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Technical Advisory Group

The social value of a COVID case January 2022

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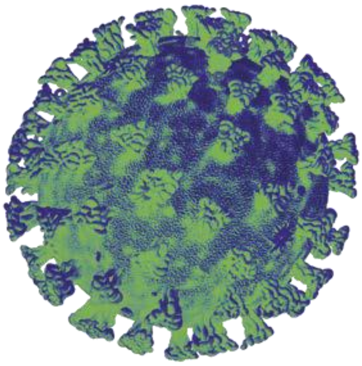

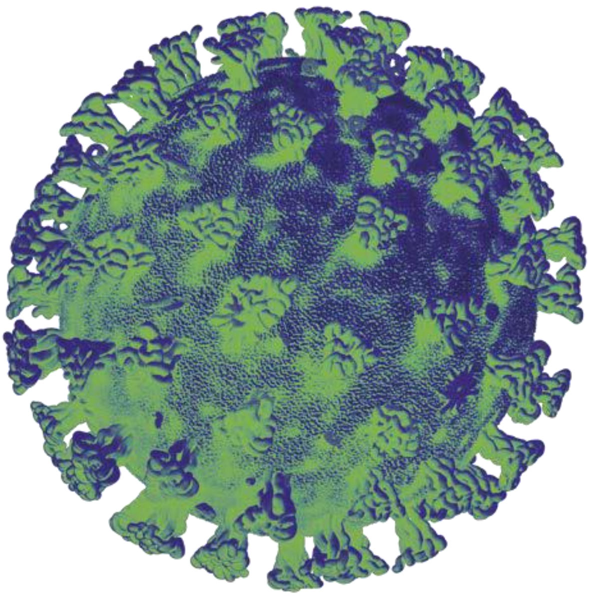

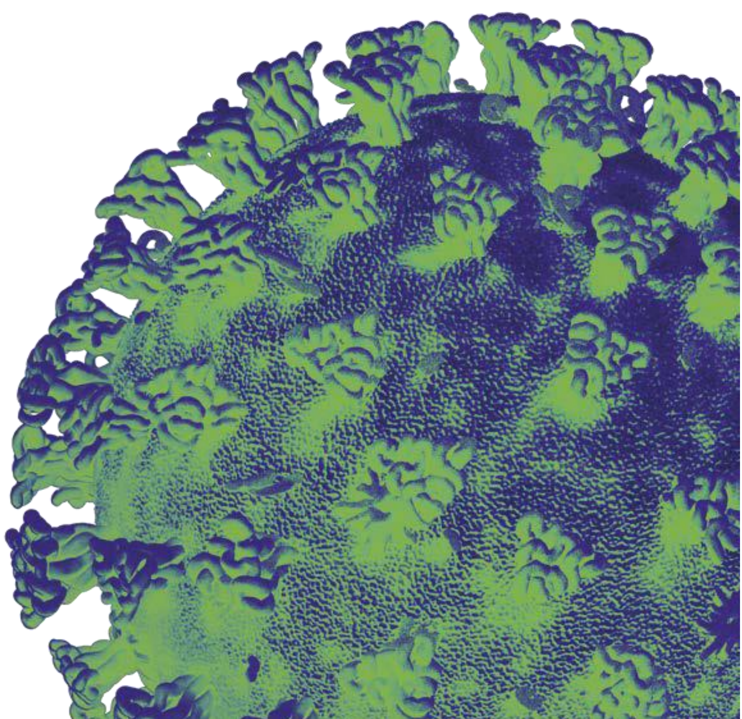

The social value of a COVID case January 2022

Welsh Government COVID-19 TAG Policy Modelling Subgroup

Summary

This paper outlines the estimated direct social cost of one COVID-19 PCR-confirmed case in January 2022. It compares that estimate with December 2020 and July 2021 estimates to understand how this has changed over the period. The cost estimates are based on the ratio of cases to other outcomes – hospital admissions, ICU admissions, deaths and estimated long COVID cases. The most recent estimates suggest a cost of one COVID-confirmed PCR case around £21,100 in December 2020, falling to around £5,800 in January 2022. January 2022 was affected by reduced PCR testing - adjusting for this the cost per confirmed case would be lower.

Assumptions have been improved in comparison with previous estimates - more robust data on costs of hospital activity, estimated QALY losses (an estimate of quality and quantity of life; QALY) and long COVID QALY losses.

Table 1. Estimated direct social cost of one PCR-confirmed case

Basis	(to nearest £100)	Comments
COVID, December 2020	£21,100	Updated assumptions (long COVID, updated costs) affect the estimate
COVID, July 2021	£8,300	Updated assumptions (long COVID, updated costs) affect the estimate
COVID, January 2022	£5,800	Affected by a greater proportion of cases being identified by lateral flow tests, so the true cost per case is likely to have fallen further.
Influenza, England, 2017-18	£6,700	See Appendix 3.

In December 2020, policies that delayed a case produced a considerable saving – if a potential December 2020 case could be delayed until July 2021 its social cost reduced to around 40% of what it would have been. This is an average – the cost ratio would likely be higher for vulnerable groups who are at higher risk of severe outcomes. Later this gain from case delay was less (around 70%). The gain from case delay may continue to decline. It may depend on the timing and effectiveness of repeated boosters. If exposure to the Omicron variant provides some immunity to potential future variants that may be more severe, there may even be a saving from increased levels of Omicron-infected individuals in the period immediately preceding a new variant becoming dominant.

As of April 2022, it is estimated that in England, around 70% of the population may have been infected[1] since the start of the pandemic, but a lot of these infections

[1] "Proportion ever infected" tab at https://epiforecasts.io/inc2prev/report

came after the COVID-19 vaccination programme was rolled out, and a high proportion of these infections occurred in the Omicron wave. Almost all adults are now estimated to have antibodies: around 99% in England and Wales were estimated to have antibodies for COVID-19 at the 179 ng/ml threshold in the week beginning 14 March 2022. Even the remaining 1% who tested negative at this threshold may still have some immune protection against the virus. Antibodies do not mean that someone will not be infected – ONS positivity has been up to 6-7% at the same time as this high antibody prevalence being observed.

Average cost per case may be useful in looking at the cost effectiveness of future population level policy measures such as the vaccination programme.

A re-estimate more comparable with the earlier paper, and examining the effect of each assumption, was also carried out. See the section "Sensitivity Analysis – resetting some assumptions" below.

Introduction

This paper updates a previous paper and explores the social cost of a covid case, in order to inform decisions around the cost effectiveness of interventions. This is a technical exercise and not putting an intrinsic value on life but recognising that decisions on allocation of scarce resources have to be made within a rational framework.

Understanding the cost effectiveness of interventions to prevent COVID-19 transmission is important. Decisions need to be based on an integrated impact assessment where costs and benefits are quantified as much as possible. Previous analysis of mass testing has suggested it was very cost effective during a time of high prevalence and when vaccines were not yet available.[2] It is likely that mass testing might not be cost effective now that the there are fewer severe outcomes from COVID-19 infections – a lot of the social value of preventing infections came from preventing deaths.

Governments and health systems have fixed budgets. There are opportunity costs of spending more on COVID-19 and less on other health conditions and social care. A lot of the spend on the pandemic has been non-recurring but as it moves into recurring budgets, decisions need to be made around prioritising spend. If preventing COVID-19 cases has a smaller return on investment than investing in other areas of health, then there may be an argument for moving investment elsewhere, for instance to other public health interventions for primordial prevention of cardiovascular disease, cancer and chronic obstructive pulmonary disease.[3] To understand more about this, it is possible to estimate the Quality Adjusted Life Years (QALYs) and costs of every COVID-19 case, on average, to help to balance the impact of interventions.

This paper estimates the social cost of one COVID-19 case in Wales in January 2022. This can be contrasted with two earlier points in time: December 2020 which

[2] Cost-effectiveness of whole area testing of asymptomatic SARS-CoV-2 infections in Merthyr Tydfil, 2020: A Modelling and economic analysis | medRxiv
[3] Return on investment of public health interventions: a systematic review | Journal of Epidemiology & Community Health (bmj.com)

was in the middle of the second (mainly Alpha) wave and July 2021 which was in the third (mainly Delta) wave.

A sensitivity analysis re-estimate enhances understanding of the changes in social cost of COVID-19 over time and as the vaccination programme has progressed, offering further insight to decision-makers around the relative value of interventions to delay or prevent COVID-19 cases. Many of the alternative assumptions used for the sensitivity run are from the previous paper. Two other alternative figures are used – a lower QALY loss from death (using a Netherlands calculation) and a lower QALY valuation - £30,000 – which is quoted as the NICE threshold. The value of a QALY is based partly on technical calculations like the value of a statistical life (VSL) but is partly a policy decision.

Methods

Data on COVID-19 cases, admissions, ICU admissions and deaths are from Public Health Wales ICNet. Sources for updated assumptions are discussed in Appendix 1.

Table 2. Assumptions used for the estimate

Hospital admissions lag (admission occurs this many days after case onset) (unchanged)	7
ICU admission occurs this many days after case onset (unchanged)	10
Death occurs this many days after case onset (unchanged)	20
QALY losses for cases	0.00167
NHS case-only costs (unchanged)	set at zero
QALY losses for hospitalisation	0.031
NHS costs for hospitalisation	£6,531
QALY losses for ICU (unchanged)	0.03457
NHS costs for ICU	£40,687
QALY losses for deaths (mortality related QALYs discounted at 3.5% per annum) (unchanged)	6.78
NHS costs for deaths (unchanged)	£232
QALY losses from long COVID	0.3
NHS long COVID costs	£100

QALYs lost valued at £70,000 per QALY.

The unchanged estimated QALYs and costs have been published previously.[4]

[4] technical-advisory-cell-modelling-update-12-february-2021.pdf (gov.wales)

Long COVID associated costs and QALY are estimated in Appendix 2. Long COVID proportion is estimated as follows:

Self-reported long COVID prevalence varies by age.[5] The proportion of COVID-19 cases that result in long COVID by age group was arrived at using the proportion of the total population with self-reported long COVID who previously had COVID-19 at least 12 weeks ago. (Some definitions for long COVID mention 4 weeks but 12 weeks is used as this is the more usual definition and is long enough for significant quality of life losses to accumulate).

The number of long COVID sufferers in Wales by age group was calculated using data from ONS's Prevalence of ongoing symptoms following coronavirus (COVID-19) infection in the UK and Wales' mid-year population estimates for 2020. The number of cases in Wales by age group was calculated using ICNET data. The earliest period for which ONS's prevalence was published related to people living in private households with self-reported long COVID who first had (or suspected they had) COVID-19 at least 12 weeks previously, UK: four-week period ending 6 March 2021. This can be used to estimate the number of people with long COVID in Wales at the time (if the UK age-group prevalence is applicable to Wales). The PHW ICNet data can be used to estimate the number in Wales who had COVID-19 in an early enough timeframe to include those who later self-reported long COVID in the first ONS survey of the type (taken to be cases up to 15 December 2020). Taking a ratio of the number of COVID-19 cases in Wales by age and the long COVID rates by age might, naively, be thought of as estimating the proportion of COVID-19 cases that became long COVID. However, this will mix the ones who have just become eligible for the survey (who, at 12 weeks, have long COVID) and those who have long COVID after even-longer-ago COVID-19 from which they have not yet fully recovered. There is insufficient information to resolve this question definitively. However, it is possible to apply a ratio of the same long COVID count to only recent cases - subtract early cases (taken to be cases up to 15 September 2020) from the count of cases up to 15 December 2020. With no further information to go on, the mid-point between those ratios can be taken as the estimated proportion of COVID-19 cases that became long COVID in the earlier period. This estimated proportion will be used for both December 2020 and July 2021.

[5] Prevalence of ongoing symptoms following coronavirus (COVID-19) infection in the UK - Office for National Statistics (ons.gov.uk)
using their Table 5 - Estimated percentage of people living in private households with self-reported long COVID who first had (or suspected they had) COVID-19 at least 12 weeks previously, UK: four-week period ending 6 June 2021

Table 3 shows the estimated percentage and number of long COVID cases in Wales in December 2020 and July 2021; this suggests that because the age structure of cases has changed, the percentage of cases that would result in long COVID may have fallen from 35% in December 2020 to 29% in July 2021. Table 3 also shows the estimated percentage and number of long COVID cases in Wales in January 2022; this suggests a further fall to 23%. Changes around testing introduced in January 2022 (detailed below) will have affected case counts which may have affected this percentage.

Table 3. Number of confirmed COVID-19 cases, and estimated long COVID cases, December 2020, July 2021 and January 2022. Actual cases data from PHW ICNet data- uses authorised date for the match to the month, excludes age unknown, and excludes cases outside Wales.

Age group	**0-24**	**25-34**	**35-49**	**50-69**	**70+**	**All ages**
Number of cases Dec 2020	14,943	11,947	15,830	17,349	6,867	66,936
Estimated long COVID cases Dec 2020	2,499	3,346	6,335	9,527	2,044	23,751
	17%	*28%*	*40%*	*55%*	*30%*	*35%*
Number of cases July 2021	9,697	3,986	3,813	2,837	833	21,166
Estimated long COVID cases Jul 2021	1,622	1,116	1,526	1,558	148	6,070
	17%	*28%*	*40%*	*55%*	*30%*	*29%*
Number of cases January 2022	36,310	24,332	27,778	21,090	7,133	116,643
Estimated long COVID cases January 2022	2,264	5,497	7,440	9,157	2,329	26,687
	6%	*23%*	*27%*	*43%*	*33%*	*23%*

From the ONS survey, those in Wales (but based on a UK-wide percentages) self-reporting long COVID at the end of 2021 would have been 45,410 - nearly 19,000 more than the 26,687 which Table 3 suggests would have been generated in January 2022. This is not surprising - long COVID is a mixture of those who have symptoms after 12 weeks that disappear soon afterwards plus a long tail of those who continue with long COVID, possibly for years. Most who are particularly susceptible to harder-to-treat long COVID will be affected already because a lot of the population have been exposed to the virus by now. There is uncertainty around whether repeated exposure to the virus increases or reduces the risk of long COVID.

Testing policy changes introduced on 6 January 2022 that may have affected the January 2022 COVID-19 case count include:

1. Asymptomatic people who have a positive lateral flow test no longer required to complete a PCR test (unless in a clinically vulnerable group which may need early access to treatment or advised to do so as part of a research or surveillance programme). People with symptoms still advised to book a PCR test. Both required to isolate for at least five days
2. Unvaccinated contacts of positive cases (self-isolating for 10 days) to take a lateral flow test on day two and day eight instead of a PCR test
3. Vaccinated contacts of positive cases should take daily LFTs for seven days and exercise caution when mixing with others but do not have to isolate
4. Fully vaccinated travellers and under 18s to take a lateral flow test on day 2 (no longer required to take a pre-departure test and a day 2 PCR test when arriving in the UK). Requirements for non-vaccinated travellers remained unchanged.

Rule changes on 28 January 2022 that may have affected January case count (to a lesser extent):

1. People who test positive for COVID-19 able to leave self-isolation after five full days subject to two negative lateral flow tests (the implementation of this in England on 17 January may also have had an effect on Wales)
2. Unvaccinated contacts of positive cases take a lateral flow test on days 2 and 8 instead of a PCR test while self-isolating
3. Settings such as care homes returned to twice a week (rather than daily) routine lateral flow testing.

These rule changes might if anything have increased the apparent social cost of a COVID case, everything else being equal– if the various costs which make up the numerator are still being calculated as they had been previously but confirmed PCR case denominator is not reaching its true like-for-like level that would result in an apparent increase. In the first full week in January 2022 around a quarter of positive cases that Public Health Wales recorded were LFT positives that the public reported. By the last week of January 2022, it was around 60% - LFT positives had increased, but PCR positives had fallen significantly due to the rule changes. The relevant data is discussed further in Appendix 4.

Initial Results

Combining the costs and QALY estimates discussed in the “Methods” section (losses, number of cases, admissions, ICU and deaths) gives an estimated number of outcomes per 100 COVID-19 cases, and an estimated social cost (financial cost plus QALYs lost valued at £70,000 per QALY) per COVID case.

The social cost of a COVID-19 case in December 2020 was around £21,100 whereas in July 2021 it was around £8,260 and in January 2022 around £5,760. In December 2020, the QALYs lost from COVID-19 deaths made up the majority of social costs. In July 2021, morbidity-related QALYs and costs – in particular, long COVID-related, made up most of the social costs, with mortality making up only around 20%. In January 2022 the morbidity-related QALYs and costs had fallen compared to July 2021 but the total loss associated with mortality had fallen more (to about 40% of its July 2021 figure). Over time the social costs of COVID-19 are moving from mortality to morbidity.

In July 2021, ICU admissions had not fallen as much as total admissions or deaths as a proportion of cases (which may have been related to differences in clinical decision making in admitting people to ICU perhaps because of changes in the age structure of hospital cases or increased severity of non-vaccinated cases with the Delta variant). Whereas by January 2022 the total loss (NHS costs and valuation of QALY losses) associated with ICU admissions fell to about 11% of its July 2021 figure.

Table 4. Number of COVID-19 cases, long COVID cases, admissions, ICU admissions and deaths per 100 COVID-19 cases in December 2020, July 2021 and January 2022, with social cost per COVID-19 case.

December 2020							
100 Cases Produces:	**Cases**	**Long COVID cases**	**Admissions**	**ICU admissions**	**Deaths**	**Total**	**Social cost per COVID case (£)**
	100	35.48	6.44	0.39	2.69		
QALYs lost	0.167	10.645	0.200	0.014	18.213	29.238	
costs (£)	0	3,548	42,047	15,904	623	62,122	
total net monetary loss (£)	11,690	748,690	56,017	16,850	1,275,534	2,108,800	21,088
July 2021							
100 Cases Produces:	**Cases**	**Long COVID cases**	**Admissions**	**ICU admissions**	**Deaths**	**Total**	
	100	28.68	3.19	0.31	0.35		
QALYs lost	0.167	8.603	0.099	0.011	2.403	11.282	
costs (£)	0	2,868	20,817	12,635	82	36,402	
total net monetary loss (£)	11,690	605,078	27,733	13,387	168,278	826,200	8,262
January 2022							
100 Cases Produces:	**Cases**	**Long COVID cases**	**Admissions**	**ICU admissions**	**Deaths**	**Total**	
	100	22.88	1.45	0.04	0.14		
QALYs lost	0.167	6.864	0.045	0.001	0.962	8.039	
costs (£)	0	2,288	9,455	1,427	33	13,202	
total net monetary loss (£)	11,690	482,756	12,596	1,512	67,348	575,900	5,759

Sensitivity Analysis – resetting some assumptions

A re-estimate was performed using cost and QALY values mostly as they had been at the time of a similar paper issued in August 2021, plus two other reductions:

- QALYs per COVID death as calculated for Wales is high compared to some countries, take an example lower figure from another country (Netherlands figure from an academic paper)
- UK Treasury Green Book QALY price is high according to some academic papers, take a lower suggested figure

The re-estimate is more comparable with results from the August 2021 paper. It offers a January 2022 figure of around £2,400 i.e. a lower estimate per COVID-19 case.

Table 5. Assumptions used for the sensitivity estimate

Hospital admissions lag (admission occurs this many days after case onset) (unchanged)	7
ICU admission occurs this many days after case onset (unchanged)	10
Death occurs this many days after case onset (unchanged)	20
QALY losses for cases	0.0000889
NHS case-only costs	left at zero
QALY losses for hospitalisation	0.0112603
NHS costs for hospitalisation	£7,085
QALY losses for ICU (Unchanged)	0.03457
NHS costs for ICU	£22,198
QALY losses for deaths	3.72
NHS costs for deaths (Unchanged)	£232

QALYs lost valued at £30,000 per QALY.

Assumptions are discussed in Appendix 1 (as alternates to the main assumptions used). Table 6 separates this out: what difference would any *one* of the updated assumptions make?:

Table 6. Results of individual parameter changes.

Effect of Separate update	January 2022 social cost per covid case	Differs from previous settings
none (previous settings)	£5,759	na
QALY losses for cases 0.0000889 (NHS case-only costs left at zero)	£5,648	-£111
QALY losses per HOSPITALISATION 0.0112603	£5,739	-£20
NHS costs for hospitalisation £7,085	£5,767	£8
NHS costs ICU £22,198 (QALY losses for ICU unchanged)	£5,753	-£6
QALY losses from deaths 3.72 (NHS death cost left at £232)	£5,455	-£304
QALY value £30,000	£2,544	**-£3,215**

The overall change from updating all these assumptions is displayed in more detail (Table 7):

Table 7. Number of long COVID, admissions, ICU admissions and deaths per 100 COVID cases in January 2022, with social cost per COVID case using the updated assumptions.

January 2022							
100 Cases Produces:	**Cases**	**Long COVID cases**	**Admiss-ions**	**ICU admiss-ions**	**Deaths**	**Total**	**Social cost per COVID case (£)**
	100	22.88	1.45	0.03	0.14		
QALYs lost	0.009	6.864	0.016	0.001	0.525	7.415	
costs (£)	0	2,288	10,257	773	33	13,351	
total net monetary loss (£)	267	208,203	10,746	809	15,778	235,800	2,358
Versus (net monetary loss with previous assumptions)	*11,690*	*482,756*	*12,596*	*1,512*	*67,348*	*575,900*	*5,759*

The costs and QALYs associated with individual outcomes were very different. The overall social costs of one COVID case were £2,358 versus the base scenarios at £21,088 in December 2020, £8,262 in July 2021 and £5,759 in January 2022.

The analysis is dependent on assumptions. Long COVID costs fell by more than half with the sensitivity assumptions. Mortality costs fell more (to around 23% of what it had been) leaving costs even more concentrated on long COVID sufferers.

Table 8. Estimated direct social cost of one PCR-confirmed case – August 2021 estimates and January 2022 re-estimate

Basis	(to nearest £100)	Comments
August 2021 estimate for December 2020	£13,000	Headline figure from last year's paper.
August 2021 estimate for July 2021	£2,500	Headline figure from last year's paper.
Re-estimate, COVID, January 2022	£2,400	Alternate assumptions around the costs and Quality Adjusted Life Year losses. More comparable with last year's paper.

Discussion

Previous modelling work carried out across UK Government has estimated the costs and QALYs lost through the pandemic at a macro level;[6] in this analysis we have not included indirect losses, whether NHS costs or QALYs (for instance through displaced healthcare, mental health problems related to social isolation, unemployment etc). COVID-19 has exacerbated health inequalities; we have not weighted costs or QALYs by socioeconomic position. This would be possible to do and social costs would be higher with these included. This paper does not disaggregate social costs of COVID-19 by age. Increased susceptibility to long COVID or hospital admission or death amongst the unvaccinated is described in the literature (see Appendix 5) so the social costs of COVID-19 amongst unvaccinated groups will have been higher during the periods analysed. Increased susceptibility to long COVID or hospital admission or death amongst those with comorbidities is described in the literature (see Appendix 5) so the social costs of COVID-19 amongst these groups will have been higher during the periods analysed. 50-69-year-olds are particularly susceptible to long COVID (see Table 3). Most recently, in January 2022, 43% of 50-69 year olds are estimated to be affected by COVID-19 for longer than 12 weeks if they are a COVID-19 case versus 23% in the population overall. A remarkable difference that was also seen in earlier time periods.

Most of the change in the social cost of COVID-19 cases is because of the vaccination programme (see Appendix 5). The vaccination programme started with health and social care workers and the oldest and most vulnerable groups in Wales and worked down the age bands. The age structure of cases is often different at different times in the pandemic which will also drive hospitalisation and mortality – so far, waves have started with more cases in younger people before moving into older people and then producing outbreaks in hospitals and care homes. There are estimates of how many deaths have been prevented by vaccination, such as PHE/Cambridge University's estimate that around 85,000 deaths in England had been prevented by the vaccination programme by 6 August 2021.[7] Naively applying

[6] DHSC/ONS/GAD/HO: Direct and indirect impacts of COVID-19 on excess deaths and morbidity - December 2020 update, 17 December 2020 - GOV.UK (www.gov.uk)
[7] COVID-19 vaccine surveillance report - week 32 (publishing.service.gov.uk)

the Wales/England population ratio (5.6%), this would have been around 4,700 deaths prevented in Wales in that period.

The number of long COVID cases per 100 cases is estimated based on self-reported data from the ONS survey. There are issues with this - the self-reported nature of the data; some of the data only available UK-wide with consequent inferring for Wales; possible issues around time lags; possible changes over time in the risk of long COVID. There may also be differences in long COVID risk between different variants – in December 2020 the Alpha variant predominated, in July 2021 Delta predominated, in January 2022 Omicron predominated. The self-reported data may be higher than the true prevalence of long COVID which may inflate cost of COVID case estimates.

What effect might waning immunity or new variants (that are more transmissible or escape immune responses) have on the social costs of COVID-19 cases? It is possible that long COVID cases will diminish over time anyway, if they are associated with a first exposure to the virus (and rarely with subsequent exposures). If this is the case, it is unlikely that increases in other categories of harm would outweigh the reduction in long COVID harms.

This paper outlines the individual costs of COVID-19 cases. There are other costs. Some costs arise at a threshold rather than in proportion. For example schools interventions: cases in the community had relatively low effects on educational outcomes until they reached the threshold when school closures happened, at which point the costs of lost education of extra cases became huge. Governments within the UK have been reluctant to repeat school closures. Alternative self-isolation or lockdown interventions on schools could still exhibit a threshold effect.

For previous COVID variants some cases were responsible for a lot of onward transmission while most cases would only infect zero or one other person.[8] At that time certain COVID-19 cases had more significance for the pandemic (but the *average* COVID case was still relevant to decision making).

Evidence from the field of economic epidemiology (the example paper uses US data) suggests that people change their behaviour based on their fear of infection.[9] Evidence from the US suggests that states that were slow to implement restrictions to control the pandemic may have seen a similar reduction in economic activity because even with light touch state intervention, people's behaviour changes in a pandemic due to fear of infection.[10] So there are externalities around high rates of cases - economic activity may be affected.

Economic activity had also been affected by self-isolation, requirements since mostly removed.

There is an emerging literature that other medical conditions can be caused or worsened as a result of having had COVID. The exact effect is too uncertain to include in this analysis. COVID-19 increases the risk of:

- Kidney disease

[8] Endo A. Estimating the overdispersion in COVID-19 transmission using outbreak sizes outside China. Wellcome open research. 2020;5.
[9] Bayham J, Kuminoff NV, Gunn Q, Fenichel EP. Measured voluntary avoidance behaviour during the 2009 A/H1N1 epidemic. Proceedings of the Royal Society B: Biological Sciences. 2015 Nov 7;282(1818):20150814.
[10] Goolsbee A, Syverson C. Fear, lockdown, and diversion: Comparing drivers of pandemic economic decline 2020. Journal of Public Economics. 2021 Jan 1;193:104311.

- Heart failure and stroke
- Diabetes - refers to a study that tracked over 47,000 people in England who had been admitted to hospital because of coronavirus before August 2020. Comparing with people of the same age and background who hadn't been in hospital with coronavirus, they were 1.5 times more likely to be diagnosed with diabetes. It is as yet unsure whether coronavirus is directly causing diabetes, or whether there are other factors that could explain the link.
- Blood clots (deep vein thrombosis, pulmonary embolism, bleeding) - incidence rate ratios were significantly increased 70 days after COVID-19 for deep vein thrombosis, 110 days for pulmonary embolism, and 60 days for bleeding.

International comparison

It was not possible to find any close comparators. There is an online article that discusses a paper from early in the pandemic 'COVID-19 Infection Externalities: Trading Lives vs. Livelihoods" (Bethune and Korinek) Economist: Societal Costs of COVID-19 Outweigh Individual Costs | UVA Today (virginia.edu)

This used a very high value for a statistical life year ($498k). The authors also calculated the benefit of having had COVID for the person who recovers: "once you recover, you no longer need to worry about the disease and you no longer need to distance". This seems to overstate that benefit very much. Calculating these two things together allowed the authors to find a statistical cost of becoming infected to be worth the equivalent of $18,000 (say £14,220) for an individual. This figure falls between December 2020 all costs figure of £21,100 and December 2020 figure for the death column only £12,755. Little else can be said in comparing these figures, given that they arise from such different methods.

Conclusion

There is uncertainty around the social costs in this paper and they may not include all relevant costs. Nevertheless, it is likely that spending more to prevent or delay one COVID-19 case would have been more cost effective in December 2020 than in July 2021 or January 2022 due to the average cost per COVID-19 case being higher in December 2020 (£21,100 compared with £8,300 in July 2021 and £5,800 in January 2022). The cost effectiveness of delayed cases depends on costs in the period delayed to. Preventing an average case currently makes a saving of £5,800, but since it is likely that prevention strategies will be concentrated on vulnerable groups the actual saving per case prevented could be higher than that since vulnerable groups would likely have more serious outcomes from contracting COVID. Any interventions would ideally be modelled on the epidemic curve but with second-stage modelling to distinguish delayed cases from cases that there is a policy desire to prevent, but this is difficult where there is still uncertainty around the impact of future variants, which themselves become more likely with higher prevalence.

Appendix 1. General estimates and costs used in the calculation.

Cost and QALY estimates.

Hospital admissions

The mean incubation period of the disease is 6.38 days (https://www.sciencedirect.com/science/article/pii/S1201971221000813). Rounding this up to 7 days would be more likely to give infection to admission lag than case to admission lag. Time between symptom onset and hospital admission depends on age – the ONS found a 4-day lag for the 20 to 80 age group (June 2021), similar to 'Clinical progression of patients with COVID-19 in Shanghai, China' of February 2020. Other studies have suggested an additional 2 days for patients from a nursing home. A case is associated with its date authorised, generally the date that a PCR test was authorised. Where there are cases associated with routine testing this date can be before symptom onset. Nevertheless 7 days seems high. However, the lag figure has little effect on the social cost calculation since a similar number of cases are found in a period shifted 4 days or shifted 7 days.

ICU admissions

'The timeline and risk factors of clinical progression of COVID-19 in Shenzhen, China' July 2020 - Figure 1c suggests that admission to ICU is 7 days after admission to hospital, which taking into account initial admission would suggest a figure of 11 days. As discussed for general admissions, this has little effect on the social cost calculation since a similar number of cases found in a period shifted 10 days or shifted 11 days.

Death

There are various estimates of time between symptom onset and death (as discussed for hospital admissions case average time could be slightly longer than symptom onset time). 'COVID-19: time from symptom onset until death in UK hospitalised patients' October 2020 Median time from symptom onset to death shorter in the second wave (7 days) compared to the first wave (13 days). ONS provided a June 2021 update (section 'Time between symptom onset and/or hospitalisation and death') in which they quote a WHO review of analysis as saying 'Time between symptom onset and death from COVID-19 reported median times of 16 or 19 days' and 'reported median times between ICU admission and death varied across studies and were estimated as 7 or 12.5 days'.

QALY losses for cases

Some academic papers (eg Fragaszy EB, Warren-Gash C, White PJ, et al. Effects of seasonal and pandemic influenza on health-related quality of life, work and school absence in England) use weighted average of QALY lost per community case of flu in England over four strains - 0.00167.

Hence the assumption will be 0.00167.

The earlier paper used asthma for 7 days as the equivalent, calculating 0.0000889 QALYs – a useful alternative figure for the sensitivity analysis.

NHS case-only costs

This was set to zero, the same as that used in the earlier paper.

QALY losses for hospitalisation

Use 0.031 as mentioned in Impact of influenza on health-related quality of life among confirmed (H1N1)2009 patients) (Hollmann M, Garin O, Galante M, Ferrer M, Dominguez A, Alonso J.)

Hence the assumption will be 0.031

The earlier paper used 0.0112603 QALYs - health-related quality of life loss for 15 days in hospital for pneumonia based on Adronis et al– a useful alternative figure for the sensitivity analysis.

NHS costs for hospitalisation

Use £6,531 – provided by Wales NHS Financial Delivery Unit March 2022.

The earlier paper used £7,085, a previous estimated provided by Wales NHS – used in sensitivity analysis.

QALY losses for ICU

Although some papers use the same figure as for general admissions, a similar but slightly higher figure seems preferable. Therefore this has been left at 0.03457, the same as was used in the earlier paper.

NHS costs ICU

Use £40,687 – provided by Wales NHS Financial Delivery Unit March 2022.

(Some papers in the public domain assume the same costs for an ICU COVID patient as for a COVID general admission. Wales NHS figures do not support that, supporting rather an ICU figure that is significantly higher than the general ward figure).

The assumption for the re-estimation will be £40,687.

The earlier paper used £22,198, a previous estimated provided by Wales NHS – a useful alternative figure for the sensitivity analysis.

QALY losses from deaths

A revised figure recalculating using Icnet data by age group might not change much because the average age of deaths does not seem to have increased significantly since the original calculation.

The assumption will be 6.78 QALYs per COVID death, as used in the previous paper. This was based on empirical data for Wales, analysed using SAIL data, and since this was calculated there has not been a significant change in average age at death for COVID cases, which would warrant a new estimate being used.

A lower figure, to test sensitivity, is of interest. There is a recent one available for the Netherlands.

That recent estimate from the Netherlands (2FEB22) gives QALYs lost because of COVID-19 mortality on average 3.9 per death for men and 3.5 for women. If this can be applied to Wales, using the ONS England & Wales COVID-19 provisional death registrations by sex for weeks 1 to 5 2022 gives females ratio of 44.2%. So by aggregation that gives 3.72 as an alternative figure for the sensitivity check.

NHS death cost

In the absence of more recent alternatives this has been left at £232.

PSSRU Unit costs of health and social care 2019, from section 8 end-of-life care - inpatient emergency. The figure was “adjusted to 16 days” resulting in £232.

QALY

The current monetary WTP value for a QALY is £70,000 in 20/21 prices - UK Treasury Green Book advice[11].

(Versus £60,000 used in the earlier paper, in line with earlier Green Book advice). There has been debate about the health production cost in the English NHS being much lower than £60,000.[12] Various studies during the pandemic (for example June 2020 Imperial College London 'Living with COVID-19: balancing costs against benefits in the face of the virus') used £30,000. The sensitivity estimate will use £30,000.

[11] The Green Book and accompanying guidance and documents - GOV.UK (www.gov.uk)
[12] Martin S, Lomas J, Claxton K, Longo F. How Effective is Marginal Healthcare Expenditure? New Evidence from England for 2003/04 to 2012/13. Applied Health Economics and Health Policy. 2021 Jul 21:1-9.

Appendix 2. Long COVID estimates and costs used in the updated calculation.

QALY losses from long COVID

Long COVID is, in the UK, typically defined as COVID-19 symptoms beyond 12 weeks, so the initial period of interest is a quarter of a year.

What proportion of those with long COVID had it bad enough to severely limit their lives during that time? Using the ONS COVID-19 infection survey, Ayoubkhani et al (2021, preprint, rated as high quality, previously unvaccinated adults (18 to 69 years), looking at the period 3 February and 5 September 2021 in the UK) did that. Of 6,729 participants that reported long COVID those who reported activity limiting long COVID were 4,747 (just over 70%). Just over seven-tenths of a group affected for one-quarter of a year, halving that (equating the QALY loss to half, the same proportion as 'bed-ridden' versus perfect health - 'activity limiting' is probably not the equivalent of losing the quarter of a year altogether) suggests 0.088 QALYs for the severely limited. The other 1,982 sufferers should be assigned some loss, so 0.1 QALYs for the group under study would seem reasonable. And if the participants had gone on to suffer the same disability for half as much time again then 0.15 QALYs, the long COVID QALY loss used in the previous paper.

More recently, scholarly articles have appeared evidencing a longer tail for long COVID – many who report long COVID at 12 weeks continue to report it for far longer than that. Tran et al (preprint, rated as high quality) examined the effect of vaccination on long COVID symptoms in adults (≥18 years old) who had a COVID-19 infection (confirmed or suspected) and subsequent long COVID symptoms (symptoms persisting >3 weeks past initial infection) between November 2020 and May 2021 in France. Participants (n=910 of which 455 vaccinated 455 unvaccinated, median age of 47 years, 80.5% female, median of 10.7 months of symptoms) had already had an average of 10.7 months of symptoms and when they were checked 120 days after recruitment both groups still had significant minorities with long COVID symptoms they found unacceptable: the vaccinated who had remission of all long COVID symptoms 16.6% and 38.9% found their symptoms 'unacceptable' the unvaccinated who had remission of all long COVID symptoms 7.5% and 46.4% found their symptoms 'unacceptable'.

Assume the following:

- ‘unacceptable’ symptoms as synonymous with ‘activity limiting’
- the four month (120 day) period is a repeatable period in the decay of ‘activity limiting’ symptoms
- 16.6% left the long COVID cohort every 4 months
- 38.9% of those who had not left the long COVID cohort found their symptoms 'unacceptable'

So in the next four month period five-sixths of the early long-COVIDs still had long COVID and around four-tenths of them had an effect that mostly lost them that third of a year = five-sixths times four-tenths times one-third equals one-ninth.

Suppose recoverers reduce this by a sixth in each subsequent third of a year. The table of losses would, at a maximum, be this

Table 9. Long COVID QALY calculation

Time period	To sum
Initial 3 months	0.176
4-7 months	0.111
8-11 months	0.0926
12-15 months	0.0772
16-19 months	0.0643
20-23 months	0.0536

So the appropriate figure over almost two years is almost 0.6 - a significant part of the original long COVID sufferers for whom their condition was ‘activity limiting’ still having that beyond two years.

Equate this to 0.3 of a QALY, equating the period of 'activity limiting’/’unacceptable' long COVID as the QALY equivalent of ‘bed-ridden’ versus perfect health i.e. 0.5.

The assumption will be 0.30 (the earlier paper used 0.15).

long COVID at 12 weeks versus long COVID over longer periods

It is possible to calculate what proportion of long COVID cases still have health deficits at a slightly later time. To do this, calculate the cases by age group after 15DEC2020 and up to 15JUN2021. Multiply this by the ratio to get long COVID cases just from those cases. This allows calculation of a residual – the long COVID cases estimated for the 4 weeks up to 4JULY2021 minus the recent long COVID cases. The residual are continuous long COVID cases – have continued with long COVID since the earlier period i.e. considerably more than 12 weeks. The residual can be ratioed to the long COVID cases in the earlier period (4 weeks up to 6MAR2021) to give the percentage of earlier long COVIDs that persisted as continuous long COVID cases (at that time).

For January 2022, assume that percentage for earlier long COVID cases that have persistent health problems. This can then be subtracted from a newly calculated long COVID number to give long COVIDs being generated amongst recent cases. Ratio that to the recent cases (those to mid-October 2021 minus the ones to 15JUN21) to get the percentages of January 2022 cases that may turn into long COVID cases. The two sets of percentages are shown in **Error! Reference source not found.**. The propensities have fallen in most age groups – the later percentage is around four-tenths of its earlier percentage for the youngest age group and has fallen, but less, for the other under 70s. The 70+ age group is affected by aspects of the data which affect the other age groups less – private households approximates to all households across most of the age range but less so for the oldest who can be in hospitals or care homes. The percentages were used as listed though, applied to cases in the months of interest by age group to get long COVID cases.

Table 10. Estimated proportion of confirmed COVID-19 cases that become long COVID, based on ONS COVID-19 infection survey data combined with PHW ICNet case data up to 14 February 2022.

Age group	Estimated proportion of COVID-19 cases that become long COVID (Early 2021)	Estimated proportion of COVID-19 cases that become long COVID (January 2022)
0-24	17%	6%
25-34	28%	23%
35-49	40%	27%
50-69	55%	43%
70+	30%	33%

NHS long COVID costs

Given the evidence above that long COVID continues for a long time and can be debilitating in patients it seems unlikely that the cost of NHS treatment would be nil. There is this announcement of £5m funding in Wales for the long COVID offer. Suppose that to be exactly the amount that will be spent on the current estimate of long COVID numbers in Wales - 45,410. This would average to £110 per long COVID case. Round this down to account for that part of the funding that will go to initial setup (not dependent on actual numbers). So an average may be £100 per long COVID.

The assumption will be £100.

A discussion of the QALY

QALY assumes that a year of life lived in perfect health is worth 1 QALY (1 Year of Life × 1 Utility = 1 QALY) and that a year of life lived in a state of less than this perfect health is worth less than 1. In order to determine the exact QALY value, it is sufficient to multiply the utility value associated with a given state of health by the years lived in that state. QALYs are therefore expressed in terms of "years lived in perfect health": half a year lived in perfect health is equivalent to 0.5 QALYs (0.5 years × 1 Utility), the same as 1 year of life lived in a situation with utility 0.5 (e.g. bedridden).

Length of Life is real and quantifiable.

Utility is intangible and not susceptible to direct observation – should “bedridden” be 0.5?

Some discussion can be found at Problems and solutions in calculating quality-adjusted life years (QALYs).

"In the system" bias can affect the perceived quality of life of the unobserved public versus those known to the medical profession. In the absence of evidence the unobserved public may be counted as in good health (QALY=1). One of them comes to their GP with a (possibly trivial) health issue. GP gives them a checkup. They have some sort of chronic condition of which they were unaware (heart murmur, low lung capacity etc.) Now the health system thinks of their remaining years as having lower HRQoL (QALY 0.99 perhaps), and perhaps even expends something on monitoring or drugs.

Appendix 3. Naïve estimate of the social cost of influenza.

Cases

One way of estimating the influenza cases in England in 2017-18 is using the Flusurvey https://flusurvey.net/en/results/

Amongst Flusurvey participants the overall ILI rate (all age groups) was 18.2 per 1,000 (42/2,306 people reported at least 1 ILI) or

1,820 per 100,000 which, using 55,619,400 ONS' mid-2017 population of England, gives 1,012,273 flu cases in the year

Admissions, ICU admissions, deaths

One way of estimating these in England in 2017-18 is using 'Quantifying the direct secondary health care cost of seasonal influenza in England' https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-020-09553-0

During the 2017-18 season there were 46,215 (for 41,730 individual patients) influenza-related hospital admissions.

£2,773 per Influenza-related hospitalisation in the 2017-18 season (£6,101 per ICU admission if an ICU admission is 2.2 times a general hospitalisation – various high dependency to ward bed costs per night ratios are a bit over 2).

Laboratory confirmed influenza was associated with a total of 3,175 admissions to intensive care unit/high dependency unit in England.

15,969 excess deaths associated with influenza in the UK as estimated by the FluMOMO model of influenza. If it is Ok to use a naïve proportion of England to UK population (ONS mid-2017 estimates 55,619,400 over 66,040,200), excess deaths England would be 13,449.

Table 11. Influenza hospitalisations and deaths, England 2017-18 season

	Number	Rate per 100 cases
Admissions	46,215	**4.57**
ICU Admissions	3,175	**0.31**
Deaths	15,969	**1.33**

Use those numbers and also two more numbers in the social costs calculator, the other replaced numbers being:

- cost per Influenza-related hospitalisation (£2,773 in the 2017-18 season)
- cost per ICU admission (take this to be £6,101 in the 2017-18 season)

Leave any unknown assumption values the same as the COVID value. Blank out long COVID. This produces this result:

Table 12. Number of admissions, ICU admissions and deaths per 100 influenza cases (England 2017-18 season) with social cost per influenza case using the same

assumptions as the updated COVID assumptions where specific values are not known.

Influenza (England 2017-18 season)							
100 Cases Produces:	**Cases (assumption same as COVID)**	**(no long influenza cases)**	**Admiss-ions**	**ICU Admiss-ions**	**Deaths**	**Total**	
	100		4.57	0.31	1.33		
QALYs lost	0.167		0.142	0.011	9.008	9.327	
costs (£)	0		12,660	1,913	308	14,882	
total net monetary loss (£)	11,690		22,567	2,672	630,867	667,800	6,678
Versus (COVID loss with Jan 22 assumptions)	*11,690*	*482,756*	*12,596*	*1,512*	*67,348*	*575,900*	*5,759*

It may be that some of the COVID QALY assumptions are too low for influenza and others too high. The COVID QALYs lost for a case (0.00167) and admission (0.031) can be contrasted with 2017 NICE report 'Flu Vaccination: Increasing Uptake':

QALY loss associated with ILI... and hospitalisation was modelled as 0.008 (i.e. they modelled an influenza case with a higher value)... and 0.018 (i.e. they modelled an influenza admission with a lower value).

Appendix 4. LFT positives and PCR Positives

Throughout this report, Cases refers to PCR positives (PHW provide this data).

Some LFT positives are also reported to PHW and they report this data in their report 'Lateral Flow Rapid COVID-19 Antigen Testing Wales Weekly Surveillance'.

(Note that the data used in Table 13 is from their Report Date: 16 March, 2022 whereas a later report will probably now appear at the above link).

Not all positive LFT tests are reported– this is something that the public are requested to do but it is probable that many do not. Nevertheless the fall in the weekly PCR positives at a time when LFT positives reported by the public saw a rise is strongly suggestive of reduced PCR testing (including confirmatory testing) during January 2022, related to the rules changes during that period.

Table 13. Lateral flow testing episodes (positive) and cases as used elsewhere in this report

Week Start	Week End	Positive (LFT)	Positive(PCR)	Ratio
03/01/2022	09/01/2022	15,312	48,649	24%
10/01/2022	16/01/2022	15,394	15,996	49%
17/01/2022	23/01/2022	21,127	16,213	57%
24/01/2022	30/01/2022	23,066	16,945	58%

Appendix 5 The unvaccinated, those with comorbidities, the effect of vaccines.

The social costs of COVID-19 amongst those with comorbidities will have been higher, including during the periods analysed.

This Public Health England December 2020 study included some analysis of pre-existing health conditions among cases (determined by admission to hospital with the condition in the previous 5 years) that could be linked to Hospital Episode Statistics. It defined pre-existing conditions against an expert clinical assessed list associated with poor outcomes for COVID-19 and other respiratory infections. 47% of cases had one or more pre-existing conditions compared with 84% of COVID-19 deaths. The proportion of cases with a pre-existing condition increased with age from 15% in under 35s, 21% in under 55s to 88% in those aged 85+. For deaths this proportion was 58% in under 55s, rising to 88% in those aged 85+.

Here is some evidence that this also applies more recently and for Wales: ONS table: died due to COVID-19 shows that most recent COVID deaths had comorbidities:

Table 14. Most COVID deaths are amongst those with comorbidities

The number of death certificates where the death was due to [1] COVID-19, and the number and proportion of these that did not have a pre-existing condition [2], Jan to Mar 2022

Geography	Number of deaths due to [1] COVID-19	of which, number of deaths with no pre-existing conditions [2]	Proportion of deaths with no pre-existing conditions [2]
Wales	497	66	13.3%

Notes

[1] "due to COVID-19" refers only to deaths with an underlying cause of death as COVID-19 (a stricter definition than "involving COVID-19" which would be mentions on the death certificate whether as an underlying cause or not).

[2] Pre-existing condition means either or both:

- an entry on the first part of the death certificate (the direct sequence of events leading to death) BUT on a lower line to (therefore clearly preceding) coronavirus (COVID-19)
- an entry on the second part of the death certificate which are independent contributory factors in the death.

It EXCLUDES mentions of fatigue and 'old age' as these are generally not valid conditions for death certification

The social costs of COVID-19 amongst unvaccinated groups will have been higher during the periods analysed due to:

- susceptibility to long COVID

  this 2021 preprint adults 18 to 69 years period 3 February and 5 September 2021 in the UK found first vaccination was associated with an initial 12.8% decrease in the odds of Long COVID and second vaccination with an 8.8% decrease

  this 2022 preprint adults (median age 47 years) in France found that vaccination helped those who already had long COVID: 16.6% patients in the vaccination group reported a remission of all symptoms from long COVID, compared with 7.5% in those who remained unvaccinated. Vaccination also reduced the number of long COVID symptoms and the proportion of patients with an unacceptable symptom state

- hospital admission this BMJ article on vaccination affecting hospital admissions and deaths gave these examples: between the week beginning Monday 16 August 2021 and the week ending Sunday 12 September, the rate of hospital admissions of over 80s was 50.5 per 100 000 in the fully vaccinated and 143.9 per 100 000 in the unvaccinated, a ratio of around 2.85 (for 60-69 year olds the hospital admission rates were 13.5 per 100 000 in the fully vaccinated and 74.3 per 100 000 in the unvaccinated).
- ICU admission: unvaccinated groups had a higher tariff of the factors that would suggest higher social costs of COVID-19: in this June to August 2021 study of hospitalized patients in Korea found that fully vaccinated status was associated with a lower risk of requiring supplemental oxygen than unvaccinated status, as well as lower risk of intensive care unit (ICU) admission
- Increased deaths: this February 2022 ONS publication noted that, for England, for the period July to December 2021, the age-standardised mortality rates for the unvaccinated are higher than those with at least some level of vaccination in all age groups. The age-adjusted risk of death involving coronavirus (COVID-19) was 93.4% lower for people who had received a third dose, or booster, at least 21 days ago compared with unvaccinated people (for simplicity use 15 times)

Most of the change in the social cost of COVID-19 cases is because of the vaccination programme. This is the case if the unvaccinated propensities mentioned above are applied naïvely:

Table 15. Possible Unvaccinated scenario

	Estimate	Scenario for unvaccinated
% of Jan22 new cases that are long COVID	23%	29%
Long COVID QALY (Table 9 calculation)	0.3	0.37
Hospital admission (using 2.85 times)	1.45%	4.13%
ICU admission (also using 2.85 times)	0.03%	0.10%
Deaths (15 times)	0.14%	2.12%

Table 16. January 2022 social cost per COVID case, Unvaccinated scenario

January 2022							
100 Cases Produces:	**Cases**	**Long COVID cases**	**Admiss-ions**	**ICU admiss-ions**	**Deaths**	**Total**	**Social cost per COVID case (£)**
	100	28.77	4.13	0.10	2.12		
QALYs lost	0.167	10.616	0.128	0.003	14.349	25.263	
costs (£)	0	2,877	26,946	4,039	491	34,353	
total net monetary loss (£)	11,690	745,971	35,899	4,280	1,004,909	1,802,700	18,027
Versus (net monetary loss with previous assumptions)	*11,690*	*482,756*	*12,596*	*1,512*	*67,348*	*575,900*	*5,759*

Some unvaccinated cases are in the January 2022 mix anyway. This may suggest that applying the full “scenario for unvaccinated” applies too large an increase. Conversely the proportion of vulnerable that are vaccinated is higher than the proportion of vulnerable unvaccinated in the January 2022 mix and no account has been taken of increased lengths of stay of the unvaccinated. This may suggest that applying the “scenario for unvaccinated” applies too small an increase. These effects will tend to balance out.