Llywodraeth Cymru
Welsh Government

Technical Advisory Group

Effectiveness of NPIs in the Local Health Protection Zones and the Firebreak in Wales

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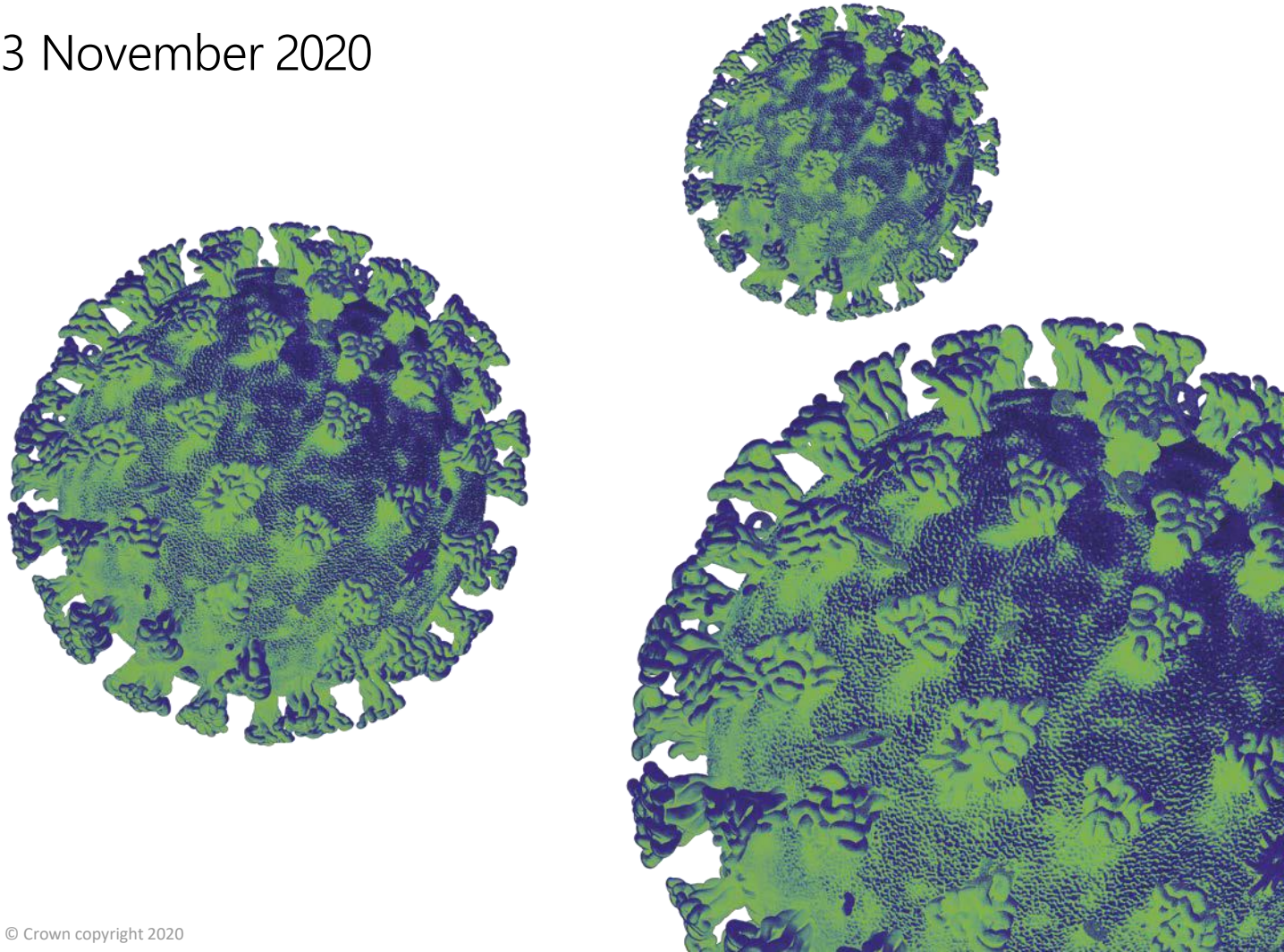

Effectiveness of NPIs in the Local Health Protection Zones and the Firebreak in Wales

Key messages

- The NPIs used for the local interventions appear to have less impact than national interventions (medium confidence)
- The population interventions used in Wales appear to wane over time and become less impactful (medium confidence)
- Further work is required to analyse the impact of local and national interventions to support the response to Covid-19 in Wales (high confidence)

Summary

The purpose of this paper was a rudimentary evaluation of the effects of the local and national control measures for Covid-19 in Wales in September and October 2020, in order to support ongoing policy discussions.

Local interventions designed to suppress the growth of the Covid-19 pandemic in Wales were brought into local authorities at different times in September and October 2020. Whilst further time and data sets will show a more complete picture, our current evidence shows that there have been mixed and limited effectiveness from these non-pharmaceutical interventions (NPIs) which is consistent with SAGE and international findings[1][2]. In no Local Authority (LA) were the restrictions alone effective enough to bring the incidence and positivity of Covid-19 low enough to warrant removing the restrictions.

Where there is an effect, the local NPI packages seem to hold their effect for no more than 21-28 days (high confidence). There may be several reasons why the effectiveness of NPIs lessen over time and they are likely to include “pandemic fatigue” in the population[3], confusion where there are competing messages or where the rules are too complex and uncertainty around how long measures will last.

The firebreak seems to have had a more significant national effect on the transmission of the virus in the population (high confidence), and it is possible that the benefits will pass across to the lagging indicators of hospital admissions, ICU admissions and deaths (low confidence). The high background incidence, high nosocomial transmission and presence of infection in many vulnerable of closed settings such as care homes mean that the benefit of the firebreak on these numbers may be lost before it becomes visible in the data.

[1] SAGE, Summary of the effectiveness and harms of different non-pharmaceutical interventions, 21 September 2020

SAGE, Non-pharmaceutical interventions (NPIs) table, 21 September 2020

[2] SAGE, Impact of Interventions TFG: The UK’s 4 nations’ autumn interventions (update), 26 November 2020

[3] World Health Organisation, Pandemic fatigue - Reinvigorating the public to prevent COVID-19, September 2020

Introduction

In order to offer the best advice based on the evidence available, there is a need to conduct a rapid analysis and review of the effectiveness of the local and national interventions that were introduced in September and October 2020 to reduce transmission of SAR-COV-2. As the 2 week firebreak comes to a close, evidence of what is and is not effective in reducing transmission of the virus in Wales will support decisions on interventions later in the year.

Wales developed a cautious approach to removing restrictions after the first lockdown, and continued to encourage people to work from home where they could, which may have had a suppressing effect on the progress of the pandemic in Wales.

The situation of the firebreak was not optimal. It was deployed as soon as was practically possible in Wales. Whilst a longer period would have been preferable, no central funding was made available until after the Welsh firebreak was underway and commitment to an endpoint had been announced. The modelling and advice that was used to consider the firebreak[4] suggested that a two-week firebreak would reduce the incidence of Covid-19 in Wales by around three weeks, whereas a three week firebreak would reduce the incidence by around five weeks. The most important part of this advice was that after any firebreak the R number should be held to a point as close to R=1 or below as possible.

Recommendations from previous advice have focussed on simplifying regulations, reducing variation at local level and encouraging sustainable behaviour changes that raise personal responsibility for personal and public health.

In some LAs, R may have been significantly higher than the national average as they entered the firebreak period. This could be demonstrated in the rapid growth in cases in the over 60s, hospitalisations and deaths in the associated health board areas.

In order to analyse the impact of the NPIs in local authorities and across Wales we need to find the appropriate set of indicators that can be analysed in order to show whether the interventions are having an effect. Indicators have value at different points in the progress of the epidemic, some leading and some lagging compared to the state of infection at any particular time. None of the indicators on their own is able to give a clear picture of the state or likely progress of the virus, but the following indicators and methods have been chosen for their availability and general value. There is a caveat that with the smaller populations and variety of geographic, demographic and economic factors across Local Authorities in Wales, caution should be taken not to read too much into individual results.

Indicator	Pros	Confounders
Cases per 100,000	Simple indicator Same time as actual infection	Change in number of tests/day Natural noise with low case incidence Small population will inflate data Lag between infection and onset of symptoms
Positivity	Simple indicator Same time as actual infection	Sample bias can be an issue Targeted testing will yield higher results than longitudinal

[4] Technical Advisory Group, Fire break advice, 19/10/2020

Hospital admissions	More complete picture of the size of the epidemic	Lags behind the infections in the population by @14 days
Deaths	More complete picture of the size of the epidemic	Lags behind the infections in the population by @20 days
Movement data	Early indicator of changed behaviours	
Spending data	Early indicator of changed patterns of behaviour	Does not discriminate between online and in store spending Lag can exist depending on timing of data

Method

Case incidence: analysis is based on the PHW incidence data (up to 6 November for the interrupted time series analysis), cutting off the most recent few days to ensure there are fewer artefacts associated with delays in test result reporting. The figure is a 7 day sum of number of positive test results per 100,000 people in the population.

Interrupted time series (ITS): data has been run on R using a single series ITS based on segmented linear regression:

$$y = \alpha + \beta_1 T + \beta_2 X + \beta_3 XT + \varepsilon$$

where T = time, X = study phase, XT = time after interruption.

The series and analysis presented in this paper are based on variation before and after the date of implementation of the local NPIs or before and after the date of implementation of the firebreak (up to 6 November).

ARIMA: We also carried out an ARIMA model in SPSS as an additional method looking at the impact of local controls, comparing before and after, 7 days before/after, 14 days before/after, and 21 days before/after (or up to 31st October 2020 if that occurred sooner). This was a first order autoregressive model (known as an ARIMA (1,0,0) model). This is predicting the confirmed case rate for each day as a multiple of its own previous value (the day before), plus a constant. The forecasting equation in this case is

$\hat{Y}t = \mu + \phi 1 Yt\text{-}1$

This is Y regressed on itself lagged by one period. In this case we are seeing whether the introduction of local health protection zones changes the trend. We followed methods from Cochrane collaborative (2017).[5]

PHW also carried out an ARIMA analysis to forecast case counts during the lockdown (LD) and a period without lockdown intervention (noLD). In (Ricoca et al. 2020)[6], ARIMA and exponential smoothing models were used to forecast the Covid-19 counts, ICU admissions and deaths in Portugal over their lockdown period. A comparison was made between the forecast (no lockdown) and observed counts (lockdown). This showed that actual incidents of Covid-19 were significantly lower than forecast.

[5] *Cochrane Effective Practice and Organisation of Care (EPOC). Interrupted time series (ITS) analyses. EPOC Resources for review authors, 2017. epoc.cochrane.org/resources/epoc-specific-resources-review-authors*

[6] Ricoca, Vasco, André Vieira, Pedro Aguiar, and Carlos Carvalho. 2020. "Rapid assessment of the impact of ' lockdown ' on the COVID-19 epidemic in Portugal." medRxiv, no. March. https://doi.org/10.1101/2020.05.26.20098244

PHW applied the same principle to case counts across Wales to make forecasts of case counts with and without lockdown measures. The method carried out is as follows:

- We generate a list the dates of local lockdowns for each LA. Note we Gwynedd (Bangor) and Carmathenshire (Llanelli) are partial lockdowns but assumed to be treated same as other lockdowns.
- In UK, national lockdown began on 23 Mar. We choose to model 7 days from this date as the cut off because of the expected time required for lockdown effect to manifest in case counts. We then split the data into LD and no-LD periods.
- For LD, we use a 60 day period after the start of the first national lockdown.
- For noLD, a period of 60 days preceding the onset of regional or firebreak lockdown (whichever is the earliest) is used.
- The timeseries is smoothed with a LOESS filter (span=0.2). The smoothed time series for each window for each LA is shown below.

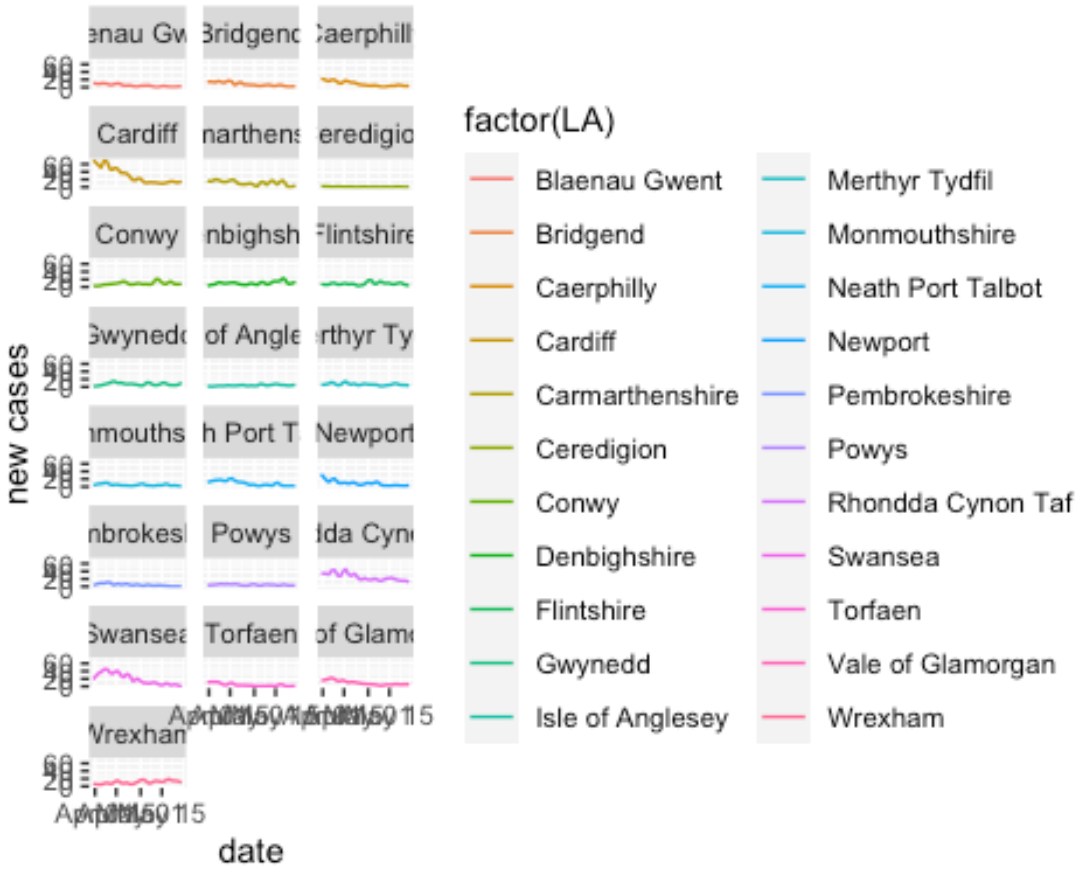

Fig. 1. Smoothed case counts data used to train the noLD model.

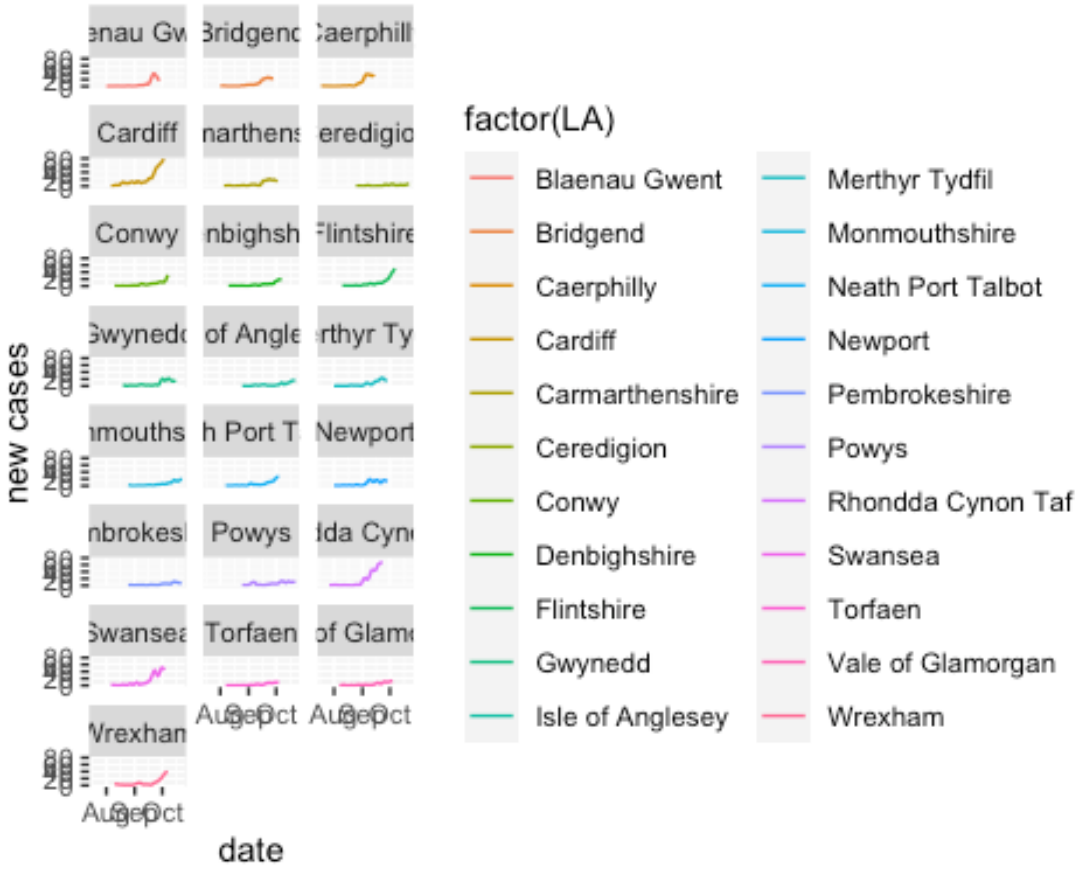

Fig. 2. Smoothed case counts data used to train the LD model.

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- We use auto.Arima function to get the optimal p,d,q parameters for the ARIMA model. This will be fixed across all LAs for the subsequent ARIMA models. We manually check which p,d,q values look the best. We use c(2,2,1) for noLD and c(2,1,0) for LD.
- Forecasts for 50 days from lockdown date (either the local lockdown or the firebreak lockdown, whichever is earliest) are generated from the LD and noLD.
- For the LD forecast, the forecast is adjusted to compensate for differences in case counts at the start of lockdown and the end of the LD period used to generate the forecast.

Mobility data: analysis is based on data from Google (up to 3 November) and data from O2 (up to 30 October)

As this analysis contains the O2 data it cannot be shared/referenced outside Welsh Government/Technical Advisory Group.

The analysis considers changes in mobility from when the local lockdowns or firebreak started. For example the local lockdown in Caerphilly started on the 8th of September whilst in Conwy it started on 1 October, these are considered as day 0 in the analysis – so 7 days in the chart would be the 8 October for Conwy or the 15 September for Caerphilly.

Changes to local estimates of doubling time and effective reproductive number (Rt) following the firebreak[7]

Public Health Wales produces weekly estimates of doubling time and Rt using routine surveillance data. All positive SARS-CoV-2 testing episodes are deduplicated based on a 42 day episode period, and analysed using the date of sample, excluding the most recent 4 days' data to account for reporting lag. Doubling times were calculated by fitting a log linear model. Reproductive numbers were calculated using the R package "EpiEstim", with a non-parametric serial interval (time of clinical onset of one case, to the next) with a mean of 6.5 days and SD 2 days. This is based on the method by Cori *et al*. [1]

We compared doubling times for the 14 days prior to lockdown (09/10/2020 to 22/10/2020) was compared to the 14 days 25/10/2020 to 06/11/2020, and Rt values calculated on 22/10/2020 with that on 06/11/2020.

Limitations

Limitations and confounders in this analysis are:

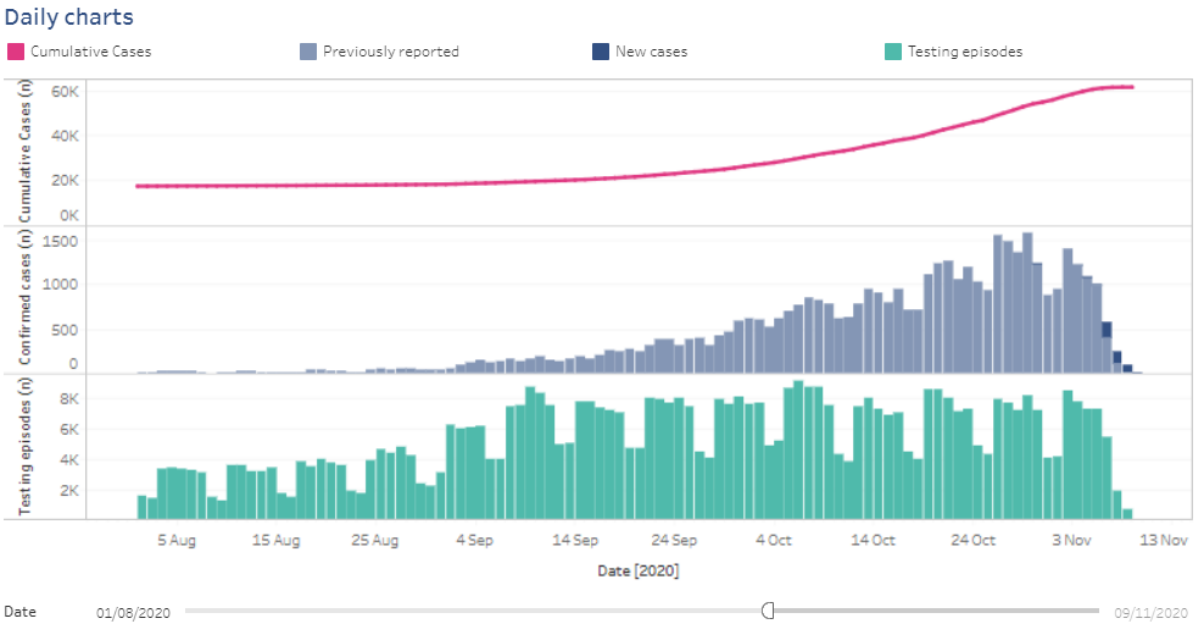
- Population size in LAs
- Testing incidence in different age groups
- Net migration during study period (e.g. borders, students)
- School half term length varied between LAs
- Timings of local NPIs
- Variations of local NPIs
- Epidemiology in LAs (e.g. multiple of single seeding events, numbers driven by outbreaks, or nosocomial transmission)
- Demographics in LAs
- Geography in Las
- Doubling time and Rt estimates are sensitive to changes in testing patterns and reporting lags. Confidence intervals should be taken into account. The Rt calculation assumes homogeneity in mixing and a closed system.

In some Welsh LAs there are less than 100,000 people, which means that a measure of cases per 100,000 will appear larger than the true value of cases.

Analysis of positive test incidence per 100,000 must take into account the difference that will come from absolute population size and from the variation in the number of tests carried out in an area. Mitigation can be made by accounting for the change in testing by location. Figure 1 offers some confirmation of a stable testing incidence in Wales over the period of investigation. Further analysis shows limited regional variation, but not enough to confound the results discussed below

[7] Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez, A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics, American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Figure 1 Comparison of confirmed cases and testing episodes in Wales[8]



There is more concern with the introduction of significant migratory populations (@40,000 students) associated with the start of further education. Significant university populations arrived in Cardiff, Swansea, Neath Port Talbot, Newport, Ceredigion and Gwynedd, and almost all Local Authorities have some migratory student population. These confounders are acknowledged and investigation is ongoing, but they have not been quantitatively mitigated in this paper.

History bias is a confounder that can lead to implied causation associated with a single activity, when there are many things that happened at the same time that may have had an effect. This has been shown in studies such as the recent SAGE paper on transmission in children and schools[9] where it was shown that many behaviours and activities are associated with the opening of a school. The proposed mitigation is to compare only LAs that have the same package of NPIs (Annex A with table of NPIs and date of introduction), and to compare against the time of intervention, rather than absolute time. Geographic position relative to a border, physical geography and urban/rural variations between LAs may be significant but are not accounted for. Meteorological variation is assumed to be largely comparable for the time series. Autocorrelation is not considered, but further regression analyses are needed, taking into account the epidemiology of the virus, to allow for a lag of at least one incubation period between the introduction of an NPI and the expected time to affect case incidence.

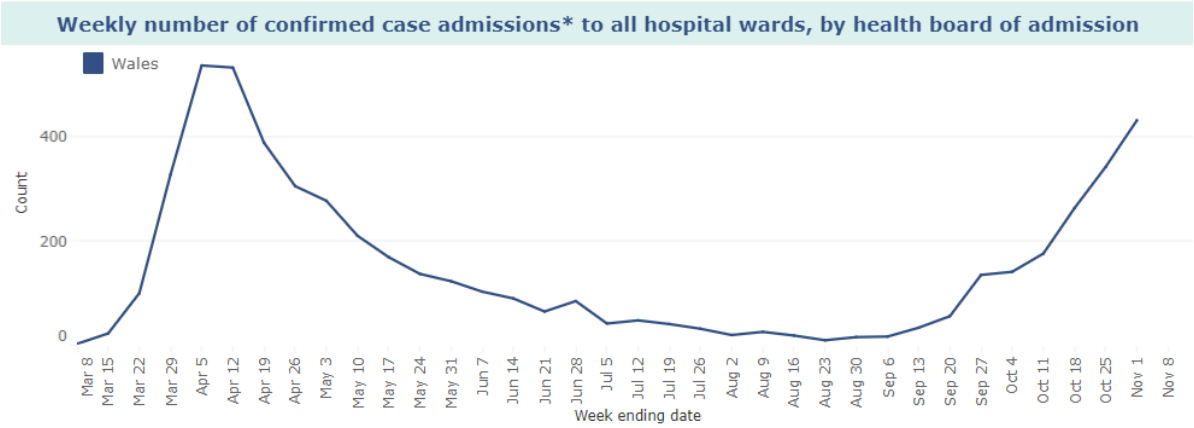
Comparability with the first wave is only possible using lagged indicators, such as hospital admissions (figure 2).

Further mitigation against could be introduced by splitting the case incidence into age bands.

[8] Source PHW Rapid Covid-19 Surveillance dashboard 10/11/2020

[9] SAGE, TFC: Children and transmission, 04/11/2020

Figure 2 Number of hospital admissions testing positive for Covid-19 in Wales[10]

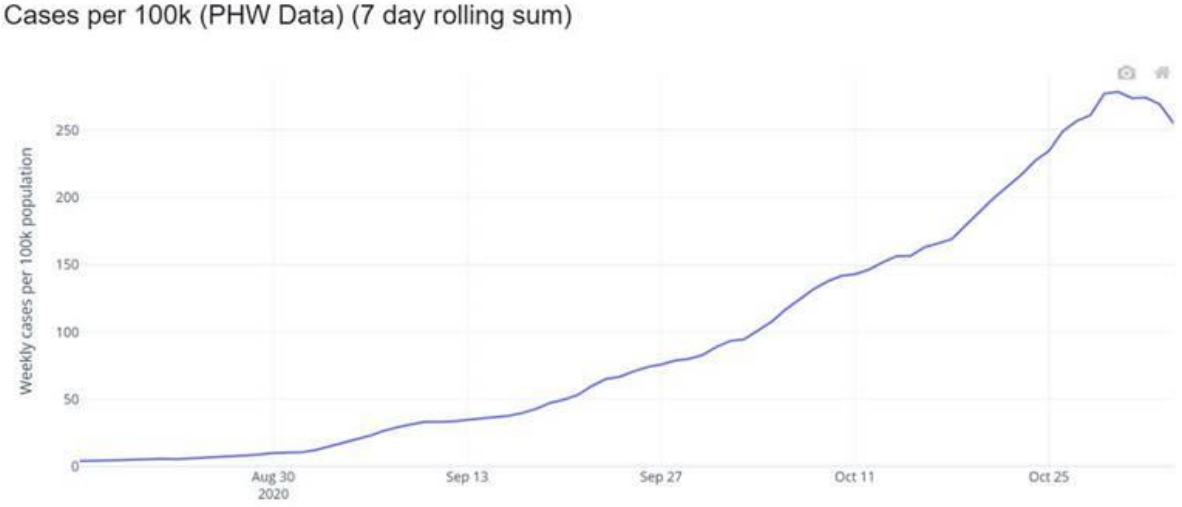


Results

Case incidence over time

Using the simple analysis of rolling 7-day average number of positive cases per 100,000 in a population, day by day, there is a basic indicator of the progress of the Covid-19 pandemic in Wales and by Local Authority.

Figure 3 case incidence per 100,000 across Wales



In considering the situation across the whole of Wales (figure 3) from late August to the present it is possible to see effects from the local NPIs on the progress of the epidemic (these are points where the curve seems to flatten on figure 3). These effects represent a slowing of the epidemic, and a slow return to the exponential rise. By comparison, the effect of the firebreak is swift and significant – the curve turns and the trend in incidence goes down. The incidence indicator shown here lags behind the intervention by around 5-8 days, and may be more pronounced in some areas than others. Importantly, on its own it cannot show a reduction in the overall epidemic, but it is promising, and if overall test positivity is shown to be declining (figure 4) at the same time then there is a more solid evidence of reduction.

[10] Source PHW Rapid Covid-19 Surveillance dashboard 10/11/2020

Figure 4 Test positivity across Wales

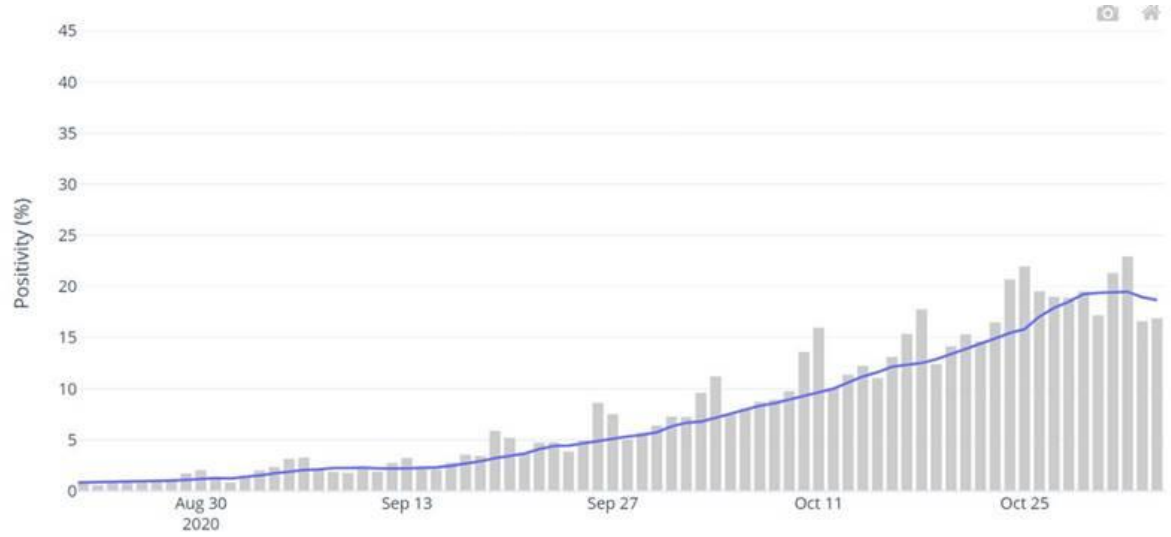
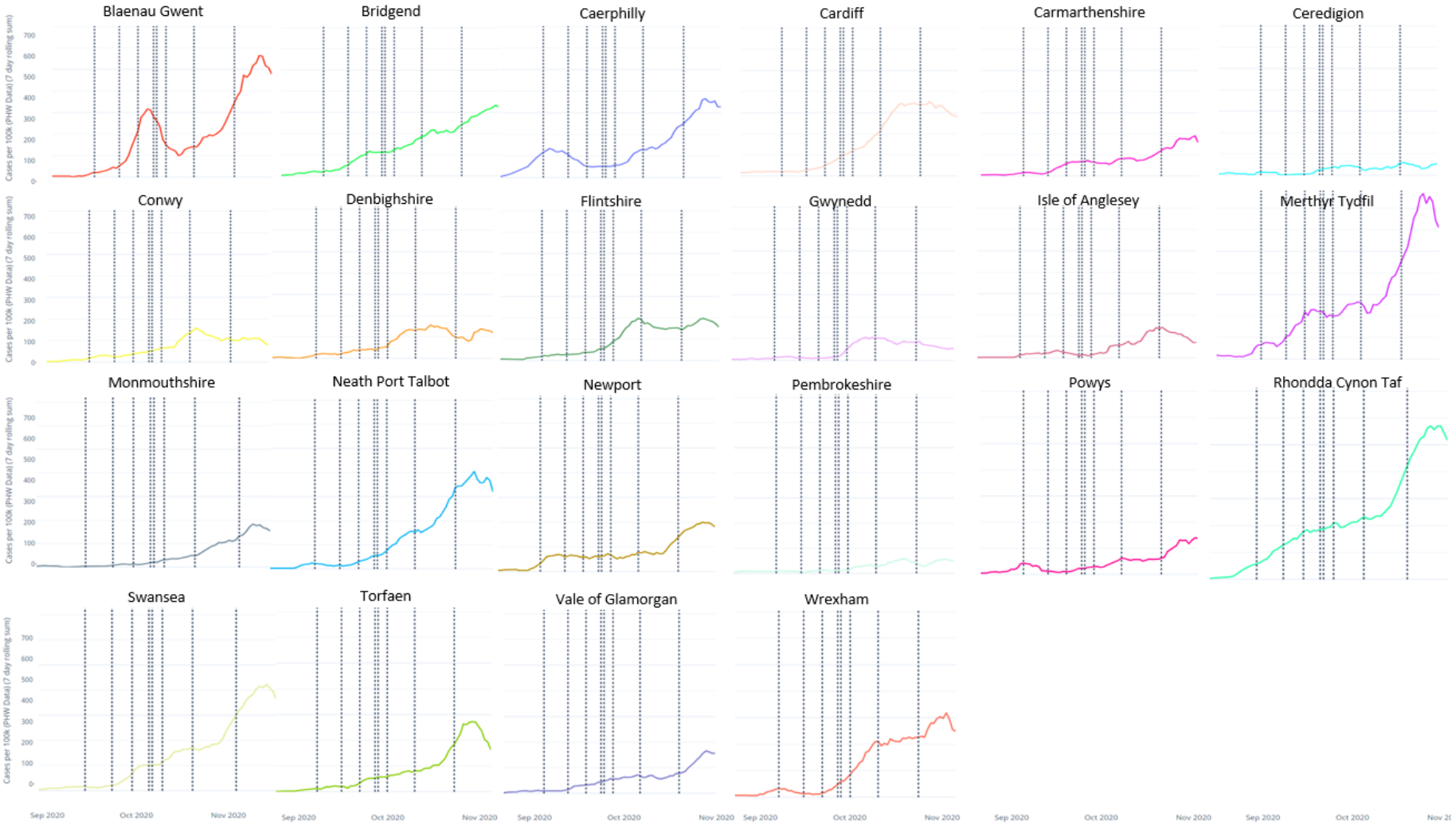


Figure 5 Case incidence by each local authority in Wales (Sep-Nov 2020)



In considering the incidence at a Local Authority level there is evidence of significant variation in the incidence of the virus, and caution should be taken to consider confounders during interpretation.

Monmouthshire and Powys have relatively clear signals of exponential growth, unchecked by local NPIs. However, Pembrokeshire and Ceredigion have also avoided local NPIs, and have followed a very different path, possibly due to the remote geography and very low density, rural population.

In the valleys and Beacons of South East Wales, Merthyr Tydfil and Rhondda Cynon Taf show only a near-plateau concomitant with an Rt of around 1.1 as a result of their NPIs, whereas Caerphilly and Blaenau Gwent, with similar geography and demographics, brought Rt below 1 for a period. In Cardiff, Swansea and Neath Port Talbot, the arrival of a proportionally significant population of students may well mask any signal of effect from the local NPIs placed there. This was highly likely the case in Gwynedd, where the arrival of students in Bangor increases the size of the population by a significant amount.

Figure 6 Local Authorities with an English Border

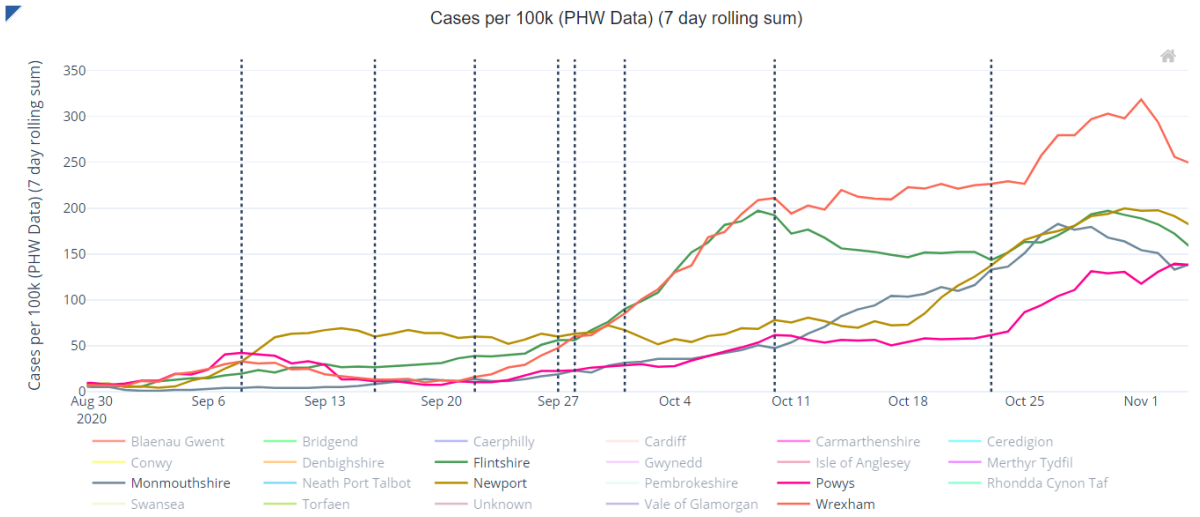
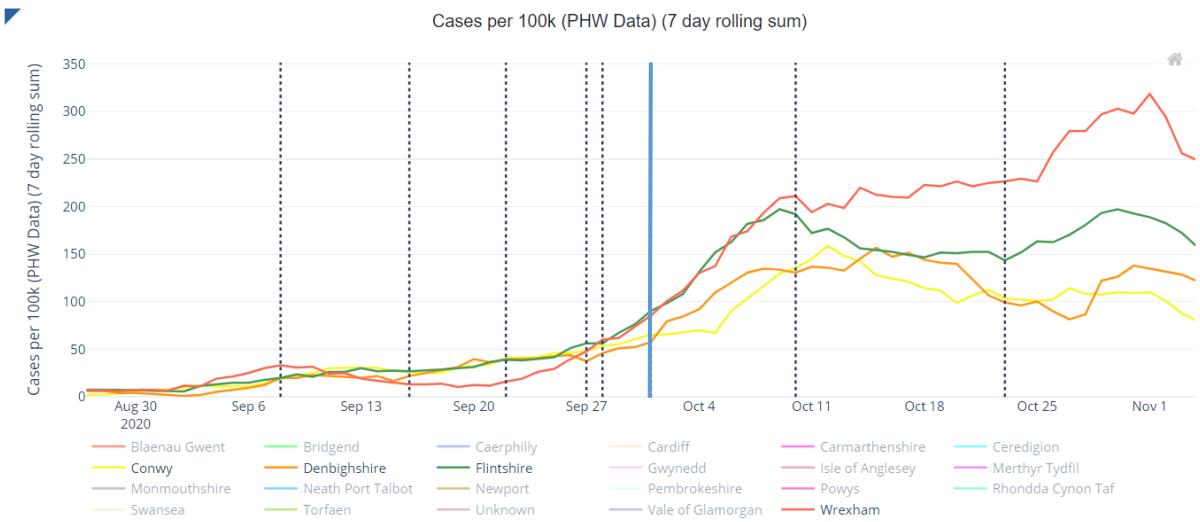


figure 7 Local Authorities with the same NPIs brought in on the same date



Whilst it is not possible to infer a great deal from the positive test incidence data alone, it has particular value as a visual signal if total testing in an area does not alter significantly. Figure 6 shows variation in the border authorities that clearly shows an early rise in case incidence in LAs close to Liverpool and Chester in the North. By comparison, the central and southern borders follow a shallower but steady increase to a point not far from the incidence in parallel English areas. There is also a very clear signal that there was some effect from the Local NPIs when the LAs that had the same restrictions at the same time are overlayed (figure 7). Even though the Rt varies, the point of inflection from the previous path comes at a remarkably similar point for all four.

Interrupted Time Series (ITS) analysis [11] [12]

Almond and Andrews (2020) conducted a local lockdown analysis using the interrupted time series methodology[13]. Interrupted time series was carried out to evaluate the effect on each local authority of the local lockdowns imposed on them as well as the effect of the national 'fire break' lockdown.

Figure 8 demonstrates the trend in cases per 100k population for each of the local authorities which had a local lockdown, with the date of the local lockdown and the date the model references (5 days post intervention) marked vertically.

The results indicated that there were significant changes in the COVID-19 case rates[14] before and after the date of local lockdowns (plus five days)[15] [16] in Conwy, Denbighshire, Flintshire, Gwynedd, and Wrexham. However, a significant reduction was only observed in Wrexham whereas the other local authorities (LAs) saw an increase in the case rate.

Figure 9 demonstrates the trend in cases per 100k population for each local authority and Wales, with the date of the 'firebreak' and the date the model references (5 days post intervention) marked vertically.

There was also a significant change in the case rate before and after the introduction of the Wales' 17 days 'firebreak' on 23rd October.[17] When analysing the case rates of the local authorities pre and post the national lockdown date (plus five days), we

[11] English, Patrick, The its.analysis R Package – Modelling Short Time Series Data (June 6, 2019).
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3398189

[12] Penfold RB, Zhang F. Use of interrupted time series analysis in evaluating health care quality improvements. Acad Pediatr. 2013 Nov-Dec;13(6 Suppl):S38-44. doi: 10.1016/j.acap.2013.08.002. PMID: 24268083.
https://pubmed.ncbi.nlm.nih.gov/24268083/

[13] TAG modelling and intelligence sub cell paper 10/11/2020

[14] The 7 day rolling sum of confirmed COVID-19 cases per 100,000.

[15] Further information on the local lockdowns implemented in wales can be found here.

[16] The analysis allows for a five day lag post local and national lockdown dates to allow for the presentation of COVID-19 symptoms in individuals.

[17] A series of restrictive measures in place in Wales from 6pm Friday 23 October until 12:01am Monday 9 November 2020.

observe significant changes in all but six[18] of them. Interestingly, five of the six without a significant change are rural LAs. The results are also significant for Wales as a whole.

It is important to be aware that significant changes pre and post local and national lockdowns **may be due to other confounding factors** most of which are not taken into account in this analysis.

Figure 10 demonstrates the trend in tests per 100k population for each local authority and Wales, with the dates of the local lockdowns and 'firebreak' as well as model reference dates (5 days post intervention) marked vertically.

A likely confounding factor is the amount of testing being conducted in each local authority, therefore the testing per 100k population for each local authority as a 7-day sum is added as a covariate. When including the testing covariate the impact of local lockdown is significant in Blaenau Gwent, Conwy, Denbighshire, Flintshire, Gwynedd and Wrexham. We also observe a significant change when including the testing covariate to assess impact of the 'firebreak' for all but seven[15] LAs.

[18] Significant changes were not observed in Bridgend, Ceredigion, Denbighshire, Gwynedd, Pembrokeshire and Vale of Glamorgan.

[15] Significant changes were not observed in Bridgend, Ceredigion, Conwy, Denbighshire, Gwynedd, Pembrokeshire and Vale of Glamorgan.

Figure 8 Cases per 100k for each Local Authority which had a local lockdown with the date of local lockdown and date model references (plus 5 days) marked vertically.

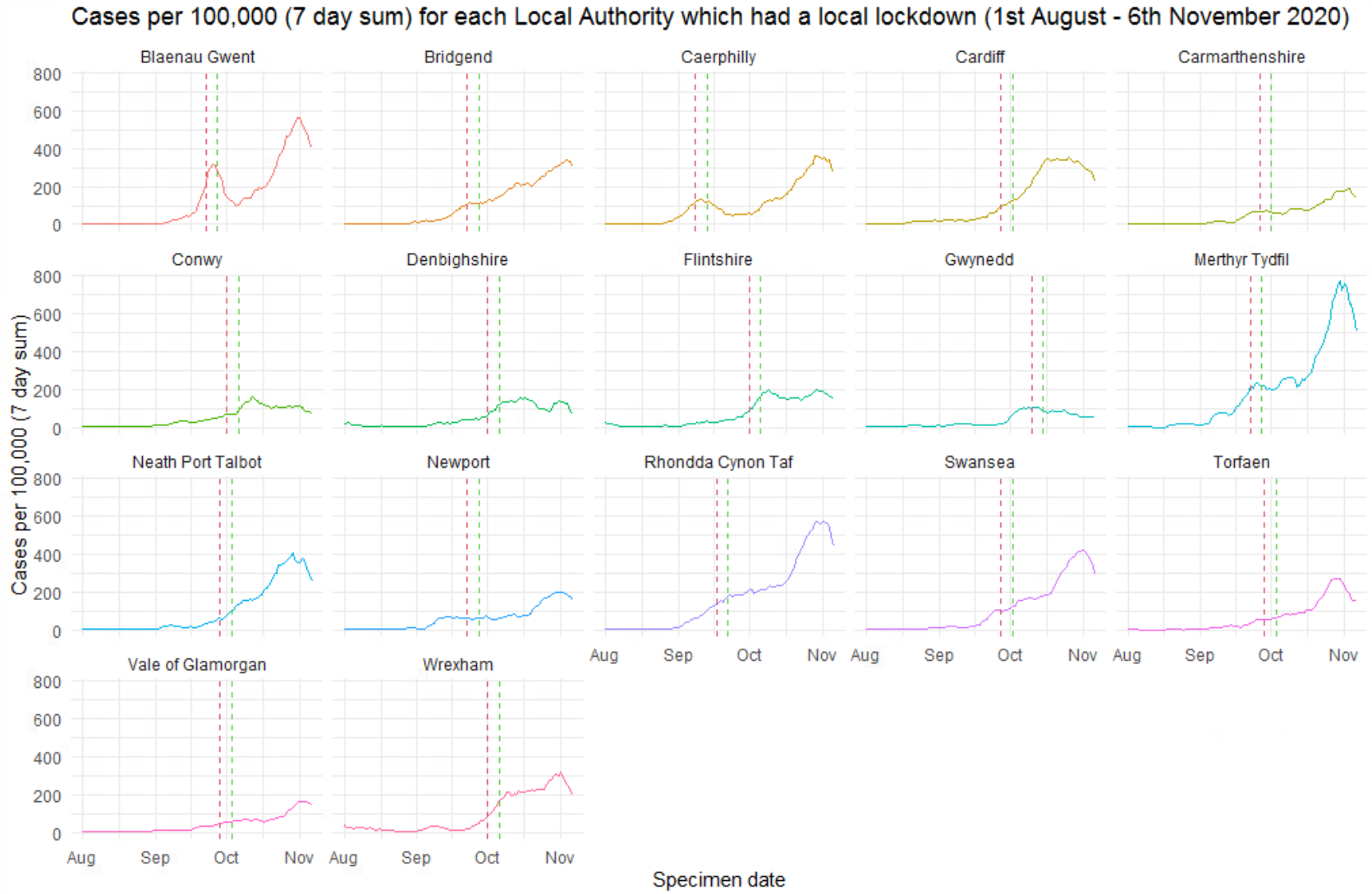


Figure 9 Cases per 100k for each Local Authority and Wales with the date of the 'firebreak' and date model references (plus 5 days) marked vertically.

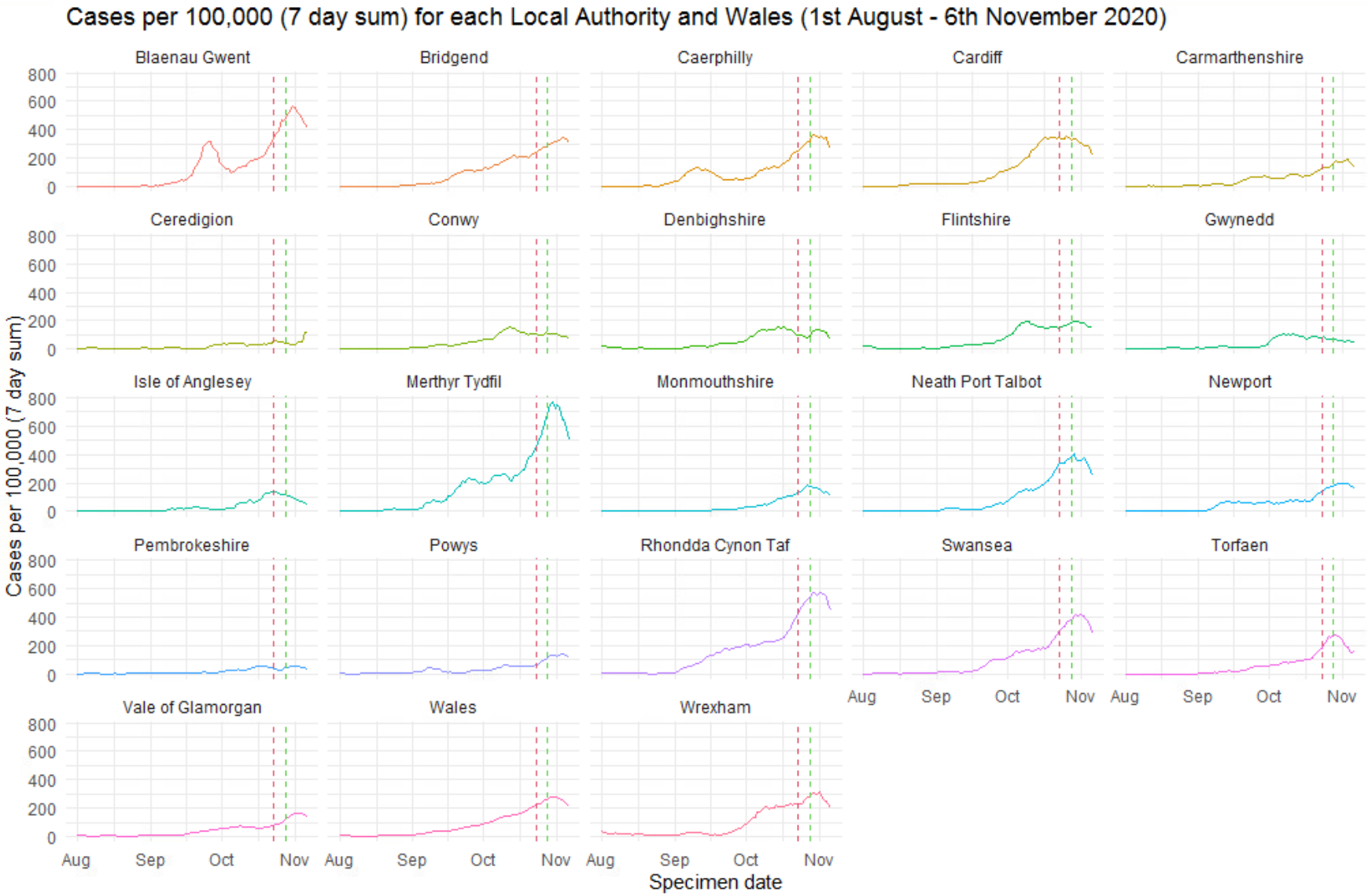
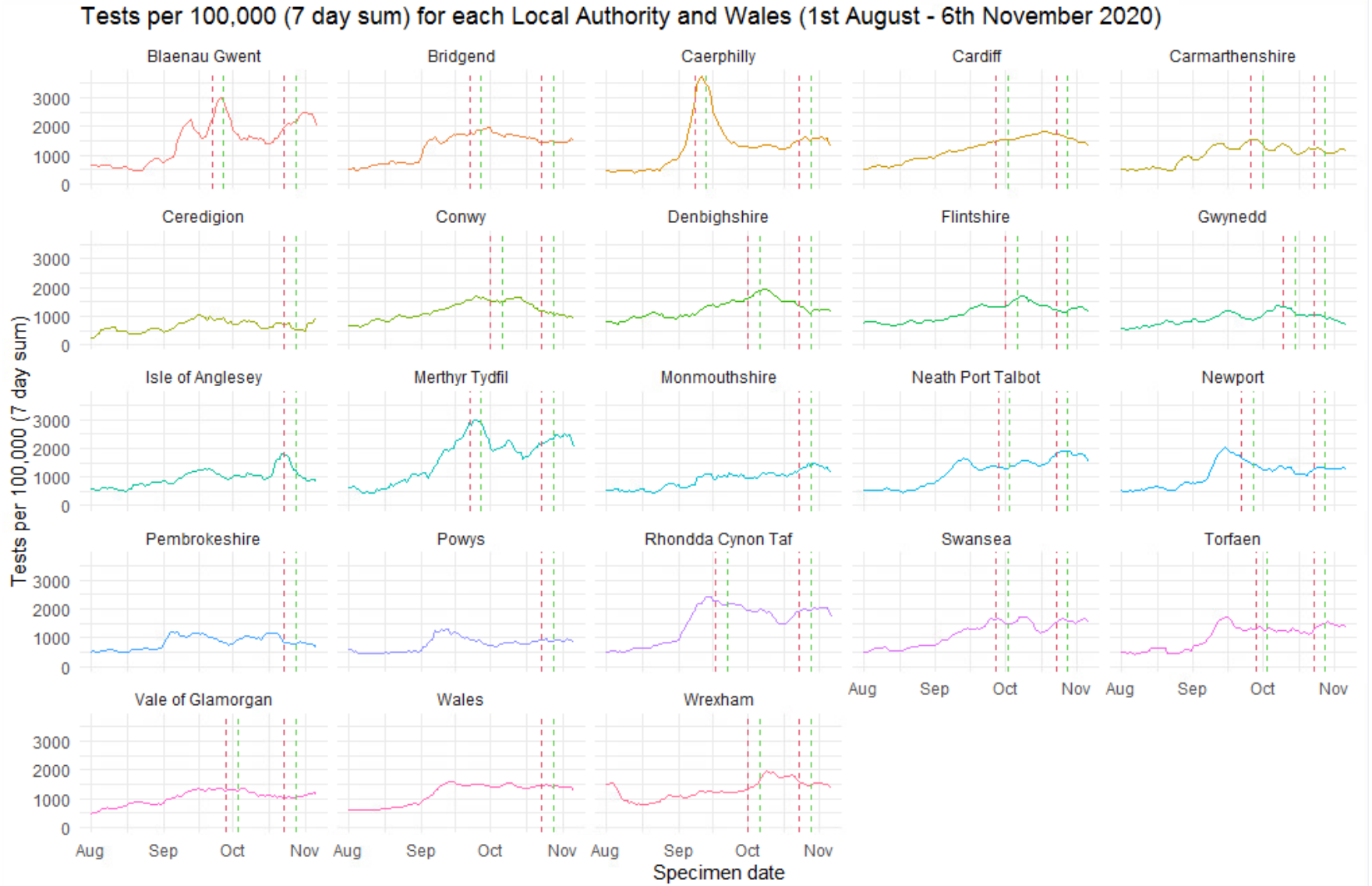


Figure 10 Tests per 100k for each Local Authority and Wales with the date of the local lockdowns, 'firebreak' and model references dates (plus 5 days of intervention) marked vertically.



ARIMA Analysis

The ARIMA model found that statistically significant reductions in case rates can be seen 2 weeks after local lockdowns dates in Blaenau Gwent, Neath Port Talbot, and Swansea, and 3 weeks after the lockdown date in Cardiff, but not in other local authorities.

So overall, between the two models (ITS and ARIMA), many local authorities show a statistically significant effect of the local health protection measures in flattening the epidemic curve, however the magnitude of these effects may not be enough to push Rt below one.

The ITS analysis indicated changes pre- and post-lockdown dates (plus five days) whereas with the ARIMA analysis, we look at whether there is a significant change one, two and three weeks post lockdown dates. Therefore these 2 methods are not directly comparable and give different results.

We are working with PHW who have also carried out ARIMA analysis to triangulate and validate our results. We would not recommend making decisions based on this analysis until this validation and peer review process is complete.

PHW ARIMA Analysis

For most projections, error margins are wide so difficult to make precise predictions. This is most likely due to lack of data over time require to make more accurate prediction. However, for some LAs there, is a clear separation between the LD and no-LD forecasts (e.g. Caerphilly, Cardiff and Neath Port Talbot). In these cases, the actual case counts exceed what is forecast from the date the regional lockdown was implemented. This indicates that regional lockdowns had minimal impact on case counts. Case counts have actually exceeded case counts predicted without any lockdown measures in these cases. There are however some LAs where case counts have dropped below those forecast (e.g. Conway, Flintshire, and Gwynedd). There appear to be very large regional variation in effectiveness of lockdown. [19]

It is important to note the LD models are trained on case counts from the first lockdown. Testing rate and strategies, as well as specific lockdown rules differed then compared the second wave so the corresponding projections should be treated with caution. It should also be noted because case counts have to be offset for the LD forecast, there is not a smooth transition from raising case counts to levelling off, as we would expect in the true case count data.

[19] Please see Annex B for charts of the results of the ARIMA analysis for each local authority.

Mobility Analysis

This analysis looks at the Google mobility data and data from O2 covering trips and commutes. It looks at the impact and effect on mobility during the local lockdowns and the firebreak (to date).

The data from O2 on trips shows a reduction following the introduction of the local lockdowns, but then after 28 days trips returned to pre-lockdown levels (on average).

Data from Google shows increases in residential mobility (the amount of time people spent at home) after the introduction of the local lockdowns, but that did not fall as time went on. However the data from Google does show that whilst other measures also show a fall after the local lockdowns (i.e. - reduced trips to shops etc.), they did increase as time went on (apart from public transport and workplaces).

The firebreak has had a much larger impact on mobility. For example trips fell by 12 percentage points in the first few days after the local lockdowns started. In the first few days after the firebreak, trips were down more than double that (26 percentage points). Similarly time spent at home (Google), rose by around 3 percentage points after the local lockdowns. After the firebreak the increase was around 8 percentage points.

Chart 1: Trips

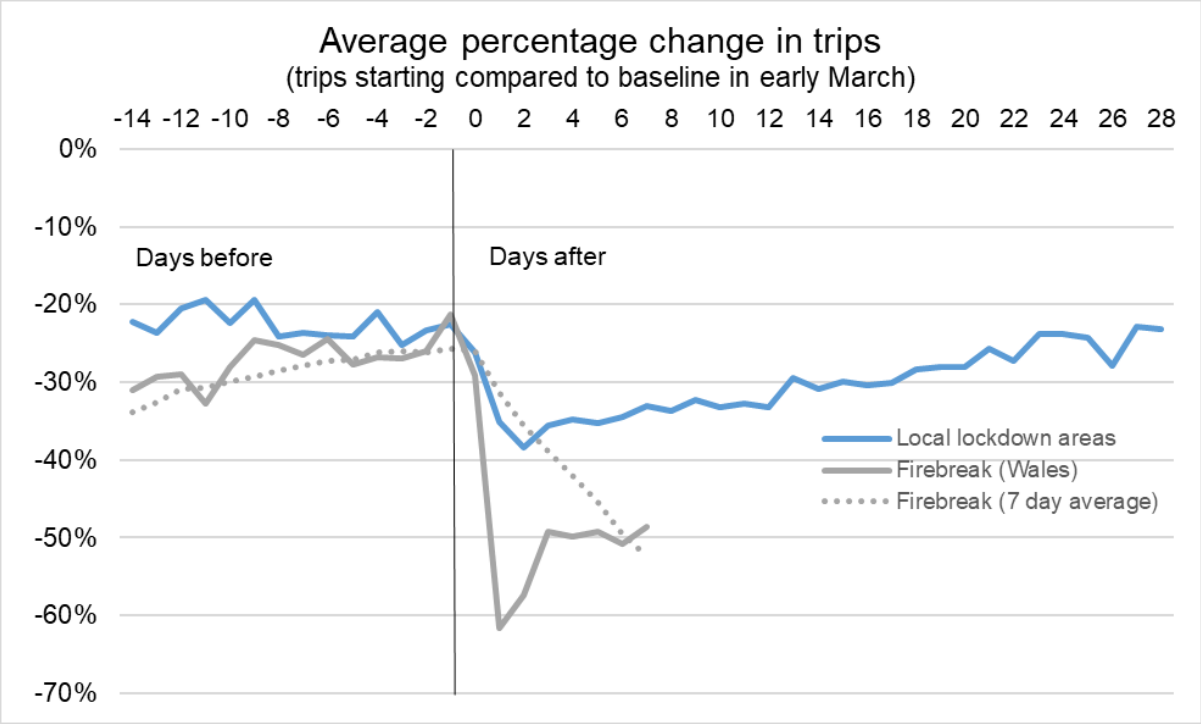


Chart 2: Residential mobility

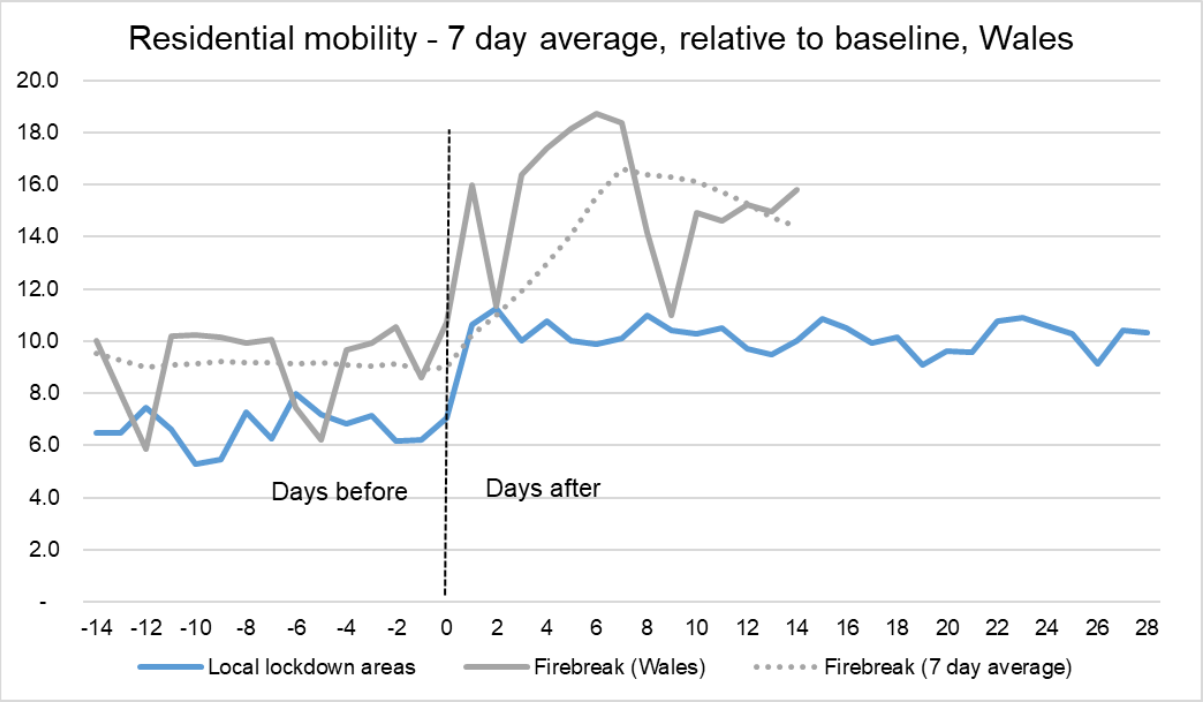


Chart 3: Workplace mobility

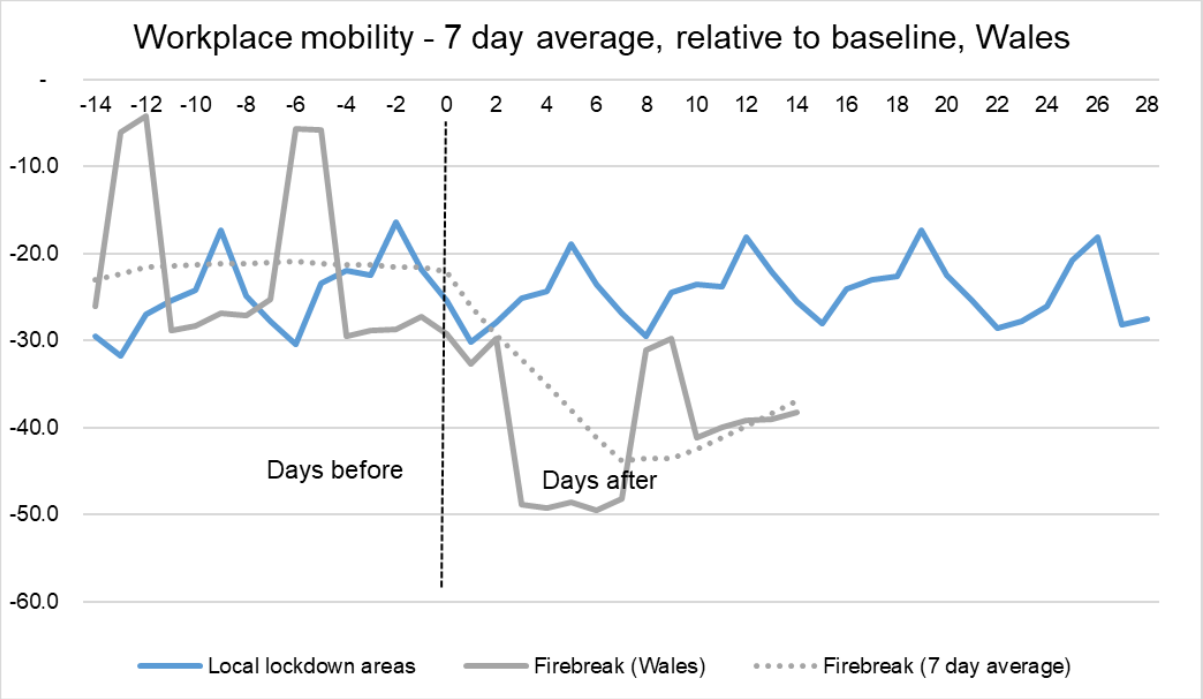


Chart 4: Retail and recreation mobility

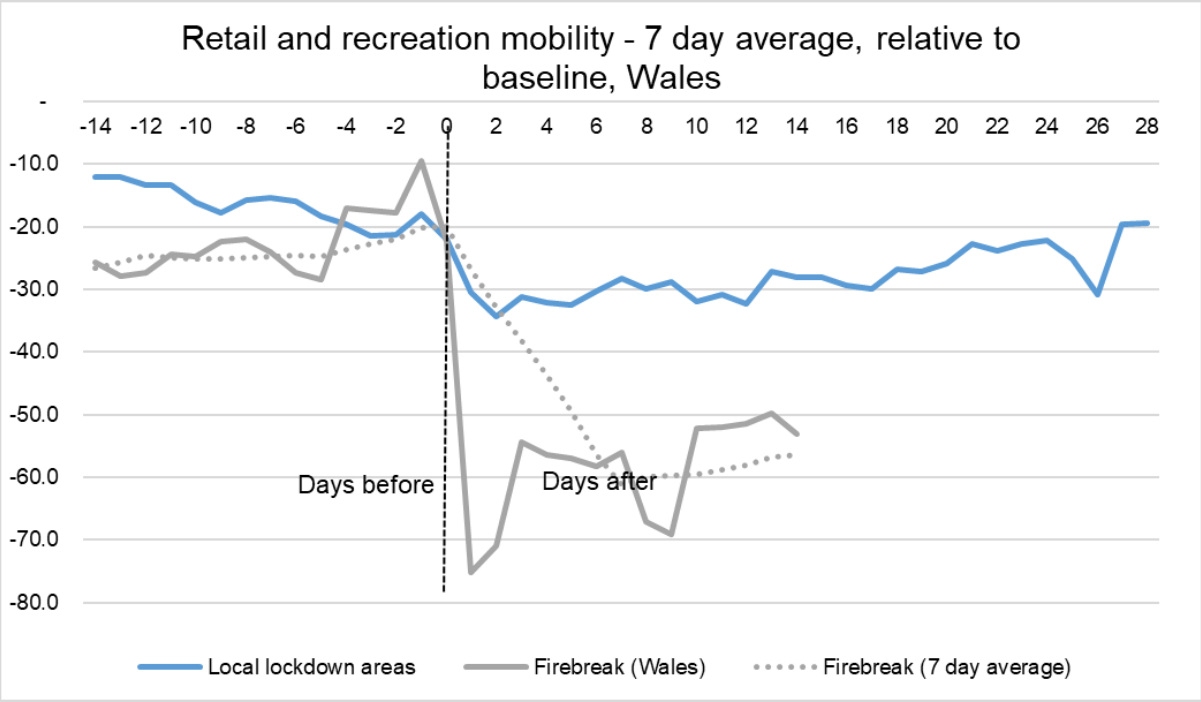


Chart 5: Public transport mobility

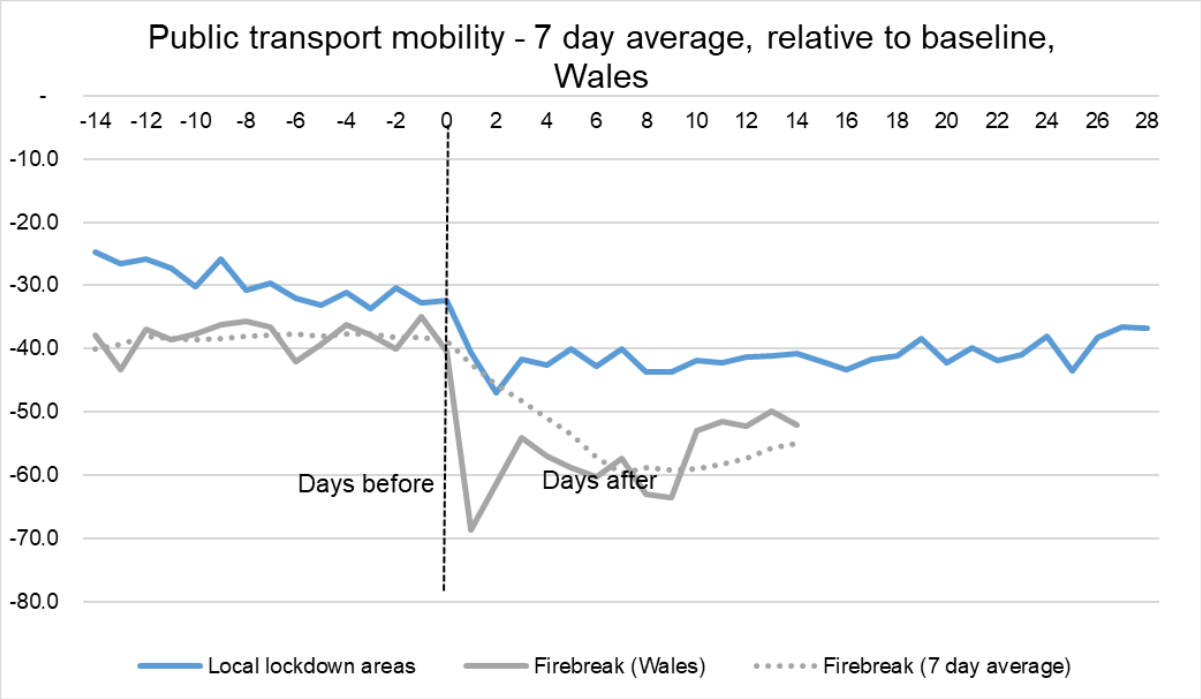
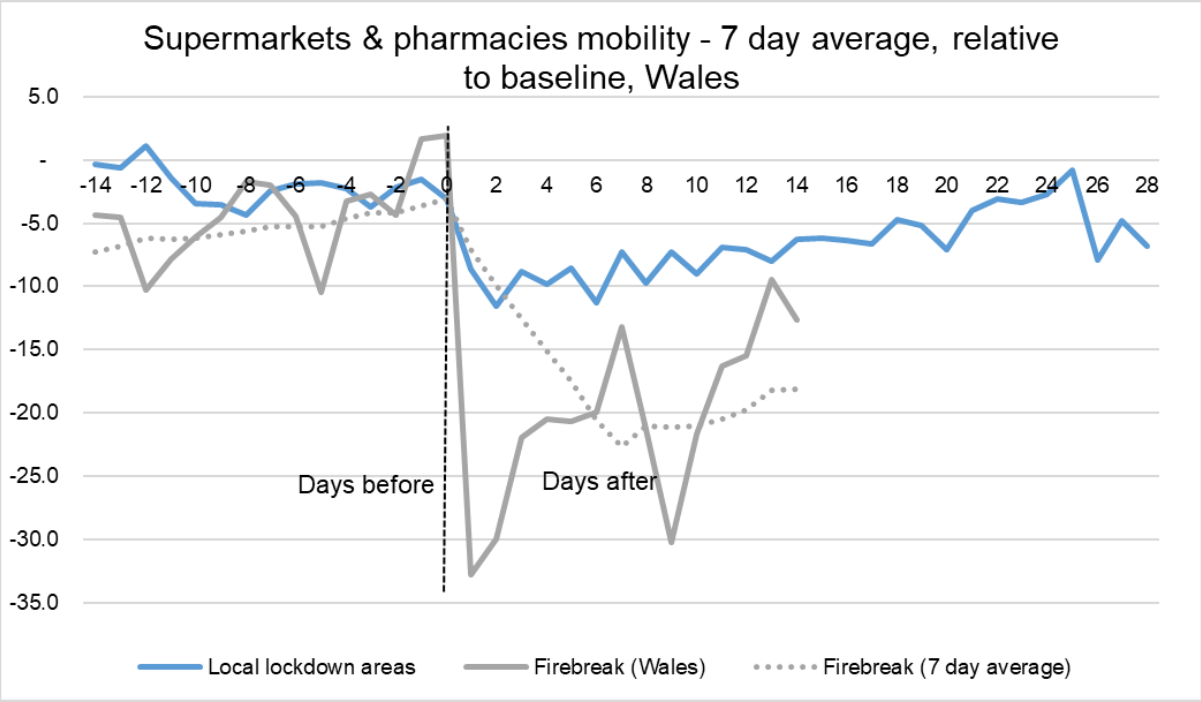


Chart 6: Supermarkets and pharmacy mobility



Results of the doubling time and Rt Estimates

The estimated doubling time in the 14 days prior to lockdown (09/10/2020 to 22/10/2020) was 20 days (CI 11 to 73). This is compared to an estimated halving time of 38 days (CI 14 to -54) from 25/10/2020 to 06/11/2020.

The estimated Rt value using all cases has decreased at an all Wales level over the previous two weeks. As at 22/10/2020 Rt was estimated to be 1.26 (CI 1.24 – 1.28) compared to 0.82 (CI 0.81 – 0.84) as at 06/11/2020.

Interpretation: The doubling time has increased and Rt decreased (to below 1) following the firebreak. These estimates should be interpreted with caution and it is too early to say this is a sustained reduction. It also may be that cases are increasing in one area but decreasing in another.

Figure 1: Estimated doubling time estimates for COVID-19, Wales. The bold line indicates the model fit for the post firebreak estimates, the dotted lines give the 95% CI.

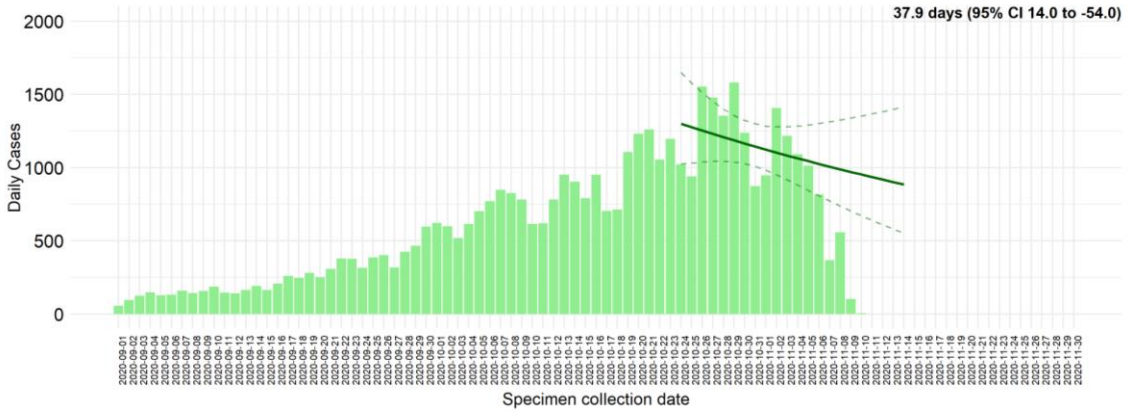
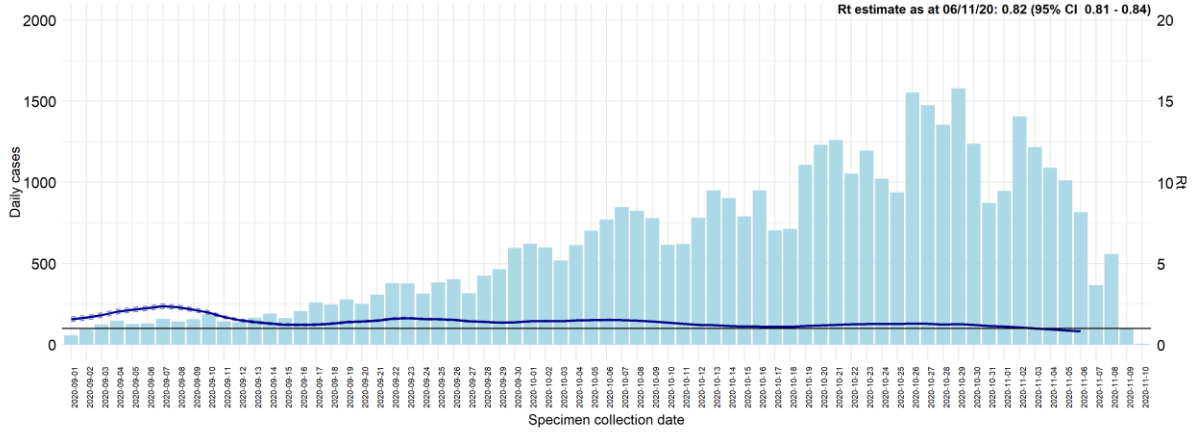


Figure 2: Estimated Rt value for COVID-19 01/09/2020 to 06/11/2020, Wales



Discussion

Taken together, the mobility, ITS and case incidence data show that the packages of local interventions had less effect on peoples' behaviours and less effect on transmission of the virus between people than the national firebreak (noting that the NPIs used were not as significant as during the 'firebreak'). Further analysis is needed to take into account health statistics, geographic differences and further social and behavioural insights.

Initial findings suggest that the local NPIs had varying effect between places, and there is not yet a clear evidence of what is responsible for the difference in effect.

Initial findings suggest that the local NPIs were not sustainable, with data pointing to a waning effectiveness and a return to exponential growth within 3 weeks of the interventions being brought in.

This limited period of effectiveness may correlate with the behavioural and economic evidence offered in previous papers[20] - that without a clear temporal end point there will be significant fatigue that will affect behaviours, wellbeing and the economy. There does not appear to be a beneficial effect in having a clear methodology and an exit point based on reducing the incidence and positivity – though this may change over time.

Emerging evidence suggests that the national firebreak has had an effect, although before it has even ended we cannot enumerate its value. This is in line with previous evidence and advice that shows simple, national restrictions will have more effect than complex, local restrictions[21].

It is not unreasonable to assume that the greater effect of the firebreak is at least in part to do with the closure of schools for half term. This is evident from some of the mobility data which shows that in the three local authorities in Wales which had 2 week long half terms there were reductions in workplace mobility and commutes (with a small increase in residential mobility and a small reduction in trips).

Since the primary route of transmission still appears to be in the household, a far greater effort and value should be placed on public health education and behaviour change. The fact that behaviour change takes time is no reason to avoid undertaking this work immediately, as the only truly sustainable approach to managing Covid-19 in the coming years will be a step change in the way the population takes personal responsibility for the health of their community.

The evidence does not support returning to a series of local interventions, but instead to clearly time limited steps. After the household, the three major sources of exposure associated with outbreaks in Wales in the previous month have been residential care homes, wet pubs/clubs and secondary schools, in that order (unpublished data).

If there is an appetite to make regulation below national level, there could well be greater benefit in working to encourage, alter and educate the owners and users of those sectors with immediate effect.

[20] Technical Advisory Group, Behavioural insights to support a post fire break Wales, 09/11/2020

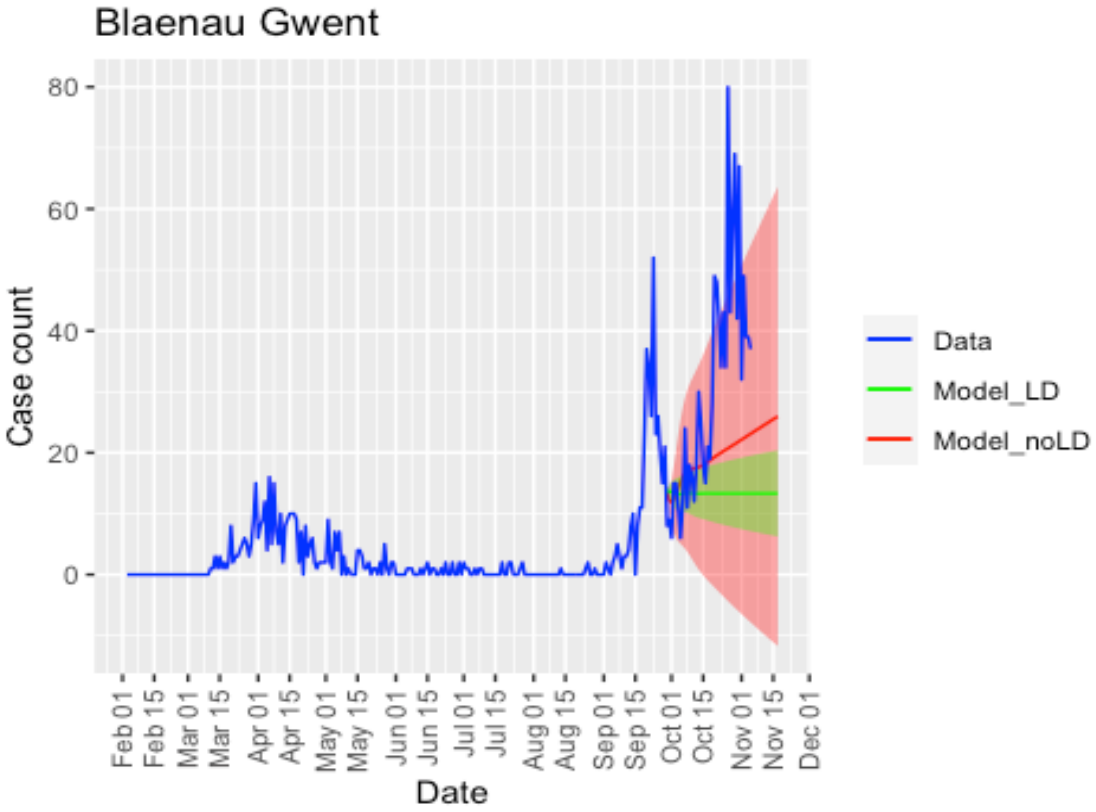
[21] SAGE, SPI-B: Consensus statement on local interventions, 29/07/2020

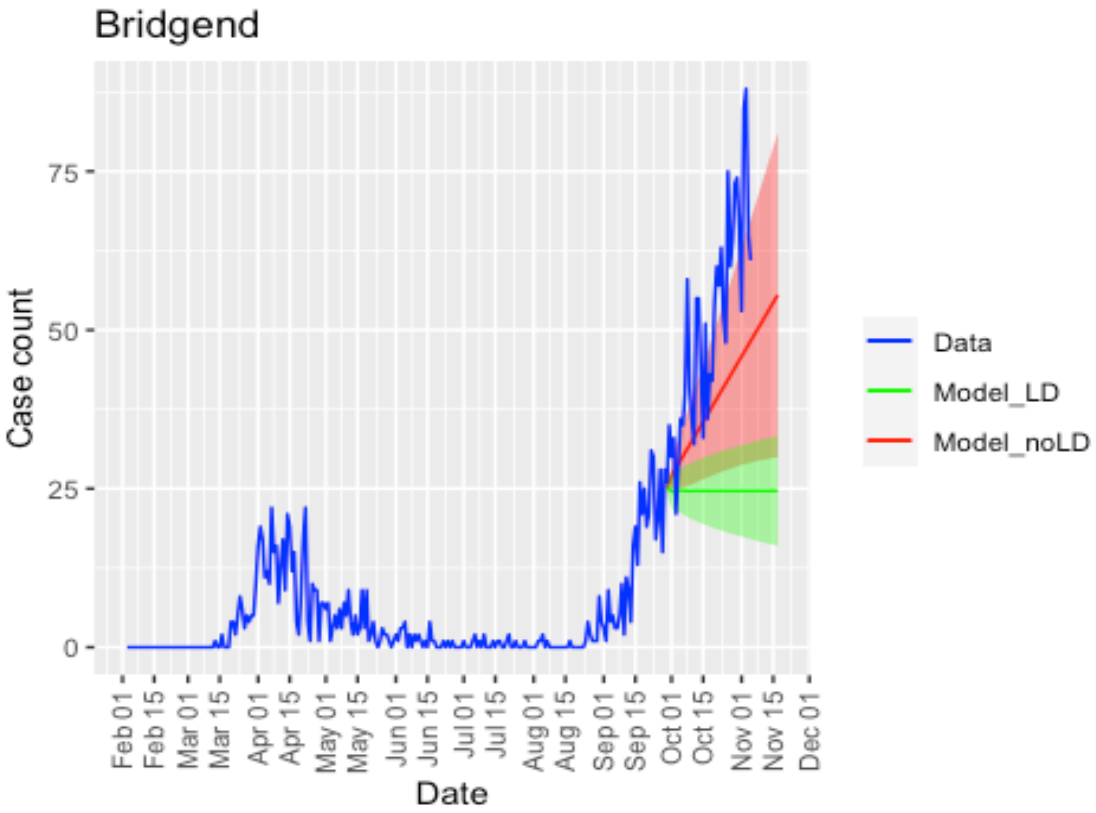
Annex A - List of NPIs and dates they were introduced. All NPIs were introduced at 6pm.

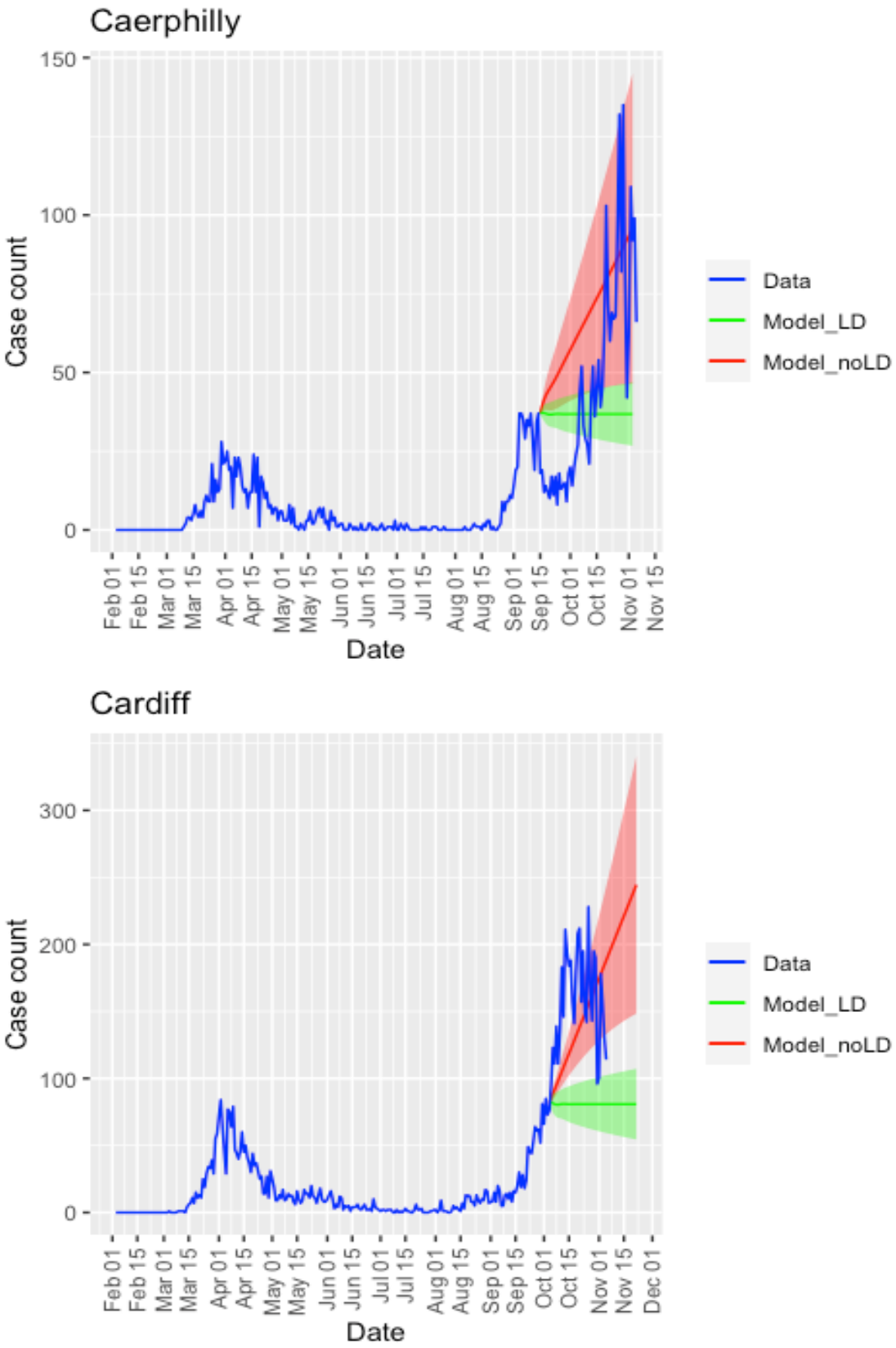
Date of NPI	Local Authority impacted by NPI
08-09-2020	Caerphilly
17-09-2020	Rhondda Cynon Taf
22-09-2020	Blaenau Gwent, Bridgend, Merthyr Tydfil and Newport
26-09-2020	Carmarthenshire*
27-09-2020	Cardiff and Swansea
28-09-2020	Neath Port Talbot, Torfaen and Vale of Glamorgan
01-10-2020	Conwy, Denbighshire, Flintshire and Wrexham
10-10-2020	Gwynedd*

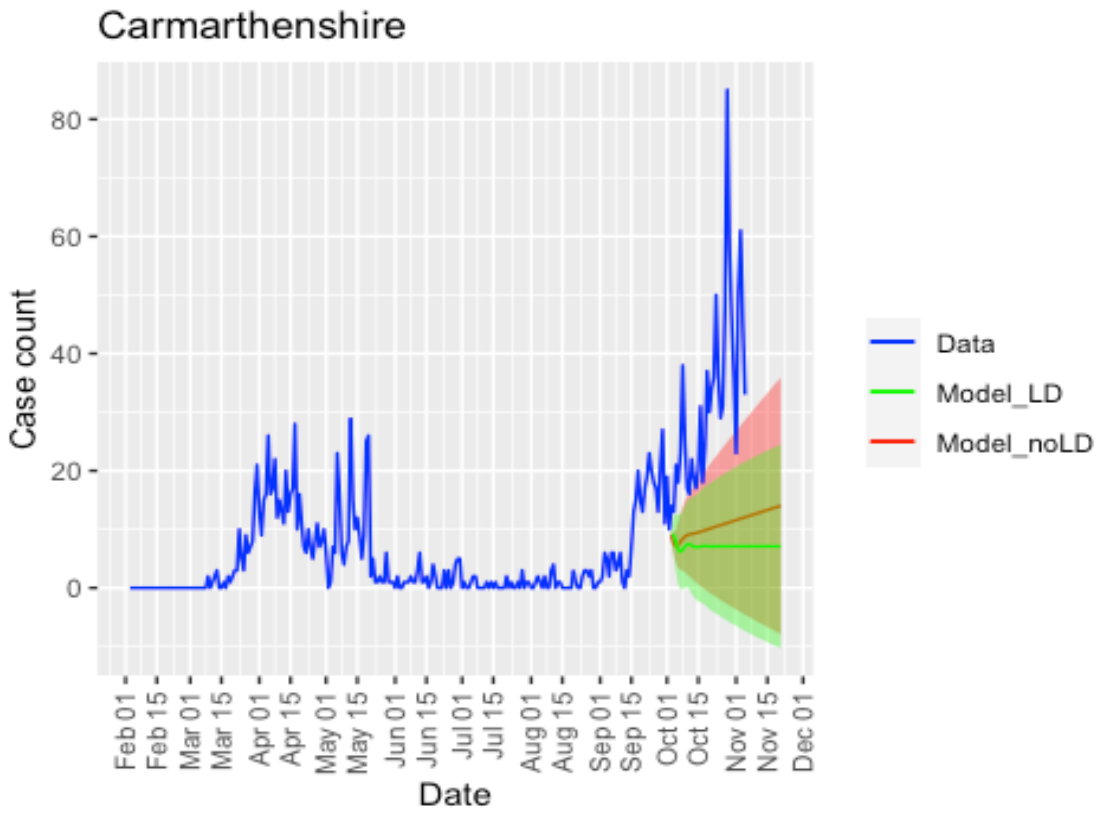
*NPI not on whole local authority but on a town within these local authorities, Llanelli and Bangor respectively.

Annex B: Charts showing the results of the ARIMA analysis carried out by PHW for each Local Authority






Caerphilly
Case count
150
100
50
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Nov 01
Nov 15
Date
Data
Model_LD
Model_noLD
Cardiff
Case count
300
200
100
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Nov 01
Nov 15
Dec 01
Date
Data
Model_LD
Model_noLD


Carmarthenshire
Case count
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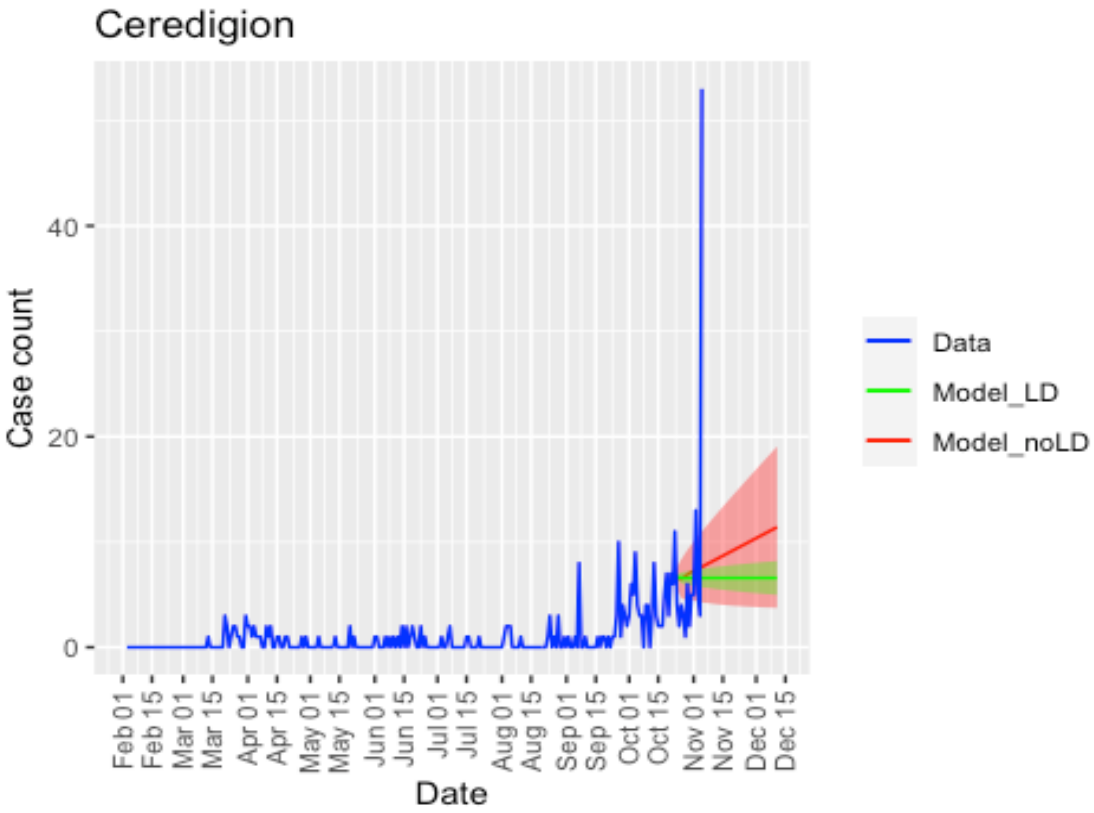
60
40
20
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Nov 01
Nov 15
Dec 01
Date
Data
Model_LD
Model_noLD


Ceredigion
Case count
40
20
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
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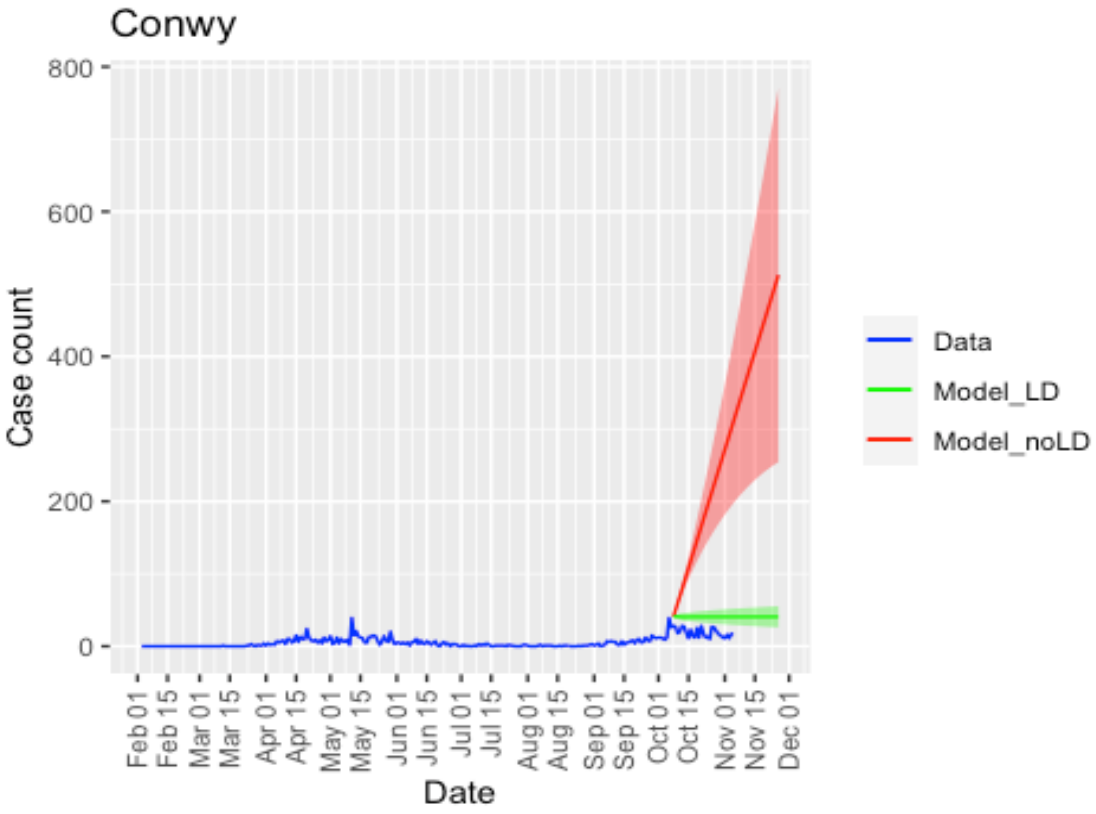
Nov 15
Dec 01
Dec 15
Date
Data
Model_LD
Model_noLD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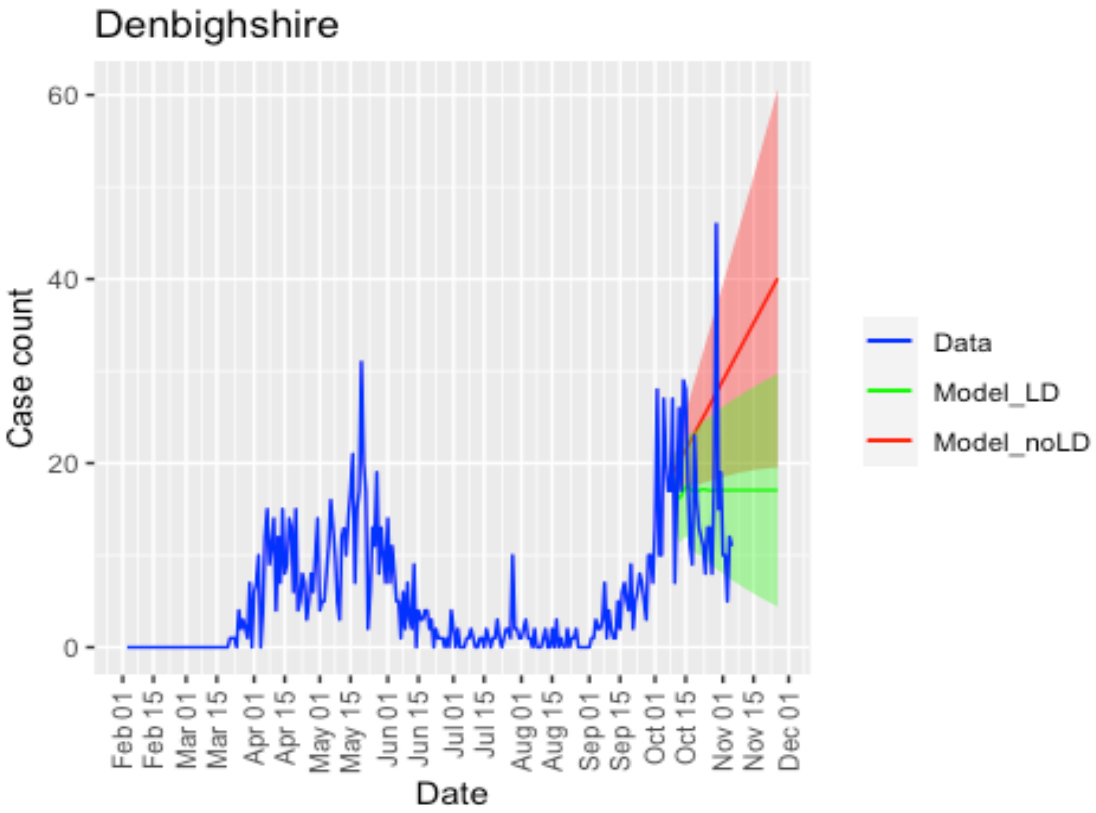
800
600
400
200
0
Case count
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Nov 01
Nov 15
Dec 01
Date
Data
Model_LD
Model_noLD


Denbighshire
60
40
20
0
Case count
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Nov 01
Nov 15
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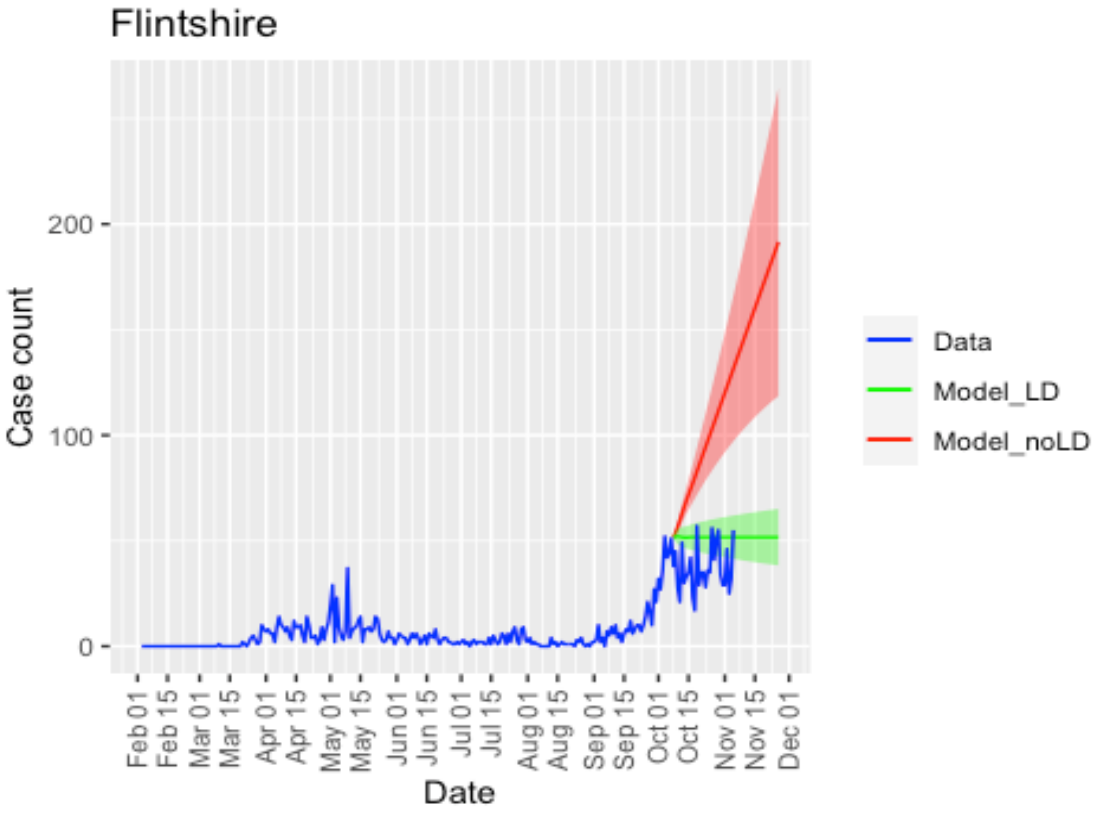
Flintshire
Case count
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100
0
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Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
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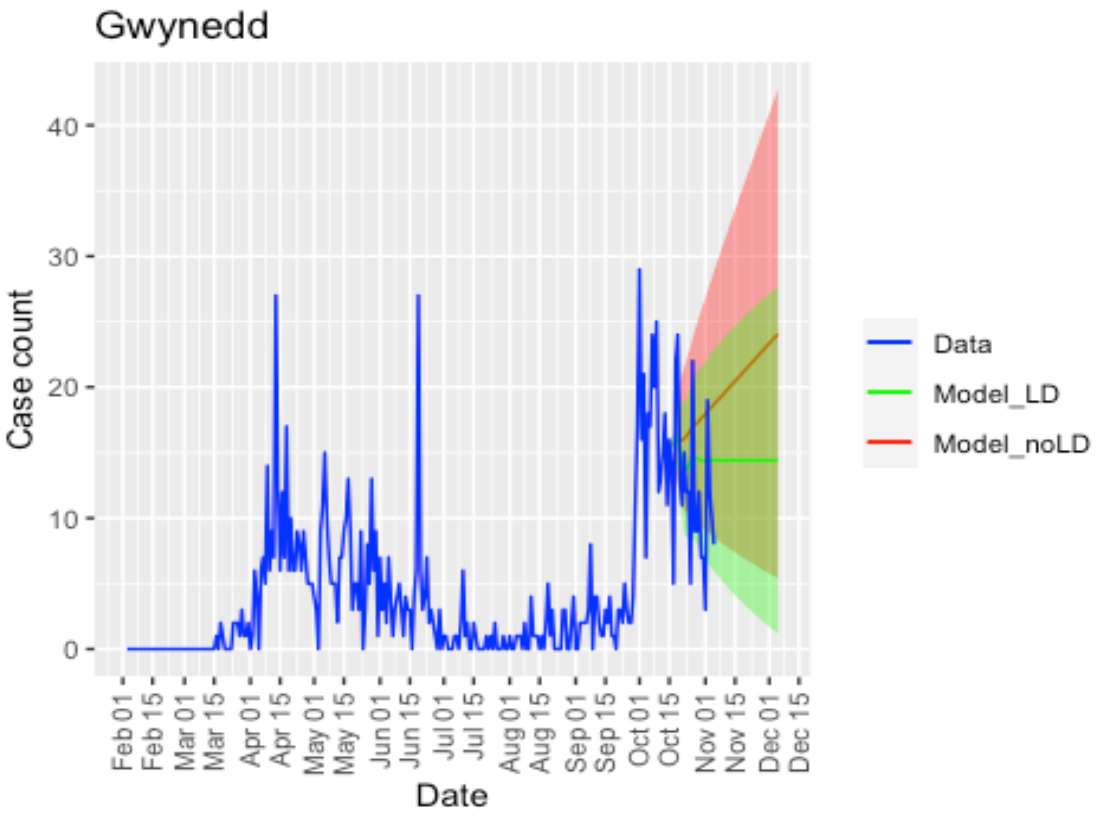
Gwynedd
Case count
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30
20
10
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
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Nov 15
Dec 01
Dec 15
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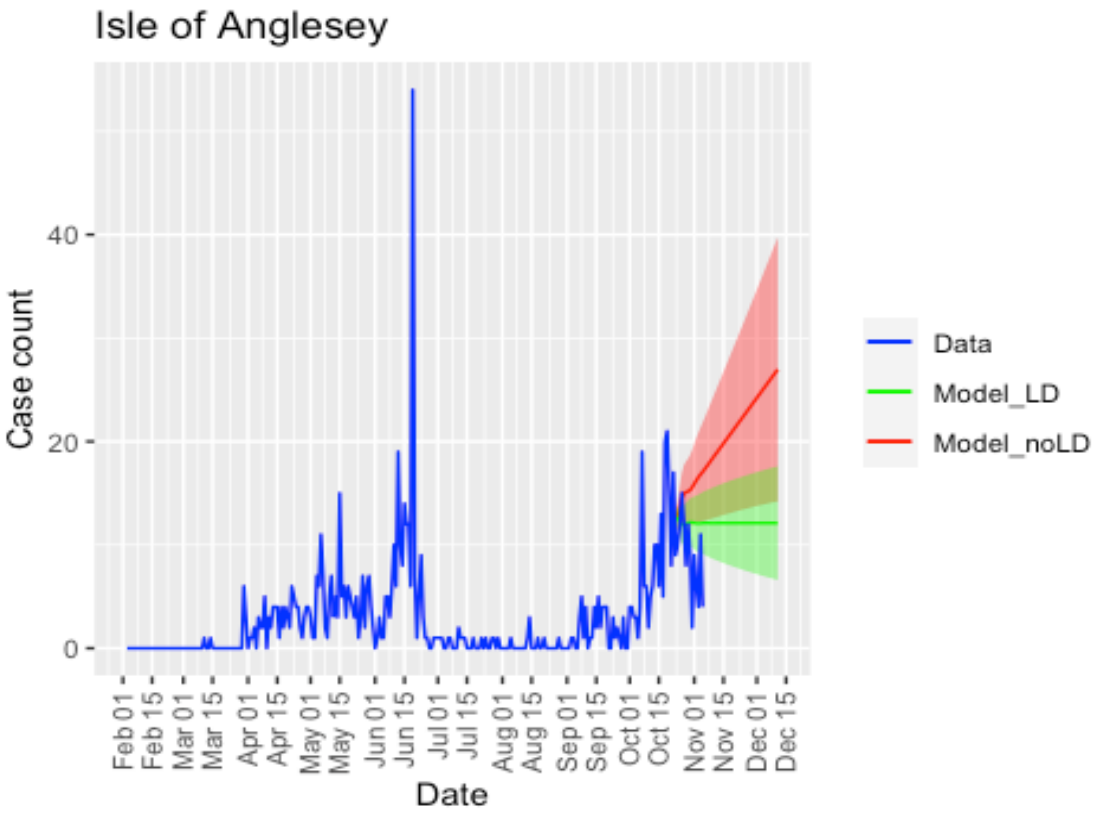
Model_noLD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Case count
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40
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
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Jul 01
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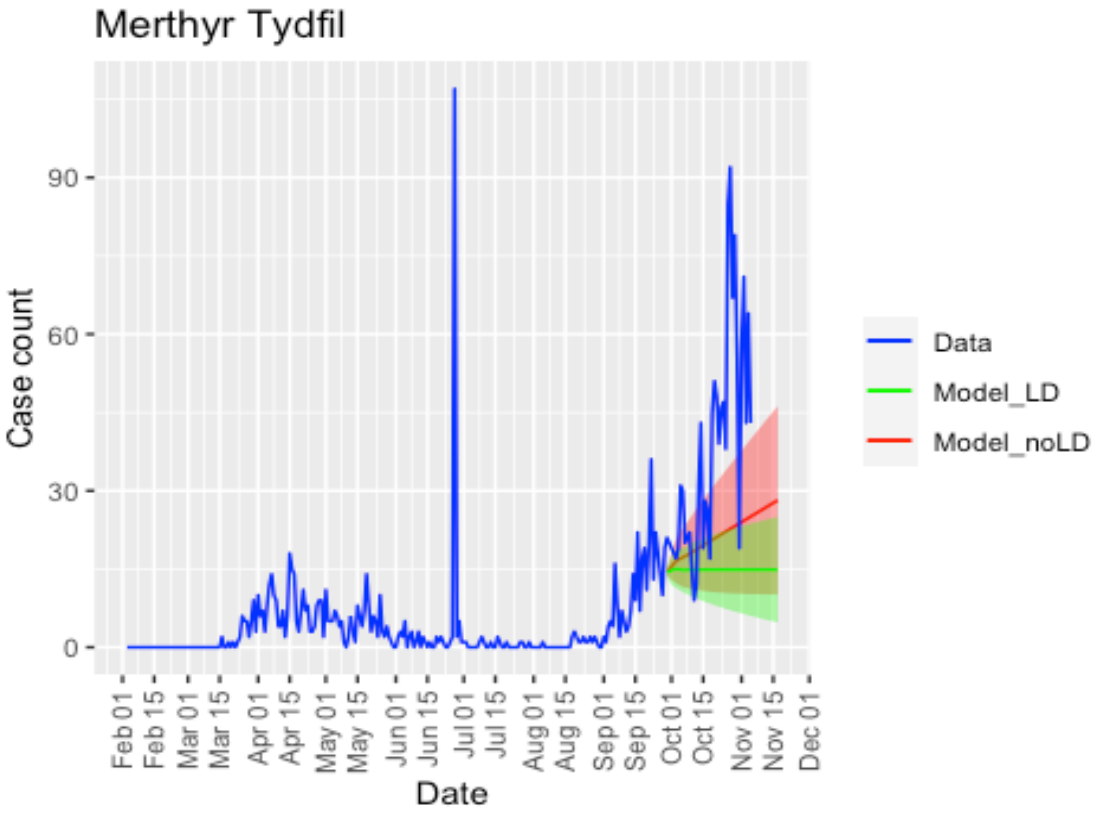
Merthyr Tydfil
Case count
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30
60
90
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
Jul 15
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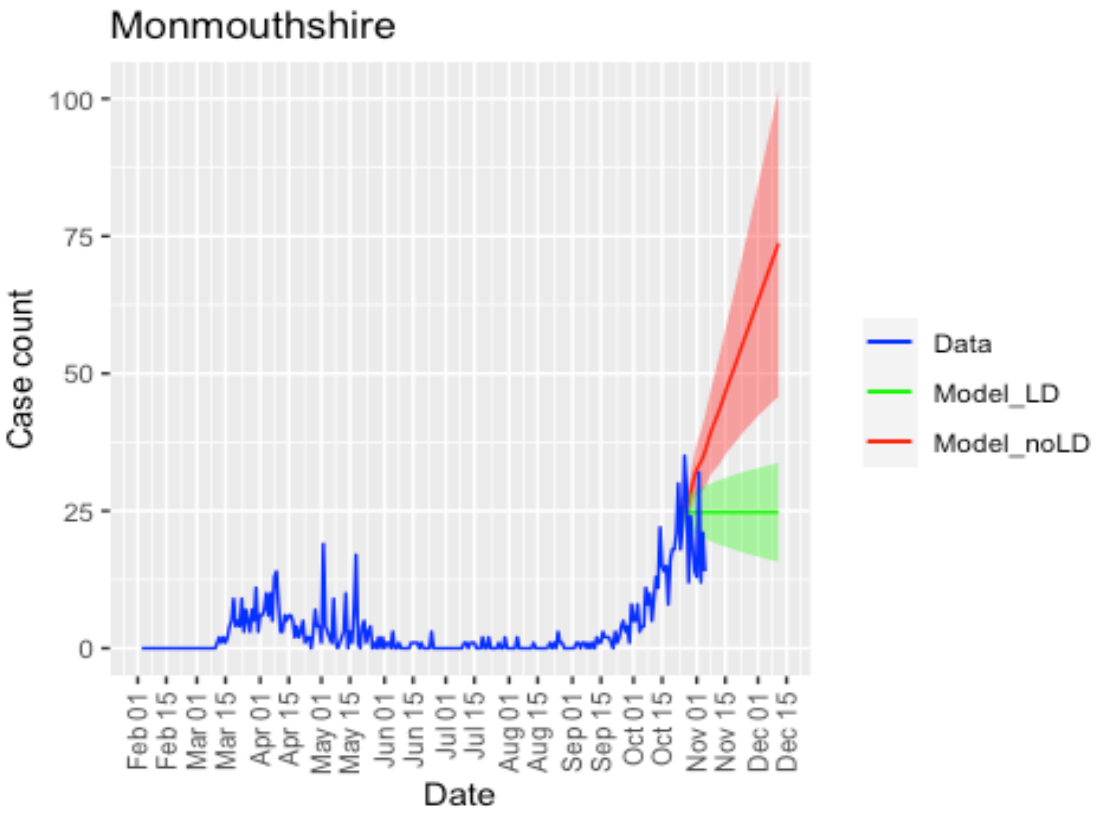
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50
25
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Feb 01
Feb 15
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Mar 15
Apr 01
Apr 15
May 01
May 15
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Jun 15
Jul 01
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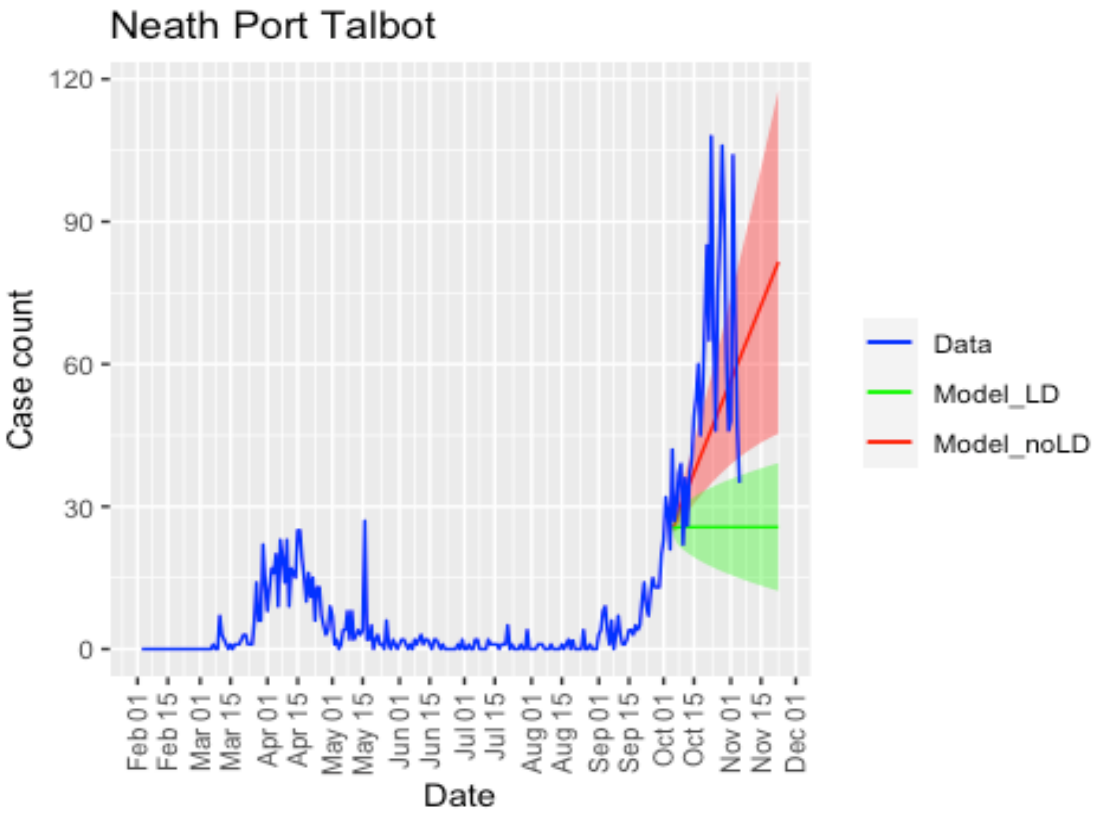
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60
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Feb 01
Feb 15
Mar 01
Mar 15
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Apr 15
May 01
May 15
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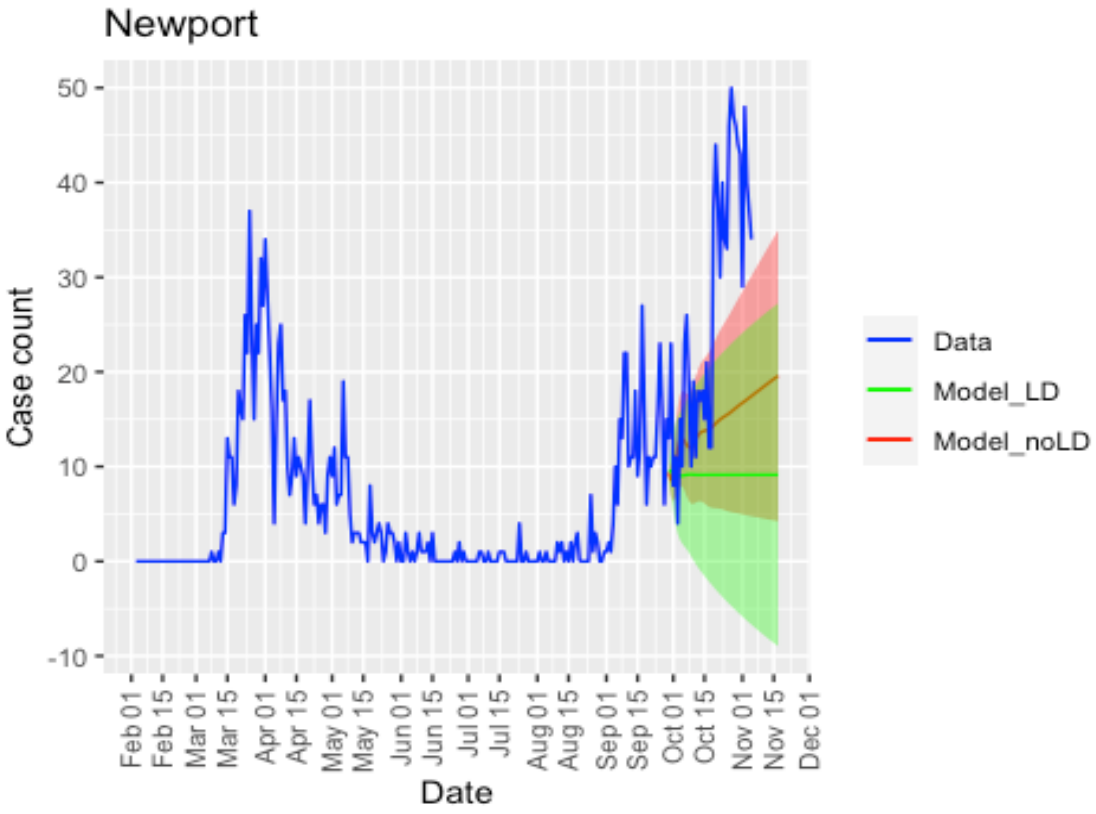
Newport
Case count
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40
30
20
10
0
-10
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
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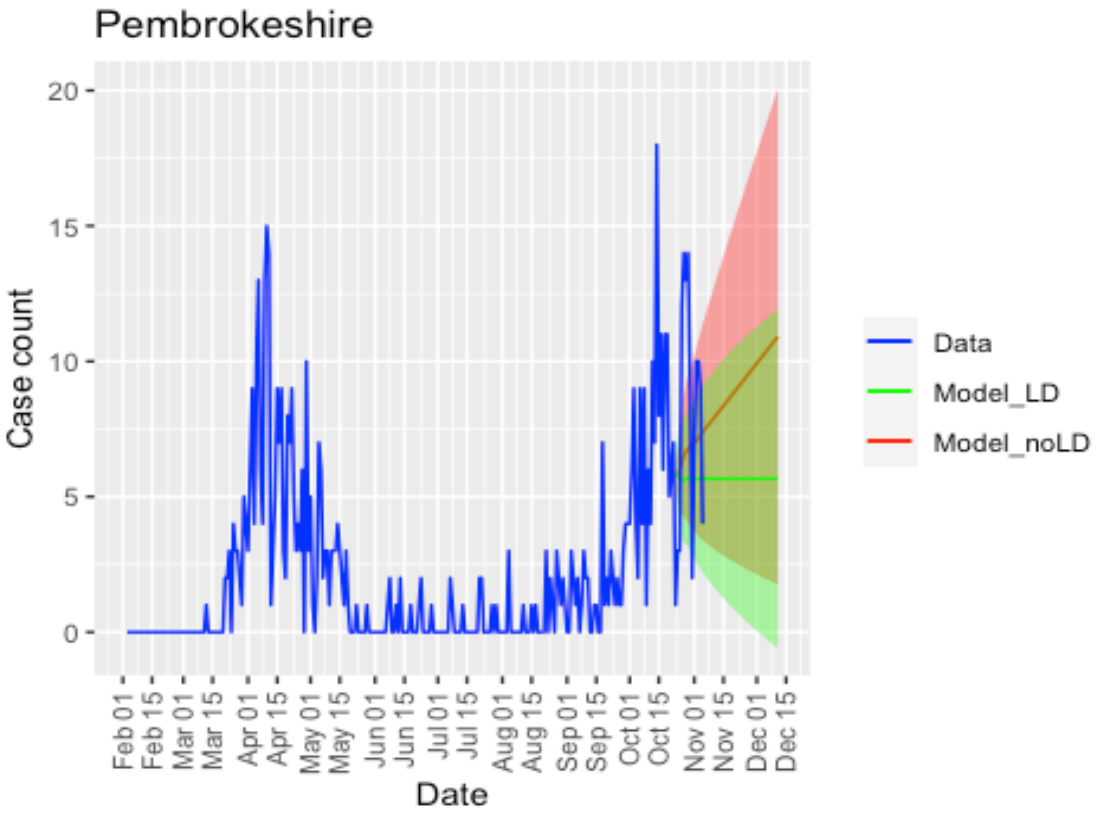
Pembrokeshire
Case count
20
15
10
5
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
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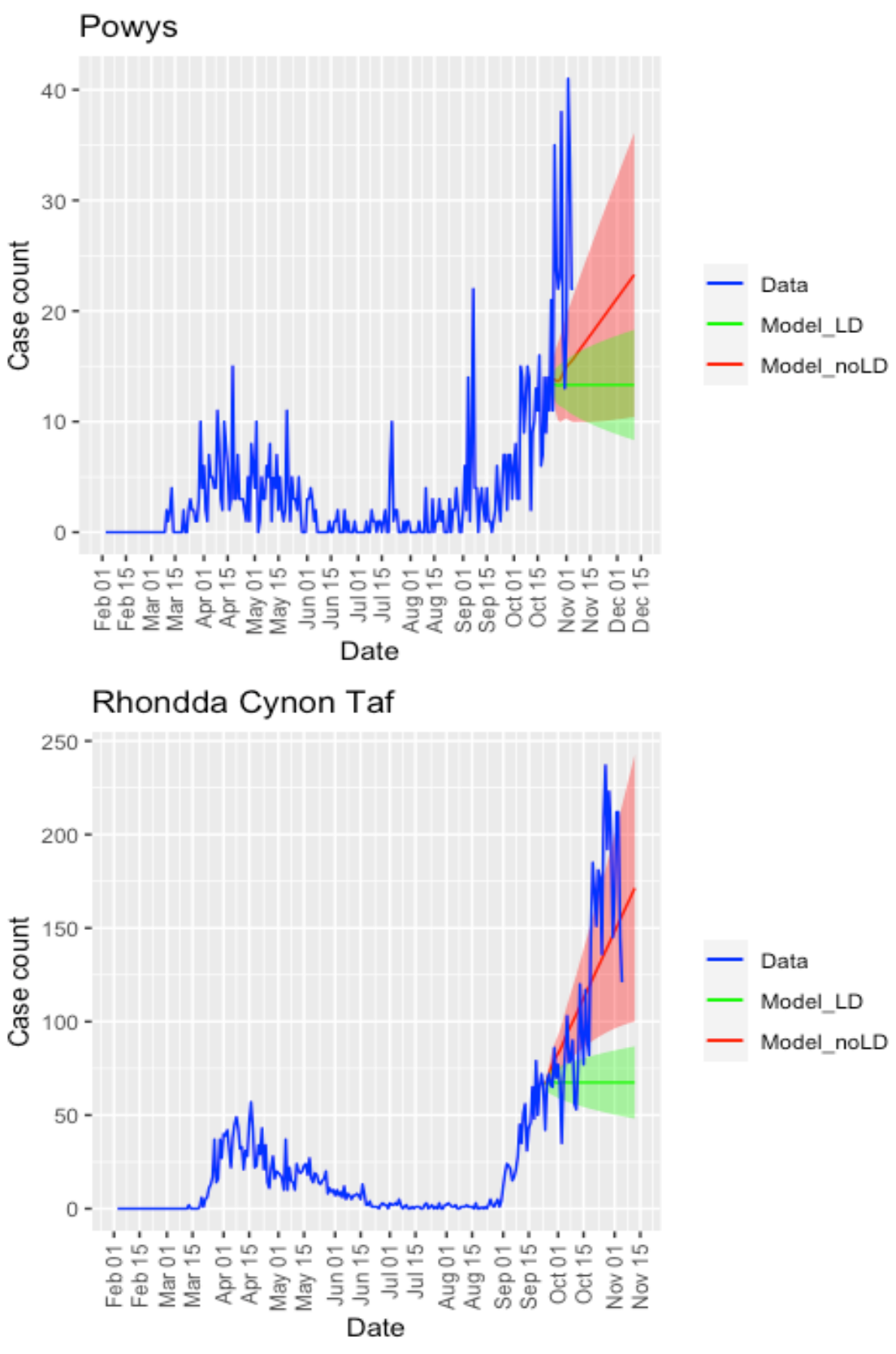
Powys
Case count
0
10
20
30
40
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
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May 01
May 15
Jun 01
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Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Nov 01
Nov 15
Dec 01
Dec 15
Date
Data
Model_LD
Model_noLD
Rhondda Cynon Taf
Case count
0
50
100
150
200
250
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
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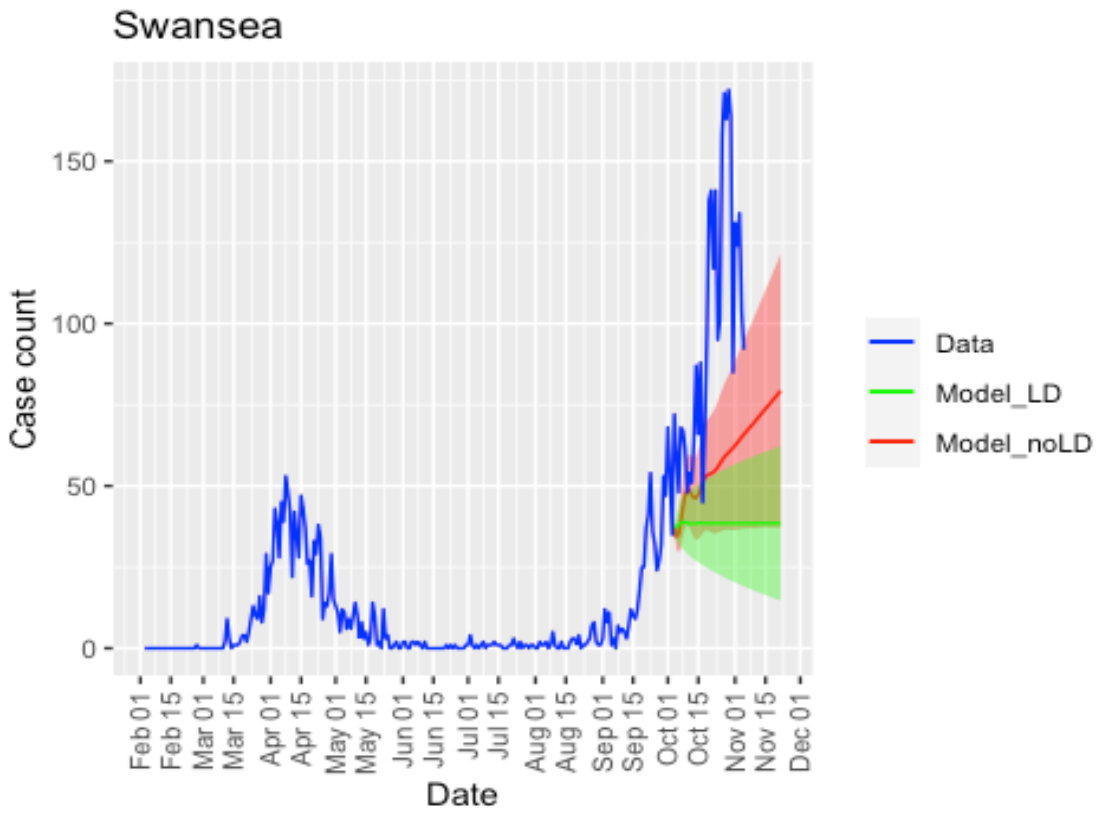
Swansea
Case count
150
100
50
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
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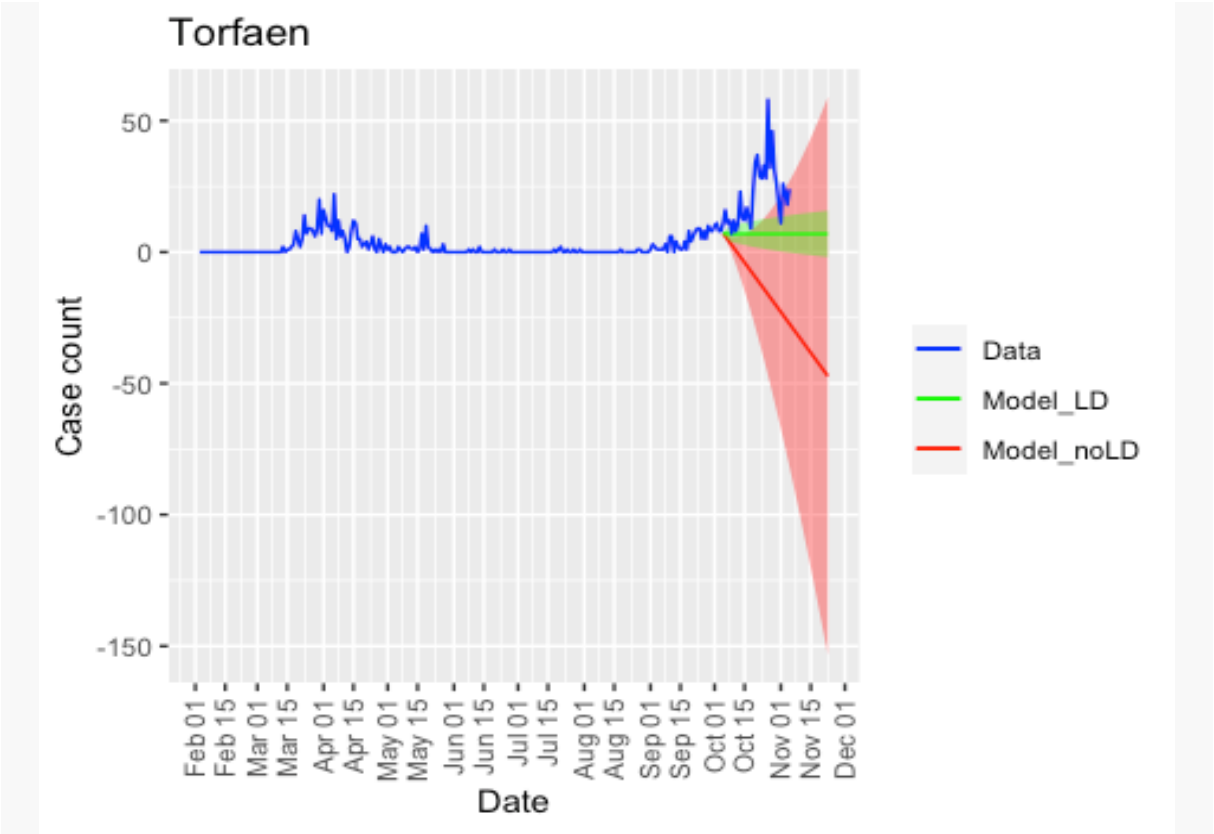
15


Torfaen
Case count
50
0
-50
-100
-150
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
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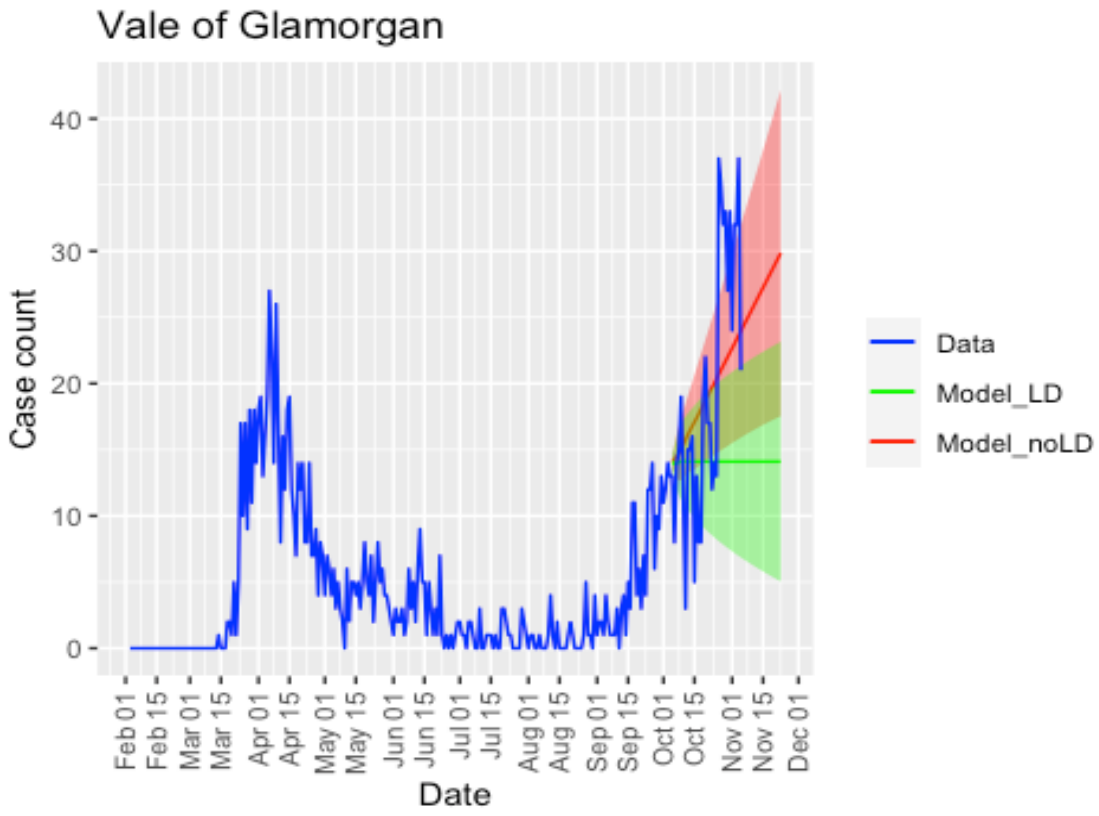
Vale of Glamorgan
Case count
40
30
20
10
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
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Nov 01
Nov 15
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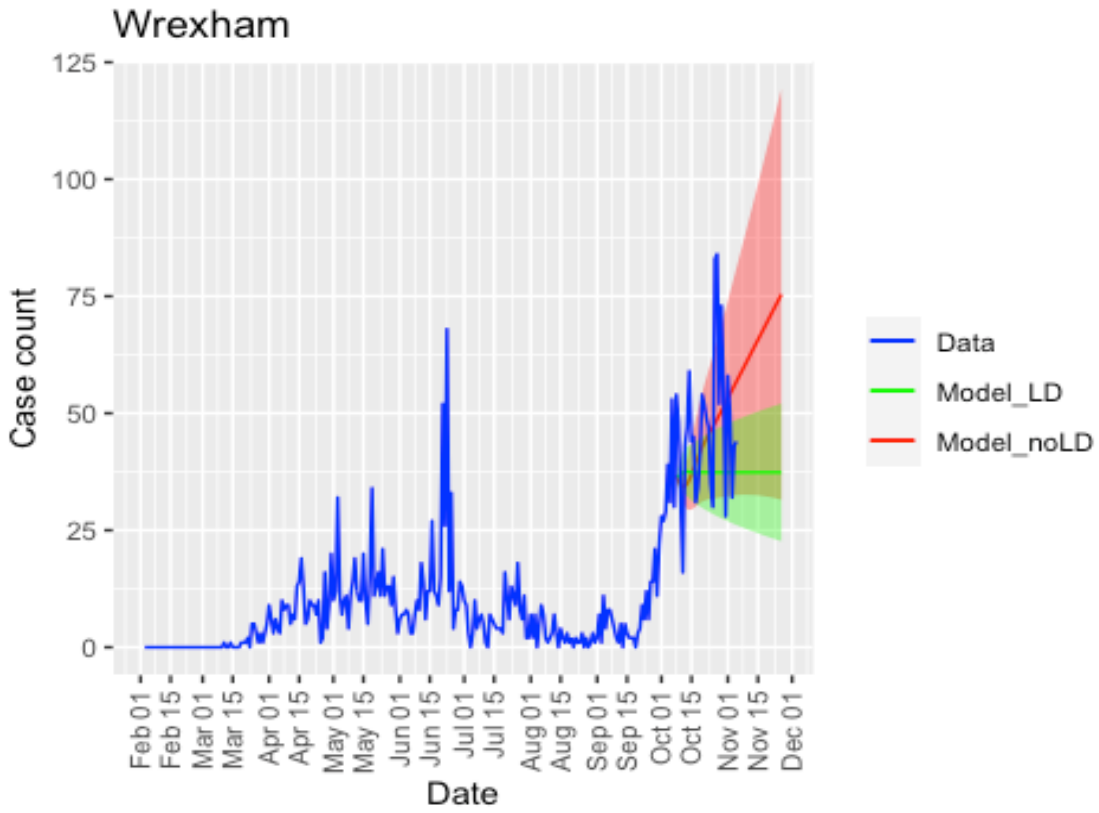
Date
Data
Model_LD
Model_noLD


Wrexham
Case count
125
100
75
50
25
0
Feb 01
Feb 15
Mar 01
Mar 15
Apr 01
Apr 15
May 01
May 15
Jun 01
Jun 15
Jul 01
Jul 15
Aug 01
Aug 15
Sep 01
Sep 15
Oct 01
Oct 15
Nov 01
Nov 15
Dec 01
Date
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Model_noLD