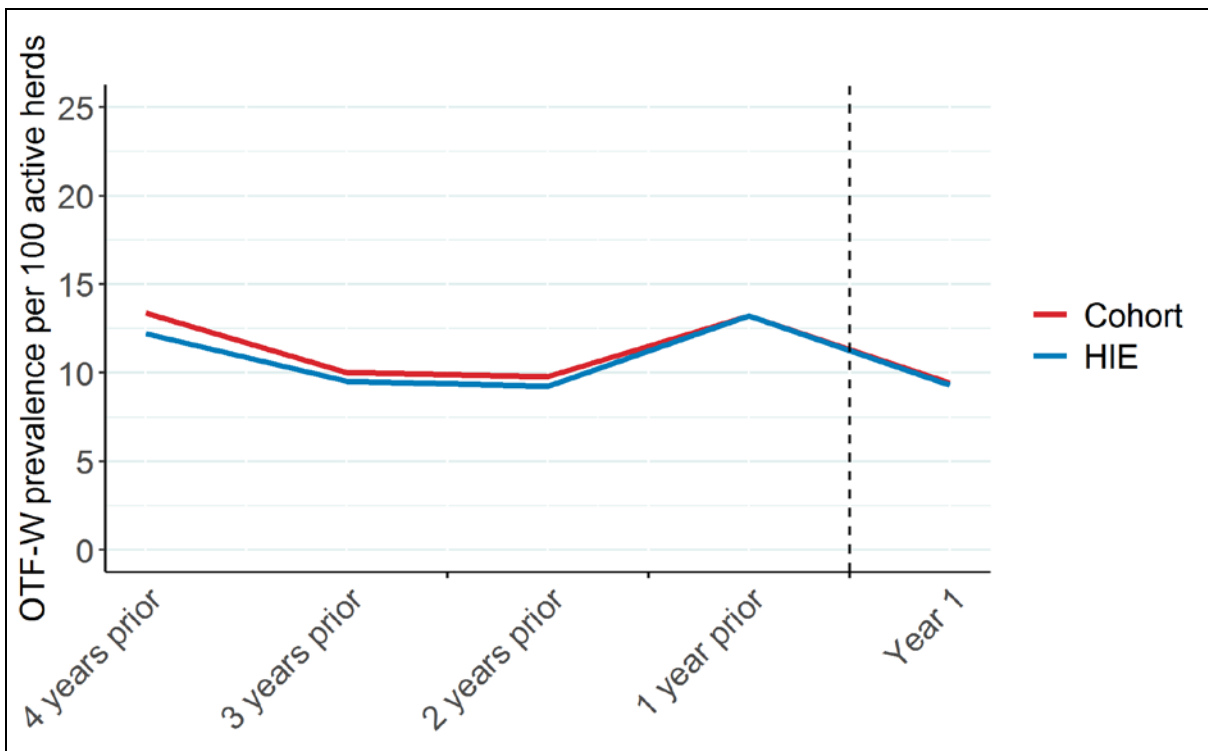
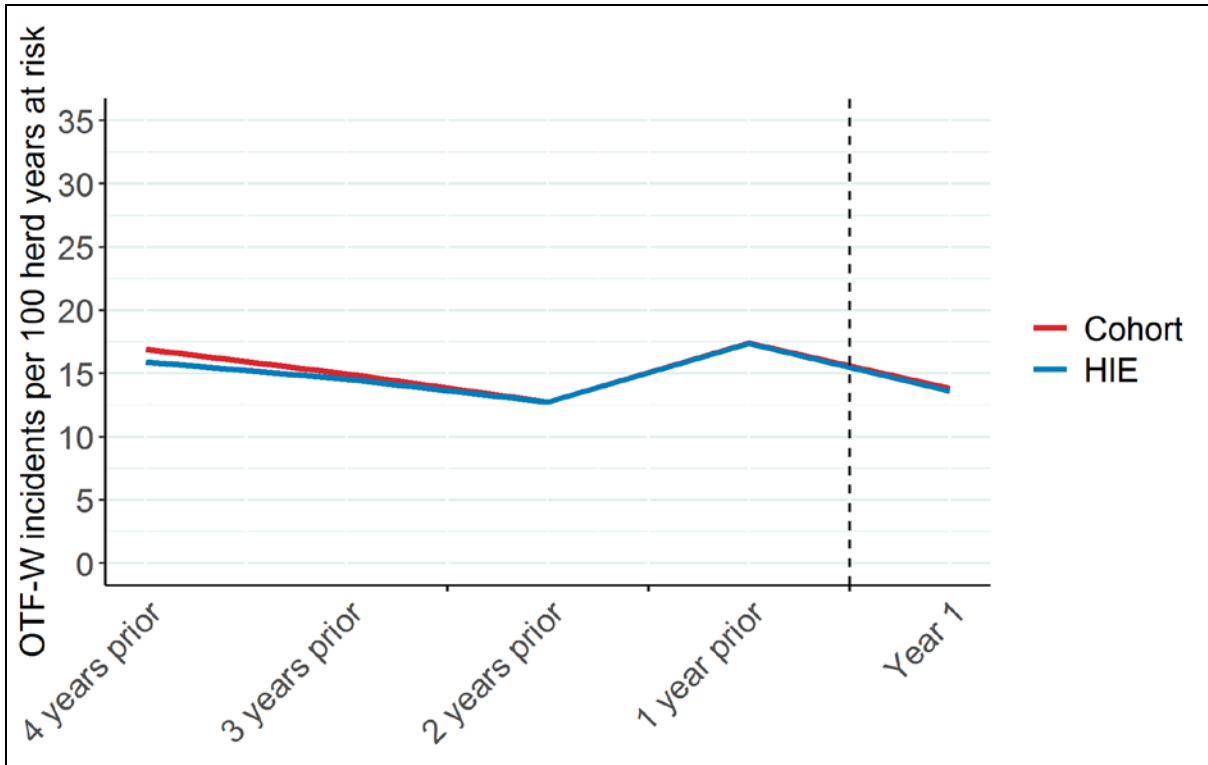
Area 28 - Devon central



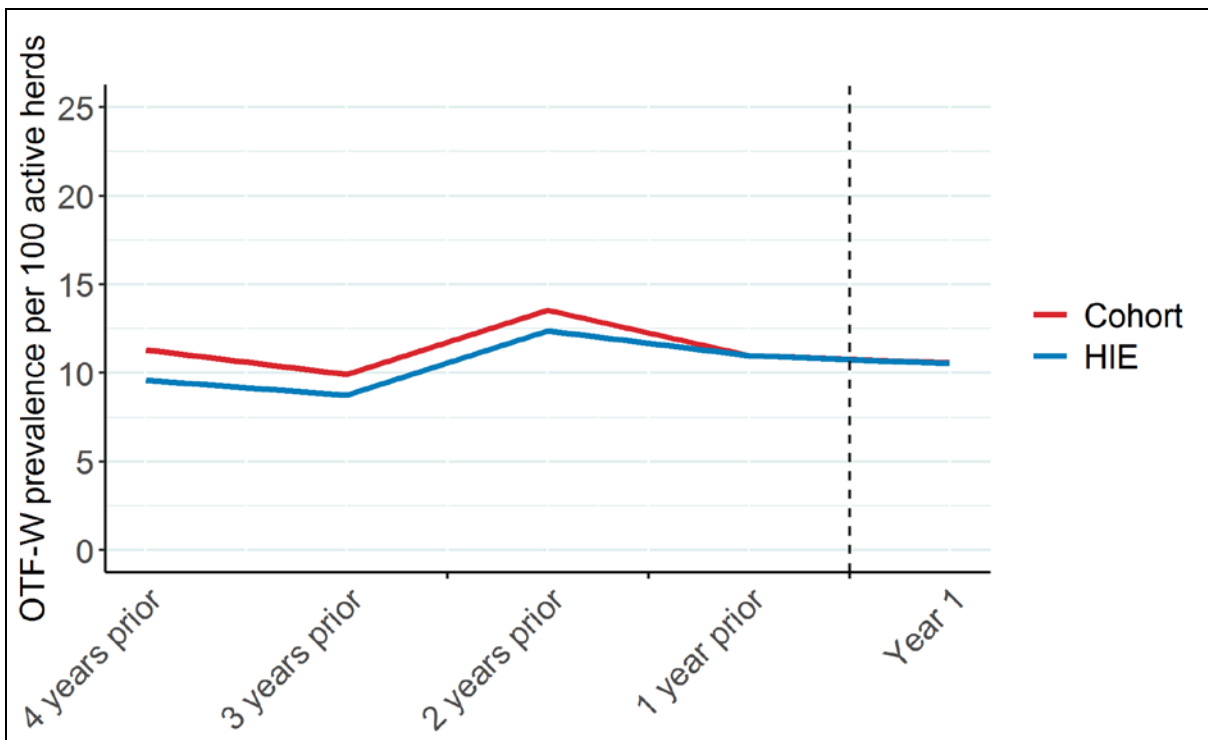
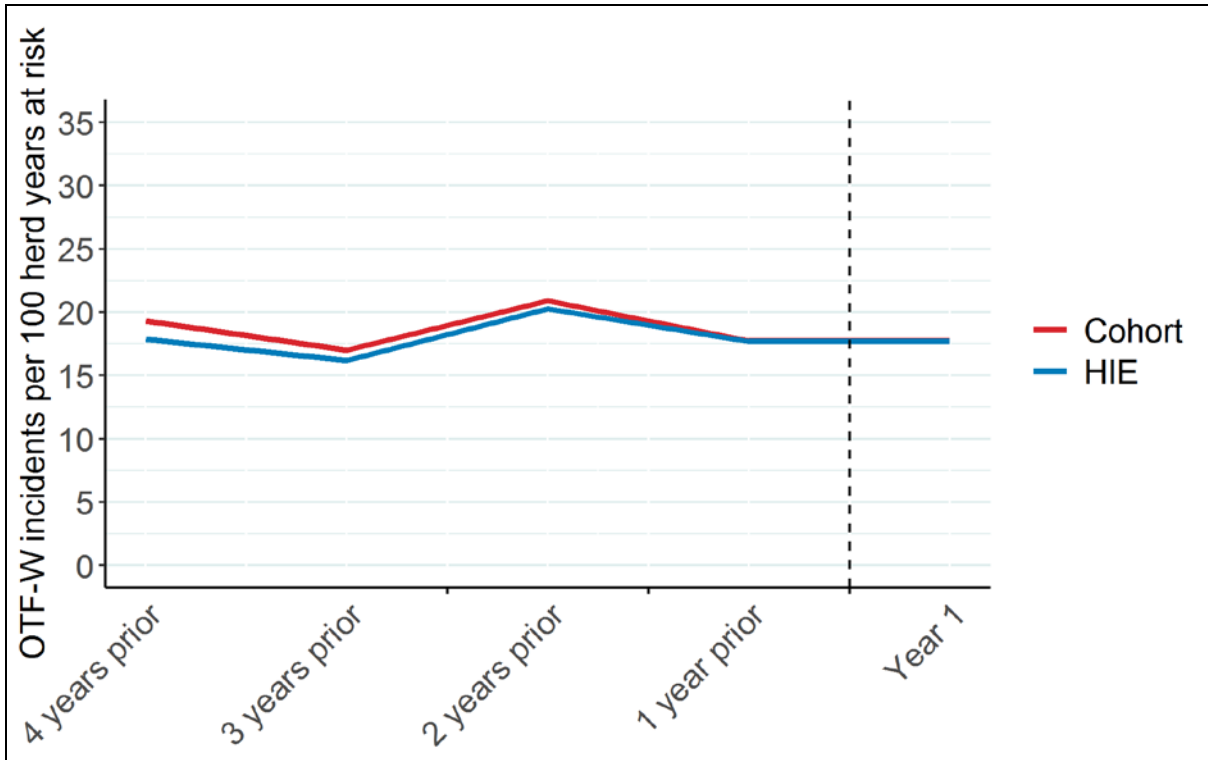
Area 29 - Gloucestershire central



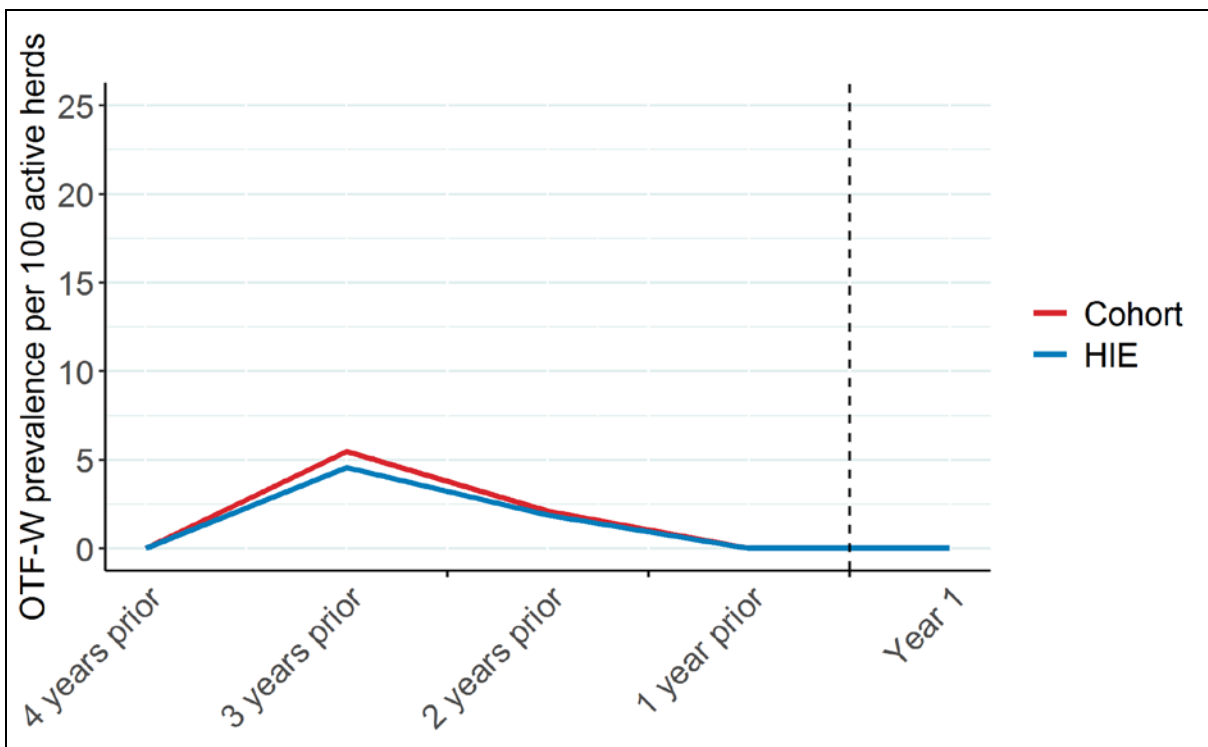
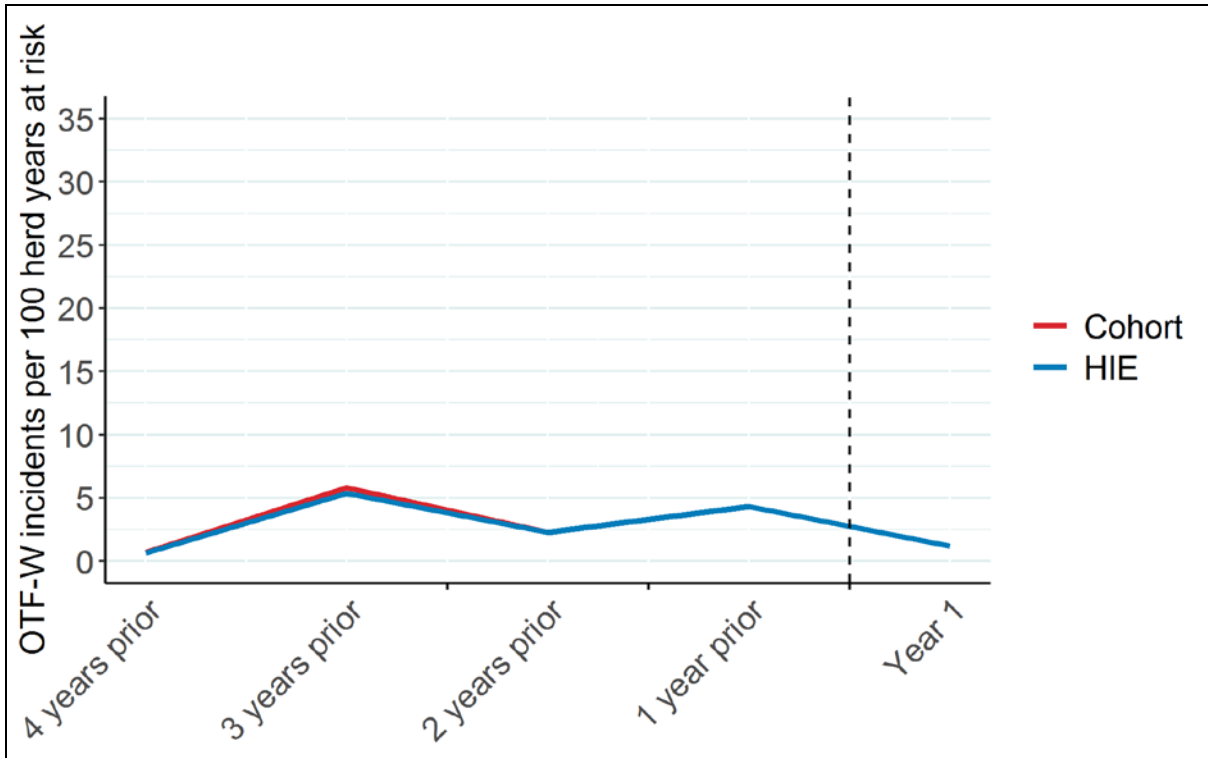
Area 30 - Somerset central



Area 31 - Staffordshire central



Area 32 - Cumbria central



Available buffer zone land and loss of buffer zone land over time

Percentage of 2 km buffer area available at start

The following table, Table 1, shows how much of a complete 2 km buffer area surrounding the central area was available on the baseline date for each area. This can be less than 100% for the following reasons:

1. Central areas are coastally located and only part of the 2km buffer area is on land.
2. The identified buffer area overlaps an existing badger control area and therefore herds in the overlap area are central area herds for that area and cannot remain as buffer herds.
3. An existing buffer area was overlapped by the extension of a central area that did not previously overlap the buffer area.

In future years, some buffer areas may become too small to warrant further monitoring and this will be apparent in this table.

Only those herds which remain as buffer area herds in the current time period are included in the current and retrospective monitoring data provided. That means that annual reports may refer to a reducing group of herds in the buffers to some areas and results are not always comparable between years.

Table 1 Percentage of a 2 km buffer surrounding each cull area at the start of badger control in year 1 and percentage of land remaining as buffer in each subsequent cull year

The dash “-“ indicates that data are not yet available because this cull year has not yet occurred.

Area name	% buffer area available at start	Year 2 %	Year 3 %	Year 4 %	Year 5 %	Year 6 %
Area 01-Gloucestershire	100	100	100	71	71	70
Area 02-Somerset	92	92	92	92	64	28
Area 03-Dorset	100	100	38	38	-	-
Area 04-Cornwall	45	45	36	-	-	-
Area 05-Cornwall	58	58	31	-	-	-
Area 06-Devon	52	36	30	-	-	-
Area 07-Devon	46	37	20	-	-	-
Area 08-Dorset	82	47	31	-	-	-
Area 09-Gloucestershire	92	92	78	-	-	-
Area 10-Herefordshire	82	82	82	-	-	-
Area 11-Cheshire	100	93	-	-	-	-
Area 12-Devon	72	6	-	-	-	-
Area 13-Devon	53	23	-	-	-	-
Area 14-Devon	92	61	-	-	-	-
Area 15-Devon	65	65	-	-	-	-
Area 16-Dorset	45	45	-	-	-	-
Area 17-Somerset	60	59	-	-	-	-
Area 18-Somerset	57	36	-	-	-	-
Area 19-Wiltshire	82	75	-	-	-	-
Area 20-Wiltshire	84	69	-	-	-	-
Area 21-Wiltshire	77	77	-	-	-	-
Area 22-Cornwall	73	-	-	-	-	-
Area 23-Devon	52	-	-	-	-	-
Area 24-Devon	33	-	-	-	-	-
Area 25-Devon	8	-	-	-	-	-

Area name	% buffer area available at start	Year 2 %	Year 3 %	Year 4 %	Year 5 %	Year 6 %
Area 26-Devon	45	-	-	-	-	-
Area 27-Devon	45	-	-	-	-	-
Area 28-Devon	19	-	-	-	-	-
Area 29-Gloucestershire	71	-	-	-	-	-
Area 30-Somerset	90	-	-	-	-	-
Area 31-Staffordshire	98	-	-	-	-	-
Area 32-Cumbria	100	-	-	-	-	-

Bibliography

- Brunton, L. A., Donnelly, C. A., O'Connor, H., Prosser, A., Ashfield, S., Ashton, A., Upton, P., Mitchell, A., Goodchild, A. V, Parry, J. E., & Downs, S. H. (2017). Assessing the effects of the first 2 years of industry-led badger culling in England on the incidence of bovine tuberculosis in cattle in 2013–2015. *Ecology and Evolution*, 7(18), 7213–7230. <https://doi.org/10.1002/ece3.3254>
- DEFRA. (2018). *Guidance to Natural England Licences to kill or take badgers for the purpose of preventing the spread of bovine TB under section 10 (2) (a) of the Protection of Badgers Act 1992*. <https://www.gov.uk/government/publications/guidance-to-natural-england-preventing-spread-of-bovine-tb>
- Donnelly, C. A., Wei, G., Johnston, W. T., Cox, D. R., Woodroffe, R., Bourne, F. J., Cheeseman, C. L., Clifton-Hadley, R. S., Gettinby, G., Gilks, P., Jenkins, H. E., Le Fevre, A. M., McInerney, J. P., & Morrison, W. I. (2007). Impacts of widespread badger culling on cattle tuberculosis: concluding analyses from a large-scale field trial. *International Journal of Infectious Diseases*, 11(4), 300–308. <https://doi.org/https://doi.org/10.1016/j.ijid.2007.04.001>
- Downs, S. H., Clifton-Hadley, R. S., Upton, P. A., Milne, I. C., Ely, E. R., Gopal, R., Goodchild, A. V, & Sayers, A. R. (2013). Tuberculin manufacturing source and breakdown incidence rate of bovine tuberculosis in British cattle, 2005–2009. *Veterinary Record*, 172(4), 98 LP-98. <https://doi.org/10.1136/vr.100679>
- Downs, S. H., Prosser, A., Ashton, A., Ashfield, S., Brunton, L. A., Brouwer, A., Upton, P., Robertson, A., Donnelly, C. A., & Parry, J. E. (2019). Assessing effects from four years of industry-led badger culling in England on the incidence of bovine tuberculosis in cattle, 2013–2017. *Scientific Reports*, 9(1), 14666. <https://doi.org/10.1038/s41598-019-49957-6>
- Jenkins, H. E., Woodroffe, R., & Donnelly, C. A. (2010). The Duration of the Effects of Repeated Widespread Badger Culling on Cattle Tuberculosis Following the Cessation of Culling. *PLOS ONE*, 5(2), e9090. <https://doi.org/10.1371/journal.pone.0009090>
- National Statistics. (2015). *Headline statistic on herd incidence : incidents per 100 herd-years at risk*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/483724/bovinetb-herdmethod-09dec15.pdf