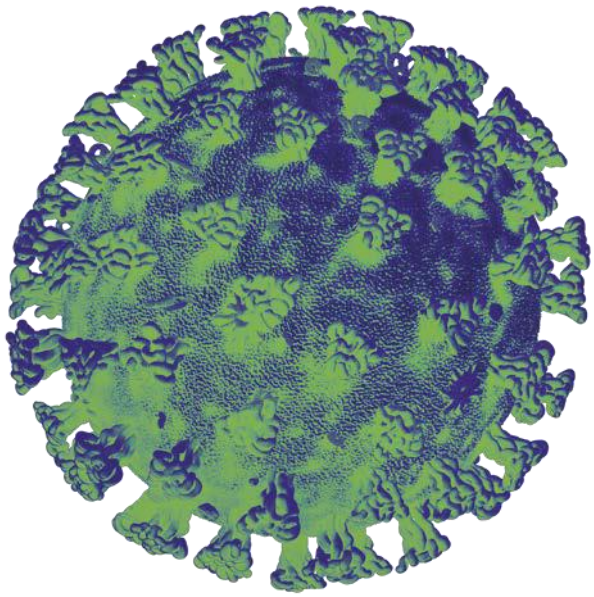
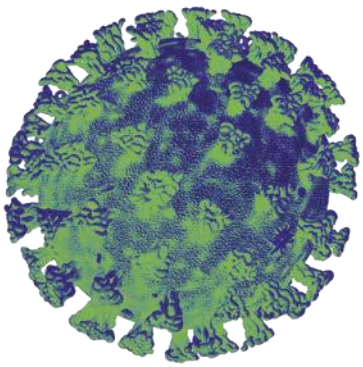
Llywodraeth Cymru
Welsh Government

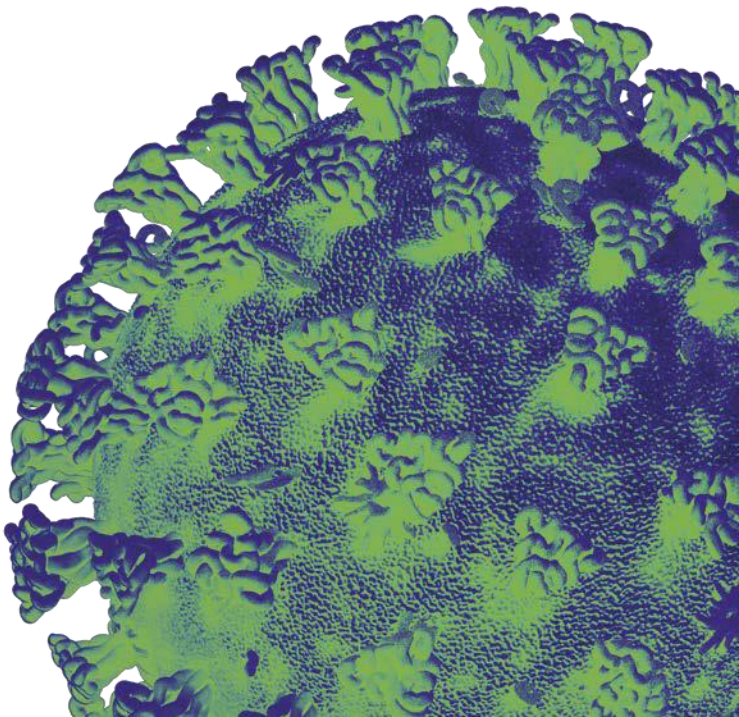
Technical Advisory Group

Policy modelling update

30th November 2021







Policy modelling update 30th November 2021

Welsh Government COVID-19 TAG Policy Modelling Subgroup

These scenarios were produced before the Omicron variant of concern was identified, and therefore do not include a factor for Omicron. The emerging scenarios for Omicron (not shown here) suggest it may be closer to the reasonable worst case (RWC) than the most likely scenario (MLS).

This is the latest in a series of papers on modelling the pandemic in Wales. Since the previous COVID-19 modelling update published in October 2021, the Swansea University models have been re-run on using updated data and the waning immunity assumptions have been updated to now include waning immunity from COVID-19 infections as well as from COVID-19 vaccines 9 months post vaccination or infections. [1]

This paper has a **new most likely scenario** (MLS) from Swansea University, as well as some scenarios from the University of Warwick, including one which represents a reasonable worst case (RWC) scenario. The new MLS has a longer plateau in cases and harms than previous scenarios which fits what has been observed in recent weeks and months.

The COVID-19 case hospitalisation ratio (CHR) and case fatality ratio (CFR) have greatly decreased since June 2021. A significant contributor may be the impact of the vaccination programme in Wales[2] (high confidence).

There is emerging evidence that the foci of the epidemic is shifting from teenagers to younger children, and from more deprived areas to less deprived and more rural areas. This may be an indication that we are seeing high levels of immunity through vaccination and natural infection in some groups and some geographical areas.

Wales may follow parts of Europe like Belgium and Austria with increases both in cases and in hospital admissions, but it may be that vaccination rates (including boosters) plus high cumulative infection rates mean that this will not happen. However, we need to continue to be vigilant for any signs of increased transmission as prevalence is still very high so a few weeks of doubling would create a very challenging situation for the NHS.

The emerging data on the boosters programme suggests booster vaccinations are very effective in preventing harms in individuals, and there are indications that this is starting to make a difference at a population level.[3] This may mean that while there continue to be high numbers of COVID-19 cases, particularly in children and young people, there could be a reduction in hospital admissions and deaths (medium confidence).

A regression analysis has also been included which indicates the points at which actual test positivity differs from what is expected based on COVID-19 confirmed

[1] technical-advisory-group-policy-modelling-update-14-october-2021.pdf (gov.wales)
[2] https://www.medrxiv.org/content/10.1101/2021.05.14.21257218v1
[3] Covid-19: Booster vaccine gives "significant increased protection" in over 50s | The BMJ

cases and prevalence. This is relevant in considering potential changes later this year, as disturbances in testing trends may be expected around the festive season in winter 2021/22.

We will continue to monitor the situation as we move through the winter and in particular, if and when new variants like B.1.1.529 (now known as Omicron) make their way to Wales and how this changes the outlook.

For future modelling scenarios, it will be really important to know more about the transmissibility, degree of immune/vaccine escape, and severity of disease that we may see if Omicron or another variant starts to produce a lot of cases or out-perform the Delta variant. A more transmissible variant that does not cause more severe disease may still cause a significant wave of pressure on the NHS because it infects all of the remaining susceptible population very quickly.

Because Omicron can be detected using S-gene target failure in some PCR tests (in the same way as the Alpha variant), having data on this for cases and hospital admissions will be important in tracking how quickly it is growing and whether it is more likely to lead to hospital admissions and other harms. This is assuming that we start to see significant numbers of Omicron cases in Wales.

Cases, hospital admissions and deaths in the third wave

We can look at the COVID-19 pandemic in Wales as three waves; the first up until the end of August 2020, the second peaking in January 2021 and stretching until end of May 2021 and the third starting in June 2021 and continuing up to now. There are different definitions of when to partition the three waves, but the scale of the differences hold when the waves are partitioned differently in time. In the first wave, testing was scarce so confirmed cases are not comparable with the second and third wave. We are now at a point where hospital cases have been higher in the third wave than in the first wave of COVID-19. However deaths in the third wave have been around half of those in the first wave. Hospital cases include nosocomial (healthcare acquired) cases and may include some people who are admitted for another reason but happen to test positive for COVID-19 on admission.

Based on these data, the case-hospitalisation ratio and case-fatality ratio were about 3-4 times higher in the first than second wave so assuming vaccines didn’t make a big difference in the second wave then it is possible about 3-4 times more cases were identified in the second wave as a proportion of total infections. But it may be that other factors made a difference like the Alpha variant in the second wave, and improved clinical management with more use of CPAP, and changes in testing behaviour as lateral flow devices (LFDs) became more widely available.

Table 1. COVID-19 cases, hospital cases and deaths in three waves of covid. Data as of 17 November 2021, from PHW ICNet.

Wave	PHW cases	PHW hospital cases	PHW deaths	Hospital admissions per case	Deaths per case
Wave 1 Feb 2020-end of Aug 2020	18,098	4,876	1,597	0.269	0.088
Wave 2 Sept 2020-end of May 2021	194,765	15,863	3,972	0.081	0.020
Wave 3 June 2021 onwards	269,425	6,398	765	0.024	0.003
Total	482,288	27,137	6,334	0.056	0.013

Case-hospitalisation ratio (CHR) and case-fatality ratio (CFR), all ages, Wales

There has been a clear decrease in the CHR and CFR since June 2020. That is, the percentage of hospital admissions and deaths resulting from COVID-19 confirmed cases has reduced.

Figure 1. COVID-19 CHR with 7 day lag, Wales, all ages

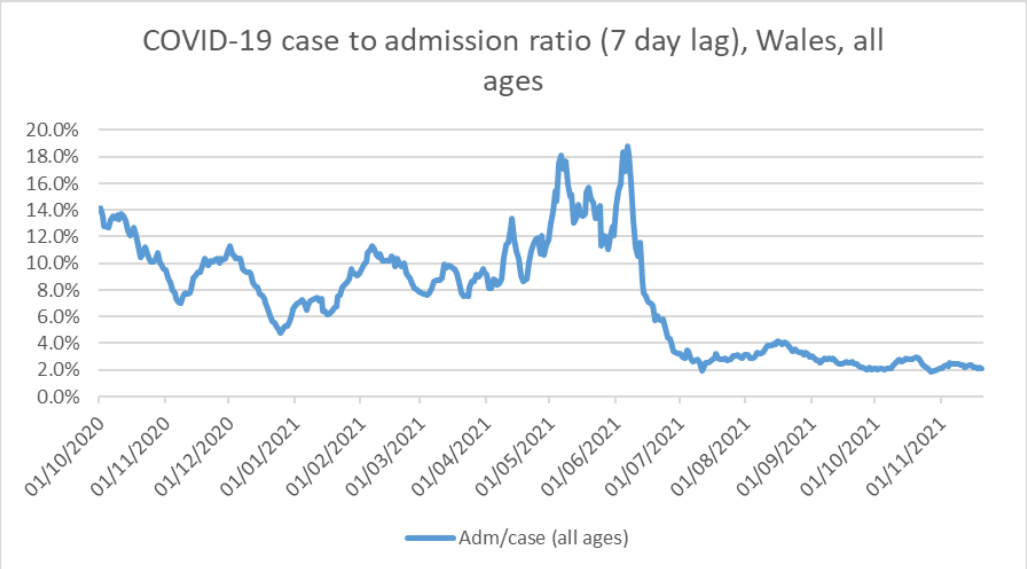
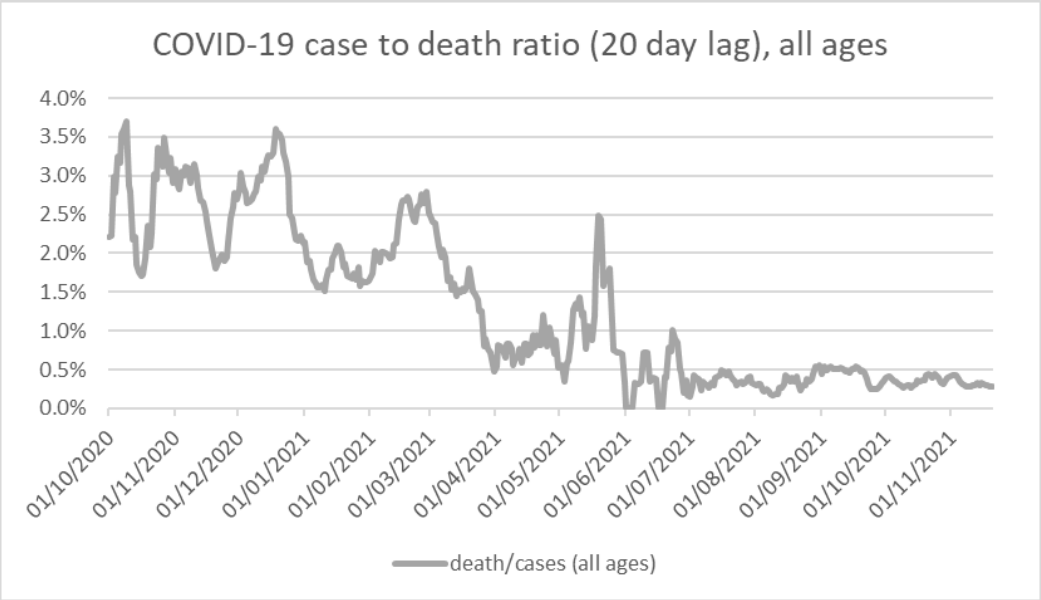


Figure 2. COVID-19 CFR with 20 day lag, Wales, all ages



For Charts showing the CHR and CFR for those aged under 25, 25 up to 70, and aged over 70, please see the Annex.

Note that the CFR and CHR are dependent on the number of tests carried out and so have biases. However, they can be used as a proxy for the infection hospitalisation ratio (IHR) and the infection fatality ratio (IFR) for COVID-19. Infections may be around 2-3 times the number of confirmed cases in the second and third wave.

Cumulative attack rate in children

Since October 2021 half term, the age profile of cases has moved from being focused around teenagers to being focused around older primary school children, which may be related to vaccine roll out in 12+ year olds and also the cumulative attack rate. Estimates from England put the cumulative attack rate at 81% in 5-14 year olds (see below).[4] This means that it is estimated that around 4 out of 5 children in these age groups have had the virus. If the picture is similar in Wales, it may explain why cases in teenagers have fallen as cases in younger children have increased; as we are starting to see a smaller pool of susceptible teenagers. The roll out of vaccinations in 12-15 year olds will also make a contribution.

Figure 3. Modelled cumulative attack rates in England, as of 18 November 2021.

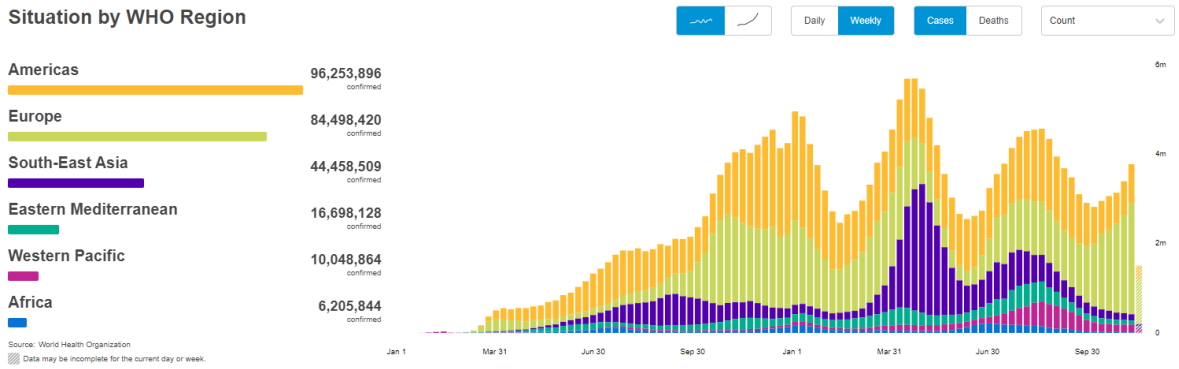
age	Median	95% CrI (lower)	95% CrI (upper)
<1yr	45%	45%	46%
1-4	59%	58%	60%
5-14	81%	80%	82%
15-24	70%	69%	71%
25-44	47%	47%	48%
45-64	36%	36%	37%
65-74	25%	25%	25%
75+	26%	25%	26%

Comparison with Europe

There is concern about the resurgence in COVID-19 in Europe, particularly places like Belgium where increased cases have been followed by increased hospital admissions. The concern is whether this is an early sign of what we can expect to see in Wales, perhaps with Europe seeing colder winter weather before us, which leads to more contacts in poorly-ventilated indoor spaces.

[4] COVID-19: nowcast and forecast 2021-11-18. Paul Birrell, Joshua Blake, Edwin van Leeuwen, MRC Biostatistics Unit COVID-19 Working Group, Daniela De Angelis. https://joshuablake.github.io/public-RTM-reports/iframe.html

Figure 4. Weekly cases by WHO region, 1st January 2020-November 15 2021[5].



A pre-print paper by Chapman et al.[6] looked at potential future burden of COVID-19 in European countries. It suggests that countries like England and Wales that have had a high previous burden of COVID-19 as measured with hospital admissions and deaths, as well as high vaccinations, and countries like England should have a lower future burden of COVID-19 harms in Winter 2021/22 than countries like Germany, Denmark and Belgium who are now seeing a resurgence in COVID-19 harms. Wales is not included in the paper but has a similar cumulative admission rate and vaccination rate to England.

The paper considers age structure but not health status of the population – so in Wales we may have a greater prevalence of risk factors that are not fully captured by looking simply at those vaccinated and hospitalised by age.

[5] WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data
[6] https://www.medrxiv.org/content/10.1101/2021.11.10.21266166v1

Most likely Scenario (MLS) and Reasonable Worst Case (RWC)

The most likely scenario (MLS) and reasonable worst case (RWC) are produced to assist with planning. They are not intended to predict what will happen but provide scenarios of what could happen. They are intended to be short term scenarios with the aim of updating them every couple of months or as the picture changes in light of new data, information, assumptions or variants. **The RWC was produced as a pessimistic Delta scenario so the emergence of new variants like Omicron might necessitate a new RWC once evidence emerges about the profile of Omicron in terms of transmissibility, severity of illness and immune/vaccine escape.**

MLS

The MLS is from the Swansea University epidemiological model described in pervious modelling updates.[7] Assumptions chosen for the MLS are a highly transmissible Delta variant (80% more transmissible than the previously dominant Alpha variant), good adherence to restrictions, and low vaccine effectiveness (70% against infections, 91% against hospitalisations/ICU, and 95% against deaths). We have chosen low vaccine efficacy for this scenario not only because it fits best to the data, but also because it fits to the PHE surveillance estimates for vaccine effectiveness very well.

RWC

The RWC is chosen from one of many scenarios for Wales produced by the University of Warwick /JUNIPER group which have been published by SAGE.[8] The scenario chosen for the new RWC for Wales is not the worst case that was provided, but provides a plausible, yet fairly unlikely, and pessimistic scenario. This is a scenario where vaccine effectiveness against infection falls to around 30% after two years, and against hospitalisation and death to around 79% after two years, and we see repeated waning, where boosters eventually revert to being as effective as second doses. The Warwick scenario includes infections but not cases so we assume that cases are 30-50% (central estimate of 40%) of infections based on previous comparison of datasets like ONS COVID-19 Infection Survey, with confirmed case data.

These scenarios from Warwick suggest that if vaccine effectiveness wanes quickly, there could be a significant further wave of hospital admissions leading to high levels of bed occupancy for COVID-19 hospital cases in 2022, but if vaccine effectiveness does not wane quickly then the scenarios suggest hospital occupancy would have peaked around 5 October 2021 at around 530 beds occupied for positive COVID-19 patients – in reality occupancy peaked at around 570 in early November, then has started to fall.

[7] https://gov.wales/technical-advisory-group-policy-modelling-update-14-october-2021
[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1027907/S1384_Warwick_Autumn_and_Winter_scenarios.pdf (Wales results on p.22)

We have chosen a RWC that happens relatively soon, and that is not the worst out of the scenarios for Wales. If, like the previous RWC scenarios, the time passes without harms reaching the peaks in this RWC, we can then re-assess the situation in January-February 2022 and select a new RWC if we still need one. One of the reasons we have not chosen the worst scenario for Wales is that if we compare the Warwick scenarios for Wales with those for England, we might expect admissions in Wales to be roughly 5% of those in England, but they are closer to 10% of those in England, so the models are predicting a potentially higher peak than they predict for the same scenarios for England. This difference is due to differences in susceptible pools, different timings of vaccination programmes, and differences in precautionary behaviour, and differences in case rates when the scenarios were run.

As with previous RWC scenarios, they represent a challenging scenario; not what we think will happen and not what we hope will happen. The RWC scenarios are there for planning purposes. Although the rapid waning scenarios are unlikely, measures to avert them may be required. The Warwick University modelling has an increase of around 50% in COVID-19-related hospital occupancy in one week but a 30% increase in one week would be enough to cause concern that pressure on the NHS as a result of COVID-19 getting out of control. This would need to be contextualised in relation to other pressures on the NHS. This would most likely be in a situation of a new variant and/or rapid waning of vaccine effectiveness in the population that was overtaking the impact of any boosters.

The following charts show the new suggested MLS and RWC plotted against actuals for COVID-19 cases, hospital admissions, hospital bed occupancy and deaths.

Figure 5. November 2021 most likely scenario (MLS) and reasonable worst case (RWC) from 1 December 2020 to 30 March 2022

(sources: MLS – Swansea University, RWC – Warwick University/Juniper, actuals – PHW tableau)

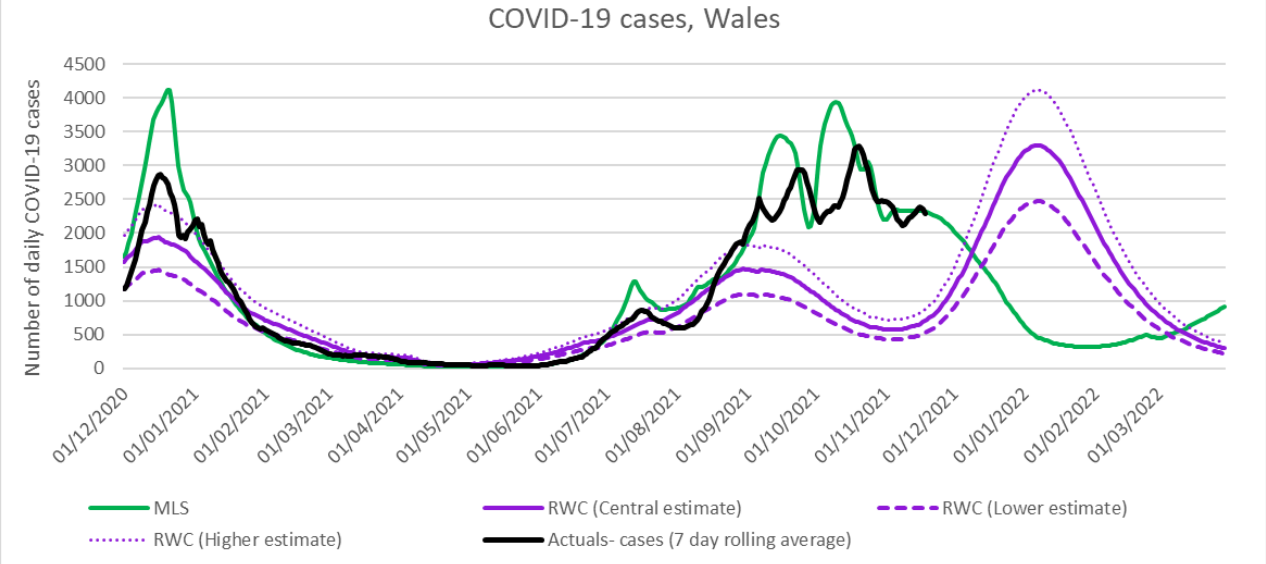


Figure 7 - November 2021 most likely scenario (MLS) and reasonable worst case (RWC) versus actuals from 1 December 2020 to 30 March 2022

(sources: MLS – Swansea University, RWC – Warwick University/Juniper, actuals – PHW ICNet)

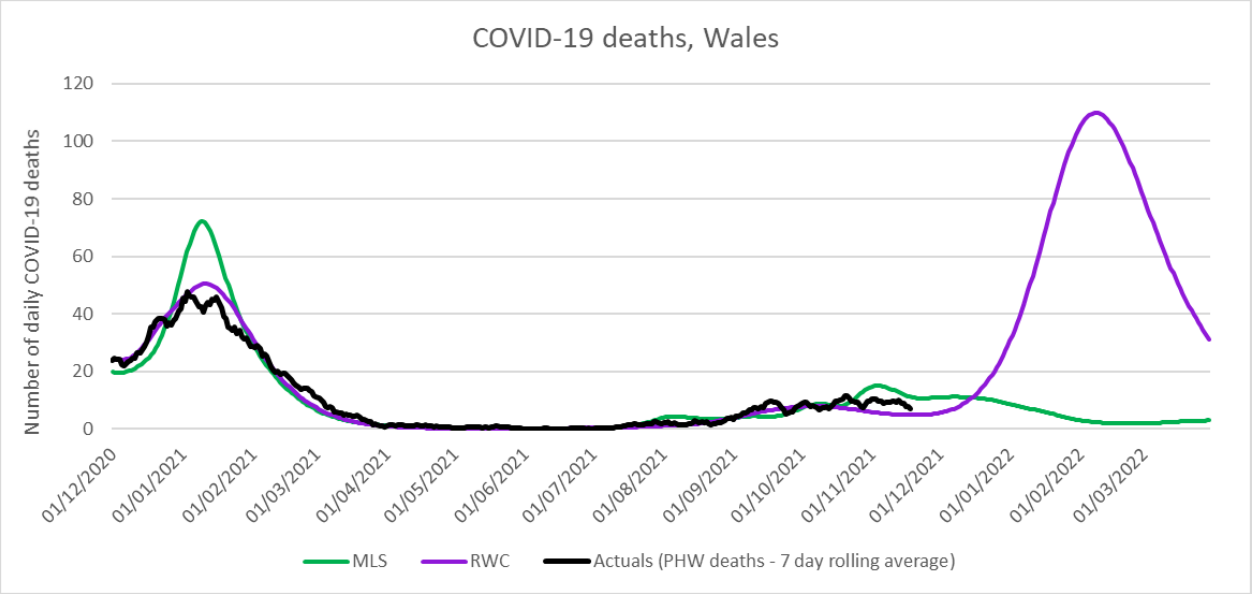


Figure 6: November 2021 most likely scenario (MLS) and reasonable worst case (RWC) versus actuals from 1 December 2020 to 30 March 2022

(sources: MLS – Swansea University, RWC – Warwick University/Juniper, actuals – PHW ICNet)

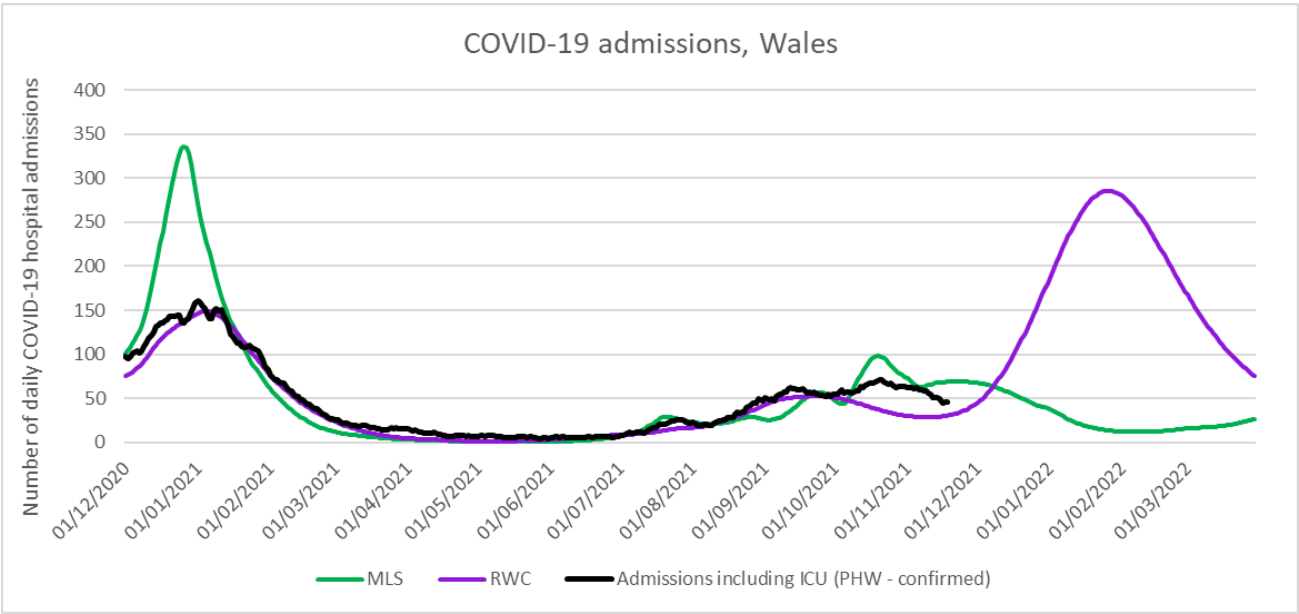


Figure 8 - November 2021 most likely scenario (MLS) and reasonable worst case (RWC) versus actuals from 1 December 2020 to 30 March 2022

(sources: MLS – Swansea University, RWC – Warwick University/Juniper, actuals – PHW ICNet)

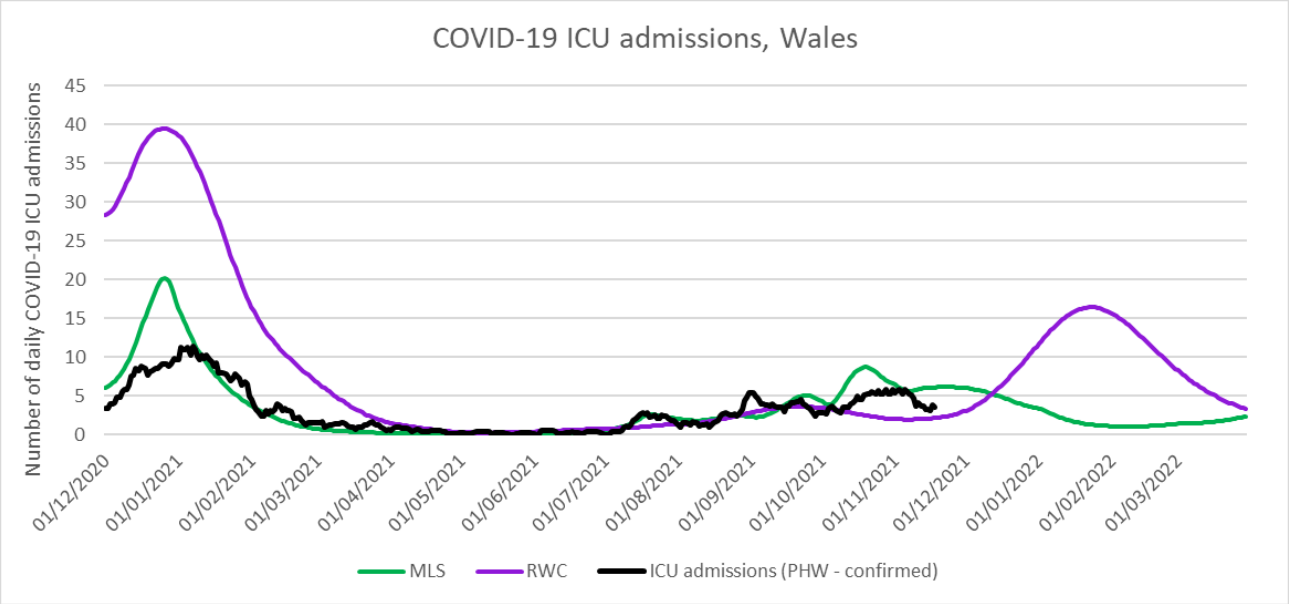


Figure 9 - November 2021 most likely scenario (MLS) and reasonable worst case (RWC) versus actuals from 1 December 2020 to 30 March 2022

(sources: MLS – Swansea University, RWC – Warwick University/Juniper, actuals – StatsWales)

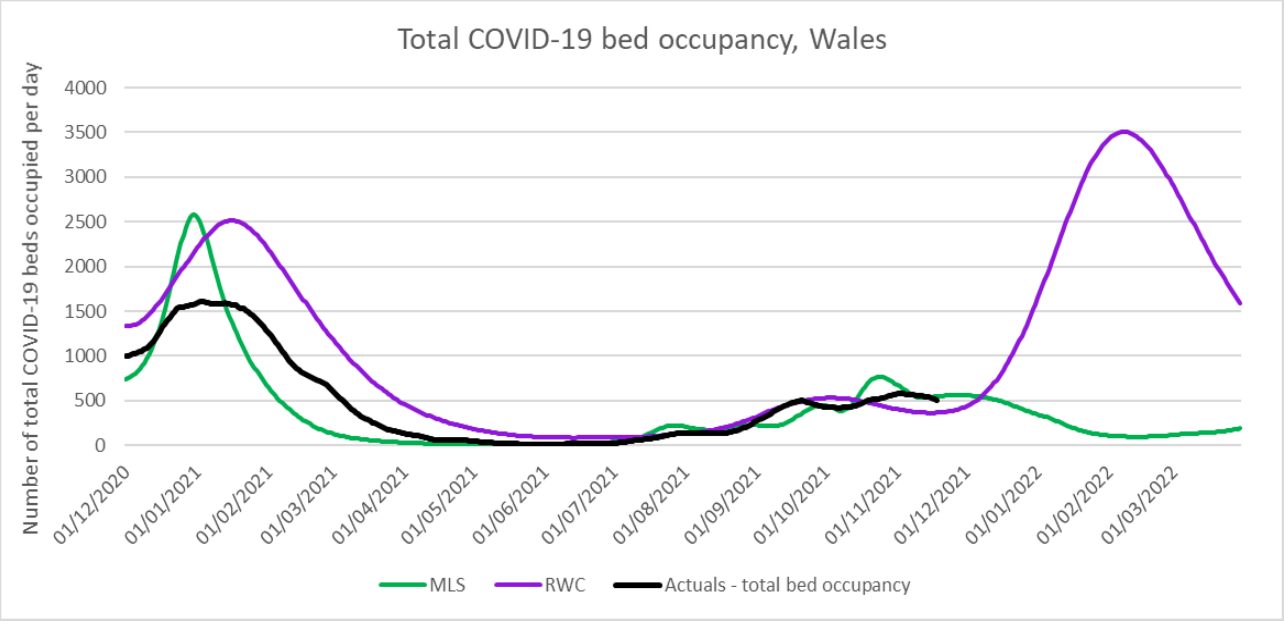


Figure 10 - November 2021 most likely scenario (MLS) and reasonable worst case (RWC) versus actuals from 1 December 2020 to 30 March 2022

(sources: MLS – Swansea University, RWC – Warwick University/Juniper, actuals – StatsWales)

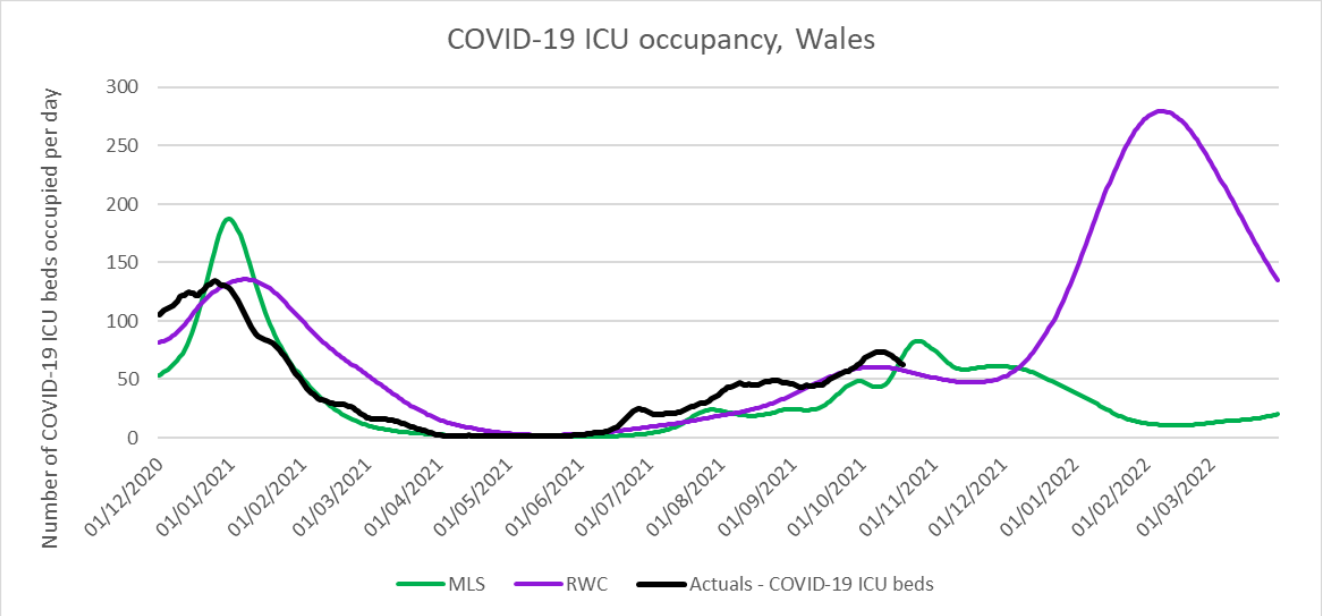


Table 2: Totals between 1 November 2021 and 30 March 2022

Scenario	Cases	Deaths	Admissions	ICU Admissions
MLS	153,700	1,030	5,300	470
RWC	234,900	7,100	22,000	1,250

Table 3: Daily peaks between 1 November 2021 and 30 March 2022

Scenario	Cases	Deaths	Admissions	Bed Occupancy	ICU Bed Occupancy
MLS	2,300	20	70	680	80
RWC	3,300	110	290	3,500	280

The RWC scenario is similar to the MLS in terms of peak cases but because the RWC includes more waning vaccine effectiveness in it, it is a lot higher for hospital activity and deaths.

The Relationship between confirmed COVID-19 cases, COVID-19 infections, and test positivity

A multiple linear regression (MLR) was carried out using SPSS on test positivity as the dependent variable and PHW case numbers and ONS COVID-19 infection survey (CIS) prevalence percentage estimates as the predictor variables. The data was from 7 November 2020 until 13 November 2021.

The MLR formula can be written as:

$$Y = a + b_1X_1 + b_2X_2 + \cdots + b_iX_i$$

Where Y represents the dependent variable, a is a constant, b_i represents each coefficient associated with each explanatory variable, X_i represents each explanatory variable and i is the number of explanatory variables used.

The test hypothesis was:

$$\begin{cases} H_0: b_i = 0 \\ H_1: b_i \neq 0 \end{cases}$$

In this analysis, we obtained the following MLR equation:

Y = 0.031 + 0.000042$\mathbf{x_1}$ + 4.24$\mathbf{x_2}$

Where **Y** = Test positivity

$\mathbf{x_1}$ = Number of daily cases (source: PHW tableau)

$\mathbf{x_2}$ = Percentage of Wales' population estimated to have COVID-19 (ONS CIS)

Figure 11. Actual positivity rate vs. regression estimate

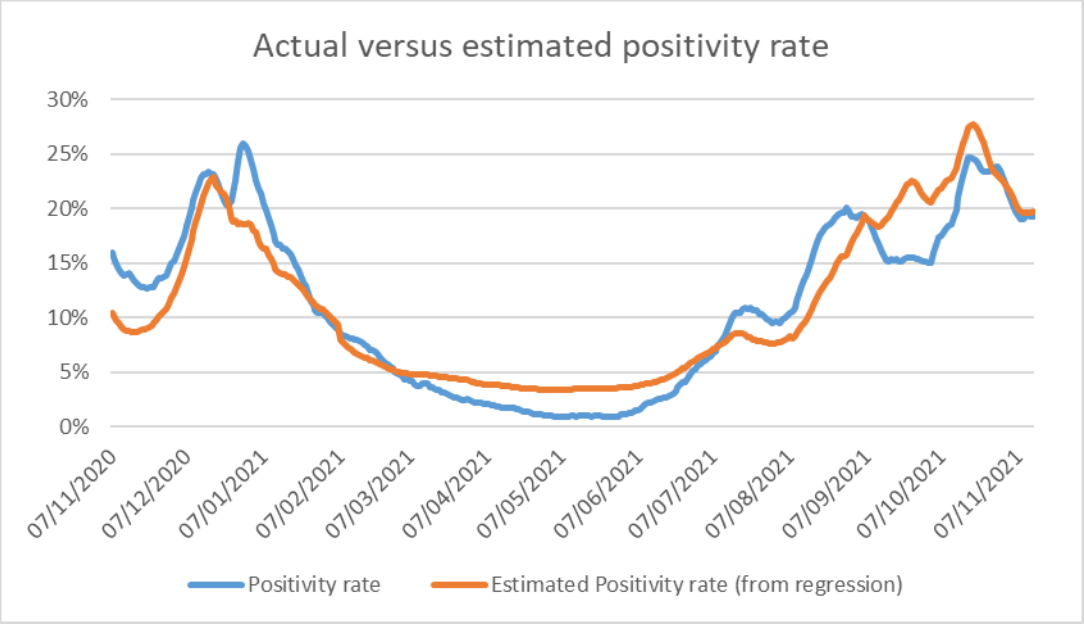


Figure 11 shows the estimate of test positivity from the regression compared with the actual COVID-19 test positivity observed. This conveys where the actual test

positivity differed from what we were expecting based on the regression formula. This occurred between Christmas and New Year's Eve 2020 where test positivity was much higher than expected around a week after Christmas. This may be due to a reduction in tests when people were off work/school over the Christmas period.

There was also a possible deviation around July 2021 which may be related to the 'pingdemic' of a lot of contacts being notified to self-isolate by the NHS Covid app, as well as a higher proportion of people with borderline symptoms potentially avoiding being tested before they were going away on holiday.

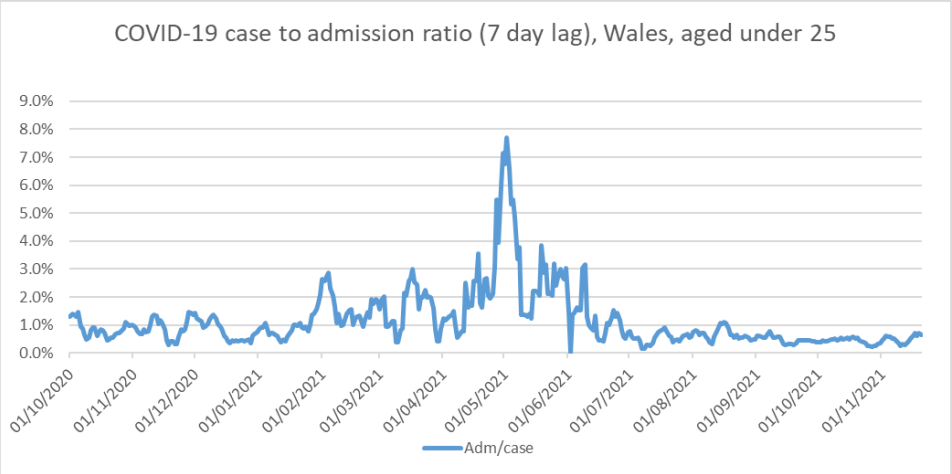
This continued until September, where we observed a lower positivity rate than expected from the regression formula. This may be because the test positivity was pulled down by the increased number of tests being carried out. Test positivity may also change depending on the prevalence of other viruses with similar symptoms to COVID-19; as of September 2021, we have high case rates but test positivity has fallen, and total testing rates are very high, which may reflect incidence of other winter viruses like RSV and rhinovirus with similar symptoms to COVID-19, as well as school aged children being tested more – although conversely, school aged children having LFD tests then confirmatory PCR would be expected to increase positivity.

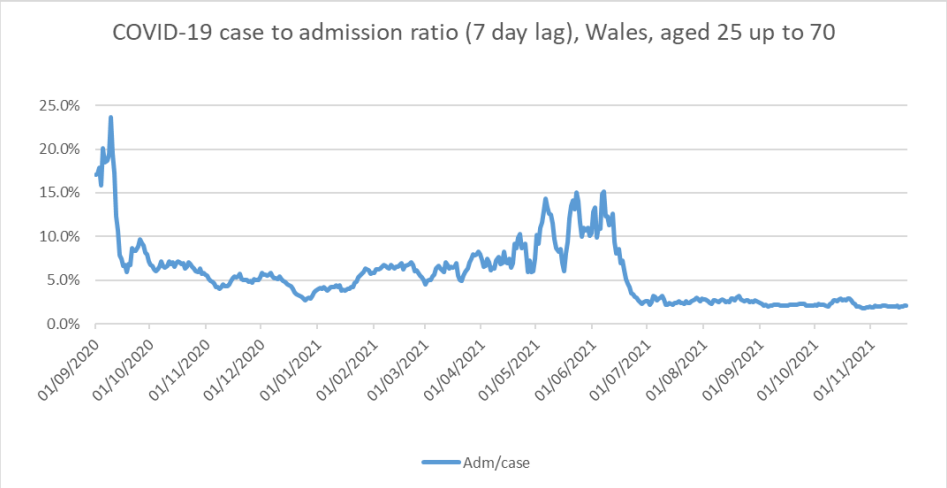
There was also an incident whereby a number of cases from a testing lab in England were falsely recorded as negative. This may largely explain why there are differences in expected versus actual positivity rates between 2 September and mid October 2021.

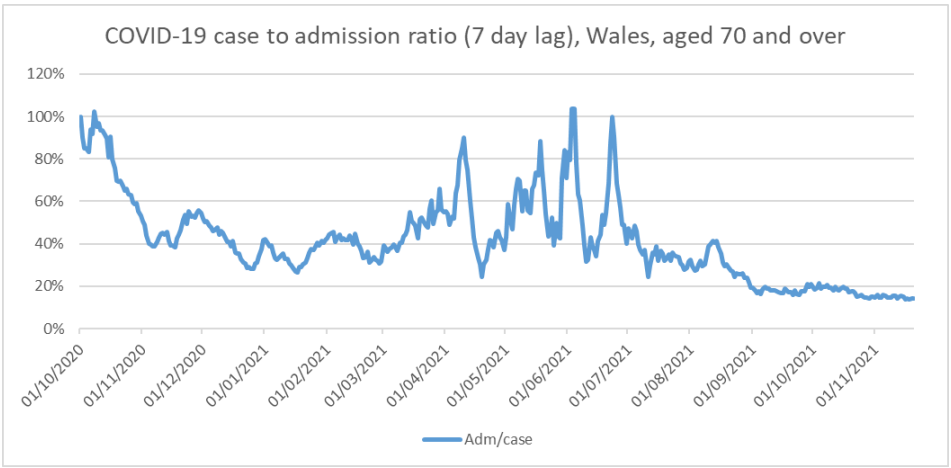
More detailed regression outputs are shown in Annex 2.

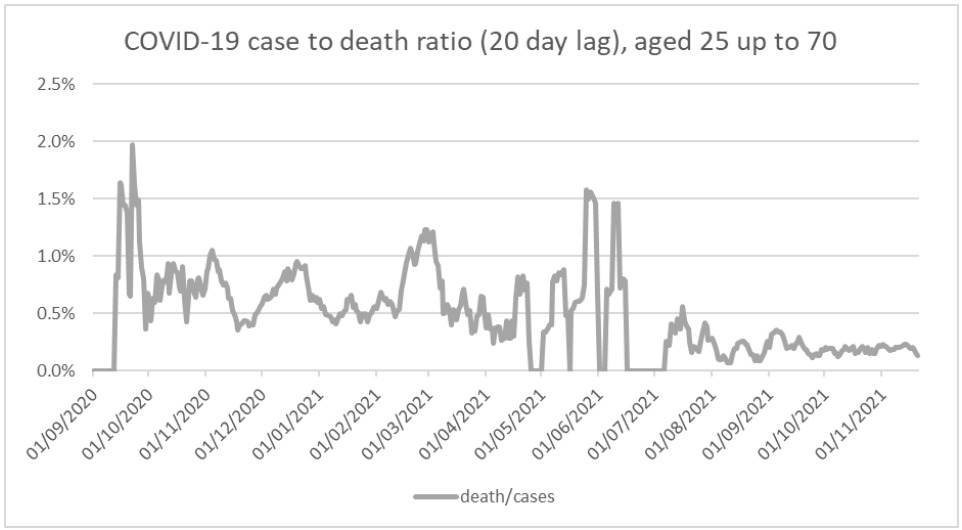
Annex 1. Case fatality ratio and case hospitalisation ratio charts by age band

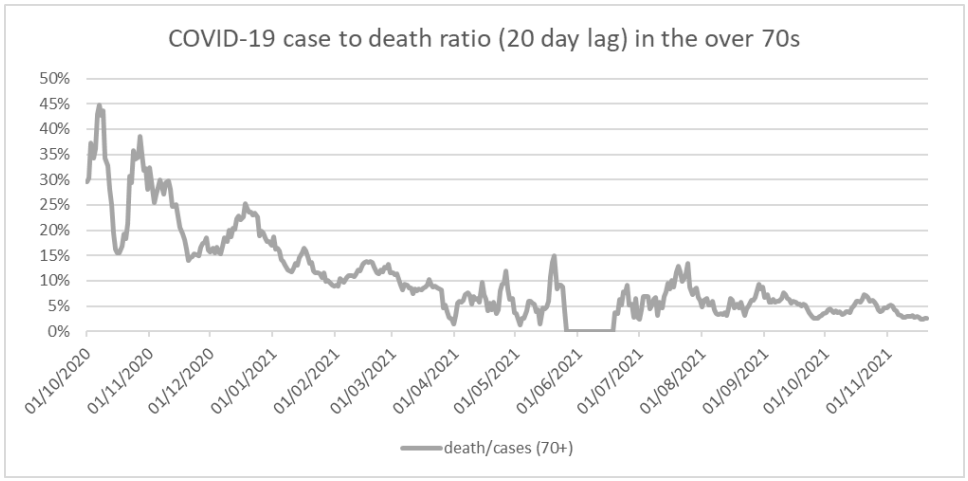
Note: Case fatality ratio for under 25s not shown as there have been less than 5 covid deaths in this age group.








COVID-19 case to death ratio (20 day lag), aged 25 up to 70
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
01/09/2020
01/10/2020
01/11/2020
01/12/2020
01/01/2021
01/02/2021
01/03/2021
01/04/2021
01/05/2021
01/06/2021
01/07/2021
01/08/2021
01/09/2021
01/10/2021
01/11/2021
death/cases


COVID-19 case to death ratio (20 day lag) in the over 70s
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
01/10/2020
01/11/2020
01/12/2020
01/01/2021
01/02/2021
01/03/2021
01/04/2021
01/05/2021
01/06/2021
01/07/2021
01/08/2021
01/09/2021
01/10/2021
01/11/2021
death/cases (70+)

Annex 2. MLR Conditions

For the MLR regression, the following conditions were satisfied:

1. Multicollinearity: The tolerance is more than 0.1 and variance inflation factor (VIF) < 10 for every independent variable included in the model; therefore the independent variables are not highly correlated.
2. The Durbin-Watson test statistic (*d*) is less than 1 and so it is not accepted that the errors are reasonably independent (since it is not the case that 1 < *d* < 3). The condition of independence of errors is not satisfied.
3. The ANOVA tables all give a p-value < 0.001. This means that we reject the null hypothesis that b=0 for all the coefficients in the model. We conclude that the regression is statistically significant. Many of the p-values given for the individual independent variables are also all < 0.05, and thus should be retained in the model. Those variables with p-values > 0.05 were removed from the model, and the model was rerun.

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	.031	.002		13.459	.000	.026	.035		
	PHW cases	4.194E-5	.000	.519	9.289	.000	.000	.000	.124	8.078
	ONS prev	4.240	.560	.422	7.566	.000	3.138	5.342	.124	8.078

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.926[a]	.858	.857	.02900511	.858	1111.156	2	369	.000	.011

a. Predictors: (Constant), ONS prev, PHW cases

b. Dependent Variable: Positivity rate

The R^2 value 0.859. Therefore, 85.8% of variation in the test positivity can be attributed to the predictor variables. These do not tell us cause and effect but that there is a lot of collinearity between these variables – they track each other very closely.

Annex 3. All University of Warwick/JUNIPER scenarios

Figure 12. All University of Warwick scenarios for Wales with repeated waning immunity. RWC is Dec-30% VE scenario.